The Emergence of the Design Stance in Early Childhood

by

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Abstract

Causal explanatory principles are considered to be central to the human conceptual system in current theories of cognitive science. Two types of explanatory principles have been well studied in cognitive development: mechanical causality and intentional causality. The former appeals to physical forces in explaining interactions between physical bodies and the latter appeals to the notions of belief and desire in explaining human behavior. By the age of four, children use these two explanatory schema to reason about objects and people.

In addition to these two explanatory principles, Dennett (1987) proposes a third explanatory schema, the "Design Stance", which is available to people in reasoning about artifacts and biological kinds. When adopting this stance, adults account for the existence of entities (e.g. a chair) or properties (e.g. the sharpness of a knife) by referring to their original intended function.

This thesis addresses different aspects of children's understanding of the Design Stance. Chapter 1 investigates four-, six- and eight-year-olds' capability of distinguishing between properties which were intentionally designed and those which are epiphenomenal. The results suggest that four-year-olds cannot make this distinction and that as children get older they become better at making it. Chapter 2 examines whether four-year-olds understand the notion of original intended design. This understanding was probed by having children create an artifact on their own, and then use it for a serendipitous function. Children were then asked what they made the artifact for. Four-year-olds show no preference for the original intended function of the artifact over other functions it can fulfill in determining what an artifact is for. Chapter 3 examined whether four- and six-year-olds rely on the original intended function of an artifact in their categorization judgments. Unlike six-year-olds and adults, four-year-olds do not rely on the original intended function of an artifact in determining what it is.

In sum, these results suggest that preschoolers do not understand the notion of original intended design and that the understanding of the Design Stance begins to emerge only around the age of six.

Thesis Supervisor: Susan Carey
Title: Professor of Brain and Cognitive Sciences

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Writing has never been a painless effort for me. Writing a thesis has been no exception. I have yet to experience childbirth, but was told by a woman who gave birth both to twins and to a thesis that the former process was far easier than the latter. I now feel ready for triplets. However, this thesis was not conceived on its own.

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Preface

In current theories in cognitive science, causal explanatory principles are considered to be central to the human conceptual system (Wellman & Gelman, 1992). Two types of explanatory principles have been well studied in cognitive development: mechanical causality and intentional causality. The former appeals to physical forces in explaining interactions between physical bodies and the latter appeals to the notions of belief and desire in explaining human behavior. By the age of four, children use these two explanatory schema to reason about objects and people

In addition to these two explanatory principles, Dennett (1987) proposes a third explanatory schema, the "Design Stance," which is available to people in reasoning about artifacts and biological kinds. When adopting this stance, adults account for the existence of entities (e.g. a chair) or properties (e.g. the sharpness of knife) by referring to their original intended function

This thesis addresses different aspects of children's understanding of the Design Stance. The first chapter of the thesis examines one of the central aspects of this understanding, namely the capability of distinguishing between properties which were intentionally designed and those which are epiphenomenal. Thus, the fact that coffee mugs can contain liquids is a property which is explained by appeal to design; that coffee mugs can be used to contain pens and pencils is not part of their intended design. The distinction between the properties which were intentionally designed and those which are epiphenomenal is often captured in English by the contrast between what something *does* and what something is *for*. Vacuum cleaners, for example have two salient features: making noise and picking up dirt from the floor. But only one of those features, namely picking up dirt, explains why vacuum cleaners were designed and manufactured. Therefore, it is appropriate to answer the question "What do vacuum cleaners do?" with both "Make noise" and "Pick up dirt," whereas it is appropriate to answer the question "What are vacuum cleaners for?" only with "Picking up dirt. Thus, "what is x for?" refers to the original function of x, while "what does x do?" refers both to the original design and to properties which are not part of the original intended design.

Chapter 1 found a developmental progression in children's capability of making a distinction between these two types of properties. Four-year-olds chose the epiphenomenal function as a good answer to “what is x for?” (e.g. - vacuum cleaners are for making noise) over 60% of the time whereas 8-year-olds were much less inclined to do so. One possible interpretation of 4-year-olds' insistence that vacuum cleaners are for making noise is that they do not understand that people make things for a purpose, that is they do not understand the notion of original intended design. Alternatively, the children may not have been privy to the design process and may not have been aware what such artifacts were designed for. If children do understand the notion of original intended design, then when they themselves make an artifact for a certain function, they should be able to say what it was made for and distinguish that from other uses to which it is put.

In Chapter 2 children's understanding of the notion of original intended design was probed by having children create an artifact on their own, and then use it for a serendipitous function. In the first study of Chapter 2, for example, four-year-olds created a funnel-shaped cone to help transfer lentils into a bottle (original function) and then used it to cover up the blue parts of a blue and yellow object (serendipitous function). The children were then asked what they made the item for. Children either gave the original function, both functions or the serendipitous function as a response. Even though children’s dominant response (60% of the time) was the original intended function , it is unclear whether this was due to their understanding of the notion of design or whether they picked out the first function that was carried out with the artifact.

In the second study of Chapter 2, 4-year-olds also created an artifact on their own, but the above materials were devised such that the object could *not* fulfill its original intended function (the lentils spilled on the table) and the first function that it carried out was the serendipitous function. In addition to the open ended question "what did you make it for?", children participated in a judgment task in which they judged whether each of three possible responses (the original intended function, the serendipitous function, a distractor response) were correct or incorrect responses to the above question. If children chose more than one response as correct, they were asked to judge which response they thought was the best. On the open ended question, children’s response pattern was the same as in the first study of this chapter. This was striking because the artifact never fulfilled its original function. It is possible that, inadvertently, the fact that the artifact never fulfilled its original function actually highlighted its original intended function. However, the dominant response in the judgment task was that both the original and the serendipitous function were correct. In addition, when asked to choose which response they thought was best, the responses were equally divided between the original function and the serendipitous function. These results show that 4-year-olds have no preference for the original intended function of the artifact over other functions it may fulfill in determining what it is for. Moreover, they suggest that 4-year-olds do not understand the notion of original intended design.

Chapter 3 demonstrates that 4-year-olds also do not rely on the original intended function of the artifact more than other functions it may fulfill in determining what an artifact is. Unlike adults and 6-years-olds, 4-year-old children did not use the original intended function of an artifact to determine category membership. For example, when told that someone is watering their flowers with an object which was originally designed to make tea in, 4-year-olds were agnostic as to whether it was a teapot or a watering can.

In sum, each of the 3 chapters of this thesis look at a different aspect of children's understanding of the Design Stance. The results suggest that preschoolers do not understand the notion of original intended design and that the understanding of the Design Stance only begins to emerge around the age of six.

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Chapter 1

"What are vacuum cleaners for?" - Children's understanding of functional explanations.

In current theories in cognitive science, causal explanatory principles are considered to be central to the human conceptual system (Murphy & Medin, 1985; Wellman & Gelman, 1992). Two types of explanatory principles have been well studied in cognitive development: mechanical causality which appeals to physical forces in explaining interactions between physical bodies (Baillargeon, Spelke, & Wasserman, 1985; Bullock, Gelman & Baillargeon, 1982; Leslie, 1994; Shultz, 1982; Spelke, 1991) and intentional explanations which appeal to the notions of belief and desire in explaining human behavior (Gergly, Nadasdy, Csibra, & Biro, 1995; Bartsch & Wellman, 1989; Estes, Wellman, & Woolley, 1989). By the age of four and earlier, children use these two explanatory schema to reason about objects and people (Wellman & Gelman, 1992; Spelke, 1991; Carey & Spelke, 1994).

In addition to these two explanatory principles, Dennett (1987) proposes a third explanatory schema which is available to people in reasoning about artifacts and biological kinds. He calls this schema the "Design Stance". When adopting this stance, adults account for the existence of entities or properties by referring to their original intended function. Thus, for example, vacuum cleaners *exist* because someone intentionally designed them for the purpose or function of picking up dirt from the floor. Umbrellas are intentionally made by the umbrella-maker from waterproof material with the goal of keeping the person beneath them dry. On the Design Stance, giraffes have long necks because it enables them to reach the leaves on tall trees[1]. Adopting these types of explanations, also called "functional explanations" (Keil 1992; Achinstein 1983), requires the ability to identify the particular purpose which a given entity or property

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[1]One cannot talk about intentions or design when dealing with biological kinds since evolution has no goals. Nevertheless, certain traits were selected for since they provided a reproductive advantage - and in that sense their design can be accounted for.

fulfills, which in turn explains why the entity or property exist.

Central to functional explanations is the idea that an item or property were *intentionally designed* to fulfill a certain *function*. Two senses of "function" should be distinguished. For the sake of clarity we will call the first the "original-function", and the second "use-function" (after Achinstein 1983). To illustrate the difference between them, consider the following example: My coffee mug was originally designed to contain coffee for drinking. It can also be used as a pen and pencil holder. The former is the original- function and the latter the use-function. Two factors are at play in these examples: the first is design and the second is intention. The coffee mug was *intentionally designed* to contain coffee. It is *intentionally* used (*not designed*) to contain pencils[2]. That is, both functions involve intentions, but the original-function also involves the notion of design. Using this terminology, functional explanations use the original-function to explain the existence of a property or an entity. Therefore, in order to be able to use the Design Stance, one not only has to be able to understand use-functions but also to be able to distinguish between use-functions and original-functions because only the latter provide an explanation for existence. Wright (1984) provides an amusing example which illuminates the necessity of making this distinction. The correct use of function explanations involves more than being able to identify some purpose that an entity is good for, since entities can be good for many things which are not part of their original design Thus, he says, livers are good for many things, among them dinner with onions. However no one would claim that that is the particular thing that livers are good for and which explains why animals have them, and why they exist. Therefore, inherent to the felicitous use of functional explanations is the ability to distinguish between properties which are accidental (use-functions), and those which are part of the original intended design (original-function).

Keil argues that functional explanations, like intentional and mechanical explanations, are an innate, or at least an early developing mode of construal which constrains young children's

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[2]Note that there is an additional notion of function - a function that was arrived at inadvertently. If, for example, the coffee mug were to be left on a pile of papers next to an open window on a windy day - it could serve the function of a paper weight. No one intended it do so, and it was definitely not designed for that purpose. But if it successfully fulfilled this function, someone might intentionally use it for that same function in the future.

understanding and exploration of the domain of biology (Keil, 1994). However, very little research has addressed children's understanding of the Design Stance.

Piaget (1929, 1959) does not speak of functional explanations per se, but proposes that the child conceives of all objects - be they natural or artifact kinds - as made for people. He suggests that the child's reasoning process is as follows: the child conceives of all objects as being made for a purpose. And if they were made for a purpose, they must have been made for men. And if they were made for men, they must have been made by men. Thus, young children will say that the mountains "are for climbing", forks are "for eating", the night is "for "sleeping", and mothers are for "taking care of us". However, from these statements it is hard to assess whether children were simply telling the experimenter what these objects can be *used* for (use-function) or whether they were referring to the original-function of the objects.

Keil (1994) explicitly addresses preschoolers' understanding of functional explanations. In one experiment he contrasts biological kinds, such as plants, with non-biological natural kinds, such as emeralds. Keil asked 5- to 7-year-olds why plants or emeralds were green. The children were given two possible answers to choose from: (a) that it is better for plants/emeralds to be green and it helps there to be more plants/emeralds; (b) that there are tiny parts in the plant/emerald which cause it to be green. Keil found that preschoolers to second-graders prefer the first type of explanation for the plants and the second kind for the emeralds. In a second experiment Keil contrasted a prickly plant with a prickly mineral and told the children that only one is prickly because it is good for it. The children were asked to pick which one was prickly because it was good for it. Keil reports that preschoolers chose the plant over the mineral.

While providing evidence for children's understanding of function. These results are inconclusive with respect to children's understanding of functional explanations. In his experiments, Keil takes children's use of the expressions "good for it" "better for it" as indicative of having the Design Stance. However, being able to say what something is good for, is not indicative of understanding functional explanations. For example, mugs are good for holding pencils, but that is not what they were originally designed for. Thus, the fact that children use these expressions can only be taken as evidence of an understanding of functions. In addition, it is probably the case that the expressions "good for it", "better for it" are rarely used with minerals /emeralds or barbed wire. They are more commonly used in conjunction with plants and might have been chosen by the children on this basis.

Thus, the evidence for young children's understanding of functional explanations in the domain of biology is inconclusive. However, there is evidence suggesting that preschoolers may possess some of the components of functional explanations which would enable them to adopt the Design Stance with respect to artifacts.

One component is understanding the notion of use-function. In addition to Keil's work with five to seven-year-olds (1992), there is evidence that even younger children understand the notion of use-function. Landau, Smith & Jones (1995), for example, have shown that already at the age of three children can say whether a certain novel object can support the same use-function (e.g. mopping up water, have pins stuck into it) as a previously presented object. Brown (1989) has shown that children as young as two years of age can understand which objects will enable them to retrieve a desirable toy which is placed out of their reach. That is, when given a series of objects to choose from they can pick out which objects can function as a tool that will help them attain their goal. At an even earlier age children can demonstrate knowledge of simple functions of familiar artifacts such as brushes and hammers (Abravenel & Gingold 1985; Zelaso & Kearsly, 1980).

Being able to identify the origin of an artifact is also important to understanding functional explanations. Gelman and Kremer (1991) have shown that young children know that artifacts are man-made. They posed preschoolers questions about origins of artifacts (cup, hammer, doll, shoe, television) and natural kinds. First, children were asked directly whether they thought people made those things. Four-year-old children clearly knew that people made artifacts and that natural kinds such as clouds or the moon were not made by people. Second, a different group of preschoolers were asked in an open-ended format where such items came from. Again, children demonstrated a clear understanding of artifact origins by citing a human cause (made by people, machines or factories) 80% of the time. Thus, there is clear evidence that preschoolers understand the origins of artifacts, namely that they were made by people.

As mentioned earlier, there is much evidence that young children understand intentional behaviour, even as young as one year of age (Woodward, 1995; Gergly, Nadasdy, Csibra, & Biro, 1995). By the end of their second year children become aware of their own goals and their achievement of these goals (Bullock and Lutkenhaus, 1988) and by the age of four they can demonstrate an understanding that other people act upon their goals (Wellman & Woolley, 1990). For example, Wellman and Woolley (1990) showed that preschool children can predict a protagonist's behaviour when they have information about her desires. Children were told about a boy who wanted to take his rabbit to school. The rabbit, however, was hiding in one of two locations. The boy looked for the rabbit in one of the locations, and depending on the conditions, either found it, did not find it, or found something else. Children were then asked what the boy would do next, would he look in the other location or would he go to school? Three-year-olds were already able to predict that child would go to school if his goal was achieved and he found the rabbit, or that he would continue to search if he had not achieved his goal (for example, if he found nothing or some other animal).

An additional component central to the Design Stance is the ability to distinguish between the original intended function of the artifact and accidental properties. Shultz (1980) shows that children as young as three demonstrate the ability to distinguish intentional behaviour from non-intentional behaviour when reasoning about people's actions. For example, a child is told to interlace his fingers with his hands crossed over. The experimenter then points to one of the fingers and asks the child to stretch that finger out, a task which is quite difficult to perform without error. The child is then asked if he meant to move that finger or not. Three- to seven-year-olds judge the correct movements as intended and the incorrect movements as not intended. Moreover, children can accurately predict other children's behaviour on these tasks even without having performed them themselves.

Thus, children are knowledgeable about origins of artifacts, about intentional behaviour, and about use-functions of artifacts. Some of the evidence for these understandings comes directly from preschoolers' knowledge of artifacts, and some from other domains. The question of interest is whether children can put these components together to explain the existence of artifacts by referring to their original-function.

As Wright (1984) suggests, one of the hallmarks of the understanding of functional explanations is the capability to differentiate between original-functions and other use-functions or epiphenomenal properties. Children can make the distinction between intended and accidental behavior with respect to human behaviour, but there is no evidence that children can distinguish between originally intended and accidental functions or properties. If children cannot make this distinction, we would not expect them to have a command of functional explanations.

The distinction between the properties which were intentionally designed and those which are epiphenomenal is often captured in English by the contrast between what something *does* and what something is *for*. Vacuum cleaners, for example have two salient features: making noise and picking up dirt from the floor. But only one of those features, namely picking up dirt, is the original function of the vacuum cleaners which explains why vacuum cleaners were designed and manufactured. Therefore, it is appropriate to answer the question "What do vacuum cleaners do?" with both "Make noise" and "Pick up dirt," whereas it is appropriate to answer the question "What are vacuum cleaners for?" only with "Picking up dirt. Thus, "what is x for?" refers to the original function of x, while "what does x do?" refers both to the original-design and to properties which are not part of the original intended design. All of these latter properties will be dubbed "activities" to be distinguished from the original function (since making noise, for example, is not a function unless it can be used to fulfill some goal[3])

In Experiment 1 we establish that young children are knowledgeable about everyday artifacts and are familiar with their functions. In Experiment 2 we use the contrast between "what x does" and "what x is for" to probe children's understanding of original intended function

[3]One such goal could be lulling a baby to sleep (I am indebted to Helen Tager-Flusberg for this example).

Experiment 1

This experiment seeks to establish that preschoolers have at minimum an understanding of use-function and are familiar with functions of everyday artifacts. We asked participants to choose the "good' artifact between two identical-looking artifacts that differed in the use that could be made of them. According to linguistic analyses, a good artifact is evaluated in terms of what it is good *for* (Vendler, 1967), or in terms of the use that is normally made of it (Katz,1964). Thus, a good artifact is an artifact which fulfills the function which it is habitually used for. For example: a good vacuum cleaner is one that picks up dirt from the floor. A vacuum cleaner which only makes noise, which is something that vacuum cleaners do but are not habitually used for, is not a good vacuum cleaner. Note that even though it is usually the case that the use-function of artifacts is usually identical with the original-function of artifact, they do not always coincide. Thus, although my coffee mug is habitually used as a pencil holder, this habitual use is not its original function.

Method

Participants

Twelve 4-year-olds (M=4;9, ranging from 4;0 to 4;11), seven boys and six girls, and twelve 6-year-olds (M=6;7, ranging from 6;0 to 6;11), six boys and six girls, participated in this experiment. They were recruited from Greater-Boston day care centres. They were all native speakers of English and from multi-ethnic middle and upper-middle class populations.

Stimuli and procedure

The questionnaire consisted of four items - a vacuum cleaner, a candle, an umbrella and a car. The children were shown two identical pictures of each item. They were told that the puppet needed to buy a “good car”, for example, and were asked to advise the puppet as to which one it should buy. One of the two identical artifacts was described as having its original function, but not some salient activity, while the other artifact was described as having the activity but not the function. The order of the two types of responses was counterbalanced across the items. Appendix A presents the four items with their two accompanying descriptions.

Results and Discussion

Participants received a score of 1 if they chose the original-function and 0 if they chose the activity. Both the 4-year-olds' and the 6-year-olds' performance was different from chance: the 4 -year-olds chose the artifact with original-function 86% of time, $t(11)=7.34$, $p<.001$, and the 6-year-olds chose it 97% of the time, $t(11)=16.316$, $p<.001$.

These results add to the body of knowledge that demonstrates that children understand the notion of use-function and suggests that young children are familiar with artifacts and their uses. It shows that children can distinguish between use-function and other properties. However, these results do not bear on the question of whether the children are differentiating between the different uses of the artifact on the basis of use-function or on the basis of original-function. In most cases these two notions coincide, but not always. Thus, an artifact can be good for something which was not part of its original intended function (e.g. mugs are good for containing pencils). Experiment 2 addresses the question of whether children can use the original intended function of the artifact to distinguish between these two types of function.

Experiment 2

Method

Participants

Twenty 4-year-olds (M=4;7, ranging from 4;1 to 5;0), nine boys and eleven girls, twelve 6-year-olds (M=6;10, ranging from 6;7 to 7;0), five boys and seven girls, and twelve 8-year olds

(M=8;3 ranging from 8;1 to 8;6), one boy and eleven girls, participated in the experiment. The children were recruited from Greater-Boston day-care centres and from Cambridge area schools. They were all native speakers of English and representative of multi-ethnic middle and upper-middle class populations. Twelve adults from the MIT community, undergraduate students, graduate students and staff also participated in the experiment.

Stimuli and Design

Children were interviewed individually at their day care centre or school. The four-year-olds were tested in two sessions, while most of the older children and adults were tested in one session.

Each child was asked a set of 'DO' questions: "What does X do?", and a set of 'FOR' questions: "What is X for?" about eight different items. All the DO questions were presented in one block, as were the FOR questions, so as not to confuse the younger children. The items were: a vacuum cleaner, a hat, a train, shampoo, the hands of a clock, shoe laces, the door of a house and the buttons on a phone. Every question was accompanied by a line drawing of the item in order to make the procedure more engaging. Every question had three possible answers and participants were asked to judge whether each answer was a "good" answer or a "silly" answer. The three possible responses were either an original function (F), an activity (A), or a distractor (D). Recall that both the function and the activity answers are appropriate answers for the DO questions but only the function answer is good for the FOR questions. Appendix B shows the eight questions and their potential answers.

The order of presentation of blocks was counterbalanced. The order of the response type was randomized across the questions. In addition to the test questions there were two familiarization items, one of which was used before each block of questions[4]. Both familiarization items had four possible answers - two of which were correct and two of which were incorrect, in order to demonstrate that the questions can have both types of answers. The children were not

[4]We did not give the adults the training items since we assumed that they would not have any problems comprehending the task.

given any feedback to avoid possible biasing. Appendix C shows the two familiarization items and their potential answers.

Procedure

The experimenter introduced a puppet to the child and asked whether she would be willing to help the experimenter teach the puppet. The children never failed to comply. The experimenter instructed the child to feed the puppet some candy or a toy ice-cream cone when it gave a good answer, and to feed it a sock when it gave a silly answer.

The experimenter and child proceeded to play the game, starting with 2 familiarization items. The familiarization items which were introduced before each of the two blocks of questions. Each item had two correct responses and two distractor responses. The DO familiarization item asked "what do birds do?" (correct responses - fly and sing songs, distractor responses - write books and live in fridges). The FOR familiarization item asked "what are pencils for?" (correct responses - drawing and writing with, distractor responses - for eating soup and for combing your hair). For each and every one of the possible answers the child was asked to judge whether it was good or silly. No feedback was given either on the familiarization items or on the test items, although children were continuously encouraged throughout the session. After completing the familiarization item, the experimenter said "now were are going to talk about what things do/what things are for". When turning to a new block of questions it was pointed out to the child that "before we were talking about what something does (is for) now we will talk about what something is for (does)". When the task was administered in two sessions, the experimenter reminded the child at the beginning of the session of the procedure.

Results

The familiarization items were first analysed to verify that the children understood the task. On the pencil item the children chose the activity responses 85% of the time and the distractor responses 5% of the time, and on the bird item 83% and 5% respectively. These results show that the children understood the requirements of the task and enabled us to proceed with further analyses.

The analyses performed were designed to answer the following questions: Are participants responding to the two types of questions differently? If that is the case, what is the pattern of responses within each question type? Do any of the above vary according to age group?

The measure was the number of times (out of eight items) that participants judged a given response (Function, Activity, Distractor) as a good answer to each of the questions (DO, FOR). Question type (DO, FOR) and Answer type (Function, Activity, Distractor) were within participants factors, and Order (DO_1st, FOR_1st) and Age (Four, Six, Eight, Adult) were between participant factors.

A 4 (Age: Four, Six, Eight, Adult) X 2 (Question type: DO, FOR) X 3 (Answer type : Function, Activity, Distractor) X 2 (Order: DO_1st, FOR_1st) Analysis of Variance on the number of responses participants judged as good was performed. There was no main effect of age. There was a main effect of Answer type, $F(2,96)=784.979$, $p<.001$: overall participants chose the Function answers (98%) more often than the Activity answers (59%). The distractor answers were hardly ever chosen (less than 1%) and were therefore excluded from subsequent analyses. There was a main effect of Question type, $F(1,48)=45.506$, $p<.001$: overall participants judged more answers good with respect to the DO questions (57%) than to the FOR questions (48%). There was also a main effect of Order $F(1,48)=11.040$, $p<.01$: overall participants judged more responses as good when the DO questions were presented first (56%) than when the FOR questions were presented first (49%). More importantly, there was an interaction between Question type and Answer type, $F(2,96)=49.251$, $p<.001$, such that overall participants differentiated between Answer types more for the FOR questions (Function 98% vs. Activity 45%) than for the DO questions (Function 98% vs. Activity 73%). There were also 2-way interactions between Question type and Age, $F(3,48)=6.116$, $p<.001$, indicating that participants' responses to the DO and the FOR questions differed with age; between Question type and Order, $F(1.48)=6.644$, $p<.015$, indicating that participants' responses to the DO and FOR questions varied as a result of which block of questions they were presented with first; between Answer type and Age (F6,96)=2.430, p<.035, indicating that children's' choices of Answer type varied with age; and between Answer type and Order F(2,96)=8.412, p<.001, indicating that participants' judgments of whether the Activity and Function responses were good varied according to which block of questions they were presented with first. There was a 3-way interaction between Question type, Answer type and Order F(2,96)=6.005, p<.025, indicating that participants' choice of answers to both the DO and FOR questions differed according to whether they were presented with the block of DO questions first or with the block of FOR questions first. There was a 3-way interaction between Answer type, Order and Age, F(6,96)=2.730, p<.02, indicating that the order of presentation of the questions influenced children's choice of the Answer type differently across the four ages. Most importantly, there was a 3-way interaction between Age, Question type and Answer type, F(6,96)=6.411, p<.001, indicating that participants' choice of answers differed according to their age group (see Figure 1). Given the interaction with age, we proceeded to perform analyses by age group. Note that over all age groups participants are virtually at ceiling in choosing the Function response (e.g. picking up dirt) as a good answer to both the DO questions and the FOR questions. Therefore, even though we shall continue to address the Function responses in the reporting the data, we shall highlight participants' choice of the Activity responses.

Insert Figure 1 about here

Preliminary analyses found main effects of item F(7,336)=8.667, p<.001, that is more "good" answers were chosen for some items than for others. There were also interactions with Answer type (F(14,672)=9.161, p<.001, indicating that participants differentiated more between Answer types for some items than for others (See Figure 2), and with age F(21,336)=1.762, p<.025, indicating that the number of good responses per item differed across the four ages. A 3-

way interaction between item, Question type and Answer type was also found ($F(14,672)=2.396$, $p<.005$), indicating that participants' choices of answers differed across the different items. A closer look at the different items revealed that two of them (shampoo and shoelaces) had negative outcomes as possible Activity responses (shampoo makes your eyes burn and shoe laces make you trip) as opposed to the rest of the items which did not have consequences which could be construed as unfavourable. The fact that the outcomes were negative may have caused children to choose these responses less frequently. These items were replaced in Experiment 3.

Insert Figure 2 about here

Four-year-olds

A 2 (Question type: DO, FOR) X 2 (Answer type: Function, Activity) X 2 (Order: Do_1st, For _1st) Analysis of Variance was performed on the number of responses the 4-year-olds judged as "good". We found main effects of Question type, $F(1,18)=4.437$, $p<.049$, Answer type $F(1,18)=38.636$, $p<.001$ and a marginal effect of Order $F(1,18)=4.020$, $p<.065$. That is, children judged that there were more good answers to the DO questions (85%) than there were to the FOR questions (78%); overall they chose the Function responses more than the Activity responses (96% vs. 68%); they judged more responses as good when the DO questions were given first than when the FOR questions were given first. In addition we found interactions between Question type and Answer type ($F(1,18)=5.794$, $p<.03$), and between Question type and Order ($F(1,18)=4.636$, $p<.05$). There was also a 3-way interaction between Question type, Answer type and Order ($F(1,18)=5.242$, $p<.035$). That is, the 4-year-olds' responses to the DO and FOR questions varied depending on whether they were presented with the DO questions first or with the FOR questions first: When children were presented with the DO block first, they chose the Activity responses to the same extent for both the DO questions and the FOR questions (76% and 78% of the time respectively). However when they are presented with the FOR questions first, they chose the activity responses more for the DO questions (73%) than for the FOR questions (44%).

Six-year-olds

A 2 (Question type: DO, FOR) X 2 (Answer type: Function, Activity) x 2 (Order :Do_1st, For _1st) Analysis of Variance was performed on the number of responses that the 6-year-olds judged as good. There was a main effect of Question type, $F(1,10)=11.748$, $p<.007$, Answer type $F(1,10)=70.279$, $p<.001$, and of Order $F(1,10)=14.382$, $p<.005$. That is, children judged that there were more good answers to the DO questions (84%) than there were to the FOR questions (74%); they chose the Function responses more than the Activity responses (100% vs. 88%); they judged more responses as good when the DO questions were given first than when the FOR questions were given first (88% vs. 68%). There were interactions between Question type and Answer type $F(1,10)=11.748$, $p<.007$; between Question type and Order ($F(1,10)=6.214$, $p<.04$) and between Answer type and Order ($F(1,10)=14.382$, $p<.007$). There was a 3-way interaction between Question type, Answer type and Order, $F(1,10)=6.214$, $p<.04$. As with the 4-year-olds, when 6-year-olds were presented with the DO questions first, they chose the Activity responses to the same extent for both the DO questions and the FOR questions (79% and 73% respectively). However when they were presented with the FOR questions first, they differentiated between the DO and the FOR questions choosing the Activity responses significantly more for the DO questions (56%) than for the FOR questions (17%).

Eight-year-olds

A 2 (Question type: DO, FOR) X 2 (Answer type: Function, Activity) x 2 (Order: Do_1st, For_1st) Analysis of Variance was performed on the 8-year-old data. There was no main effect of Order and no interaction with Order. There were main effects of Question type, $F(1,10)=8.045$, $p<.02$ and Answer type, $F(1,10)=58.329$, $p<.001$. That is, the children chose more good answers to the DO questions (79%) than to the FOR questions (66%), and they chose the Function answers more often than they chose the Activity answers (97% vs. 47%). Importantly, we found an interaction between Question type and Answer type, $F(1,10)=5.961$, $p<.04$. That is, the 8-year-olds' pattern of response to the FOR questions was different from their pattern of response to the DO questions - they choose the activity responses more for the DO questions (59%) than for the FOR questions (35%).

Adults

A 2 (Question type: DO, FOR) X 2 (Answer type : Function, Activity) x 2 (Order: Do_1st, For_1st) Analysis of Variance was performed on the adult data. There were no main effects of order and no interactions with order. There were main effects of both Question type, $F(1,10)=31.617$, $p<.001$, and Answer type, $F(1,10)=31.073$, $p<.001$, and an interaction between the two, $F(1,10)=31.617$, $p<.001$: the adults found more good responses to the DO questions than to the FOR questions (96% vs. 64%), and they chose the Function responses more often than they chose the Activity responses (100% vs. 57%). The adults also gave different response patterns to the two questions: as was the case for all of the other age groups, adults found the Function responses appropriate for both the DO and the FOR questions while they chose the Activity responses significantly more for the DO questions (88%) than for the FOR questions (27%). As expected, adults showed a strong differentiation between the two types of questions.

Comparison of the four age groups

Given the overall interaction between Question type and Answer type and Age, a series of eight planned comparisons between each of the 4 age groups was performed. An Analysis of Variance on Age (Four, Six Eight,Adult), Question Type (DO, FOR) and Answer type (Function, Activity) probed which of the age groups differed from one another with respect to the way they responded to the two questions. The three-way interactions between Question Type, Answer Type, and Age between the 4-year-olds, the 6-year-olds and the 8-year-olds were not significant.

However, each of these 3 age groups' performance was different from the adult performance ($F(1,30)=17.258$, $p<.001$; $F(1, 22)=8.063$, $p<.02$; $F(1,22)=7.456$, $p<.015$ respectively).

Discussion

At all ages there was an interaction between Question type and Answer type indicating that participants found different types of responses appropriate to the question "what is x for?" and to the question "what does x do ?" Namely, the Function responses (e.g. picking up dirt) were considered an appropriate response to both these questions, whereas the Activity responses (e.g. making noise) were considered a more appropriate answer to the latter than to the former question. However adults were significantly better than children in judging that even though vacuum cleaners do make noise, that is not what they are for. There was a developmental progression in children's capability of distinguishing between the two questions: 4- and 6-year-olds had a shaky understanding of this distinction. This was demonstrated by the fact that the 4- and 6-year-olds' choice of the Activity responses was influenced by the order in which the blocks of questions were presented: when the FOR questions were presented first the children differentiated between the DO and FOR questions and judged, for example, that vacuum cleaners do make noise but are not for making noise. However, when the DO questions were presented first, children judged that vacuum cleaners both make noise and are for making noise. The 8-year-olds were no longer influenced by the order of presentation demonstrating a more secure understanding of the distinction between the two questions.

One possible explanation for the difference between the childrens' and the adults' performance is that the children were not quite sure of the meaning of the question "what is x for?" We noted that although "what is x for?" is usually interpreted as "what is x made for?", this expression is actually ambiguous between "what is x made for?" and "what is x used for?" Thus, it is possible that instead of answering "what is x made for?" children may have been answering "what is x used for" or "what can x be used for?" Given that children have fertile imaginations, they may have imagined uses for most of the activities or functions of the artifacts. Thus, even though vacuum cleaners were not made for the purpose of making noise, one could imagine a possible use for them as noise-generating machines.

The fact that the 4- and 6-year-olds are unsure of the meaning of "what is x for?" and how it relates to the question "what does x do ?" is demonstrated by the order effects. If children really understood the distinction between these two questions, they would not be swayed by the order in which they were presented. When the FOR questions are presented first, their weak understanding of the question results in a tendency to reject the fact that vacuum cleaners are for making noise. However, when the DO questions are presented before the FOR questions, the children have already accepted "making noise" as a good answer to the question "what does a vacuum cleaner do", thereby highlighting it as a good answer. Then, when asked whether "making noise" is a good answer to the question what is a vacuum cleaner for, the children could easily imagine that it could be made for that purpose.

Note that across all ages, even though both the Activity and Function responses are accepted as good responses to the questions "what does x do?", the Activity responses are always chosen slightly less than the Function responses. For example, making noise is chosen less than picking up dirt as a response to what vacuum cleaners do. Given the fact that both answers are equally good answers, this suggests that participants may not have fully comprehended the task. The slight preference for the Function responses may be due to the fact the original function of the artifact is more highly associated with the artifact than other activities or uses. Thus, for example, someone might say "the carpet is dirty" and immediately thereafter proceed to vacuum. It is less likely that someone will say "it's quiet in here" and proceed to turn on the vacuum cleaner. Therefore, there are stronger associations between the original intended functions of artifacts and other epiphenomenal properties.

Further evidence for the fact that the task may have been slightly unclear came from comments of several of the adults. When asked for their judgments on the second block of questions, after having completed the first block of either the DO or FOR questions, a few of them remarked "Oh, now I get it". That is, the juxtaposition of the two parts of the questionnaire suddenly elucidated the distinction between the two questions.

Experiment 3 addresses the possibility that the task was somewhat unclear. In this experiment, participants will be trained explicitly on the distinction between what something does and what something is for before participating in the task itself. If children's performance improves as a result of the training, it will suggest that the differences between the adult and child performance in Experiment 2 were due to pragmatic difficulties.

There were also two methodological issues which were addressed in Experiment 3. The Activity responses of two of the items had negative outcomes (shampoo makes your eyes burn and shoe laces make you trip) which caused them to be chosen much less than the other Activity responses. These items were replaced.

It was also noted that in Experiment 2, participants were asked to judge whether the different responses were 'good' or 'silly'. Given such a choice, the Function and the Activity responses are both plausible answers: even if the Activity responses are not a correct response to the FOR questions (e.g. vacuum cleaners are for making noise) they are not a completely silly alternative in comparison to the distractor items (e.g.vacuum cleaners are for cleaning the dishes). It could be, therefore that the children were making a distinction between completely implausible answers and answers which, if not correct, were at least plausible. Therefore, in Experiment 3, participants were asked to judge whether each of the responses was "good" or "bad".

Given the fact that both the 4- and 6-year-olds exhibited order effects and were no different from one another in their performance in Experiment 2, only 4- and 8-year-old children were included in Experiment 3.

Experiment 3

Method

Participants

Twenty 4-year-olds, nine boys and eleven girls (M=4;8, ranging from 4;2 to 5;1), twelve 8-year-olds, five boys and seven girls (M=8;4, ranging from 7;3 to 8;11) and twelve adults from the MIT community participated in the experiment. The children were recruited from Greater-Boston day-care centres and from Cambridge area schools. They were all native speakers of English and representative of multi-ethnic middle and upper-middle class populations. The adults were from the MIT community, undergraduate students, graduate students and staff. None of the participants had participated in the previous experiment

Stimuli and Procedure

The procedure for this experiment was similar to that of Experiment 2 with a few changes. As in Experiment 2, each child was asked set of DO questions: "what does X do?" and a set of FOR questions: "what is X for?" regarding eight different items. All the DO questions were presented in one block, as were the FOR questions. Every question was accompanied by a line drawing of the item. Each question had three possible answers. Six of the items were the same as in Experiment 2: a vacuum cleaner, a hat, a train, the hands of a clock, the door of a house, the buttons on the phone. We replaced the shampoo and shoe laces items with a candle and with soap with the following potential answers:

(1) What does soap do?/What is soap for? It makes you clean [F]; It makes bubbles [A]; It sings songs [D].

(2) What does a candle do?/What is a candle for? It gives light [F]; It melts [A]; It helps

you comb your hair.[D]

The difference between what something does and what something is for was explained in the following fashion: using the vacuum cleaner as a training item, the DO or the FOR questions with the different response were introduced in turn. For each response, participants were asked to judge whether the answers that the puppet was giving were "good" answers or "bad" answers. Participants received positive and negative feedback to their judgments. For example, if a participant judged that vacuum cleaners were "for making noise" he or she were told that this was not true. The experimenter proceeded to explain why: she pointed out that making noise "is not what vacuum cleaners were *intended* for, that is not why people *made* them, that's not the *purpose* of using a vacuum cleaner, that is not what they were *meant for*". When participants gave a correct response to this question they were reinforced with the above explanation as to why their response was correct. Having gone through the two questions once, the questions and their possible responses were repeated a second time, under the pretext that the puppet wasn't completely sure of the correct answers and wanted to go through them again. Participants' responses were reinforced and corrected as needed.

Results

Scoring was as in Experiment 2: namely, for each participant, on each question, the times he or she chose the Function, the Activity or the distractor as a "good" answer was counted separately. As in Experiment 2, the distractor items were hardly ever chosen and were therefore not included in the analyses.

A 3 (Age: 4-year-old, 8-years-old, adult) X 2 (Question type: DO, FOR) X 2 (Answer type: Function, Activity) x 2 (Order: Do_1st, For_1st) Analysis of Variance on the number of responses participants judged as good was performed. There were main effects of Question type $F(1,38)=116.458$, $p<.001$, and of Answer type $F(1,38)=154.155$, $p<.001$: overall there were more good responses to the DO (92%) questions than to the FOR (70%) questions and the

Function (99%) responses were chosen more often than the Activity (62%) responses. There were no main effects or interactions with Order. There were 2-way interactions between Question type and Age, $F(2,38)=30.733$, $p<.001$, and between Answer type and Age ($F(2,38)= 5.548$, $p<.009$), indicating that children's responses to the DO and FOR questions, and children's choice of Answer types varied according to Age. There was an interaction between Question type and Answer type, $F(1,38)=126.357$, $p<.001$, indicating that participants differentiated between Answer types for the FOR questions (Function 98% vs. Activity 41%) more than for the DO questions (Function 100% vs. Activity 84%). There was also a 3-way interaction between Age, Question type and Answer type, $F(2,38)=46.474$, $p<.001$, indicating that children's choice of answers to the DO and FOR questions differed across the age groups (see Figure 3). Given this latter interaction, separate analyses for each age group were performed.

Preliminary analyses found a main effect of item ($F(7,266)=4.384$, $p<.001$), and 2-way interactions between item and Answer type $(7,266)=4.318$, $p<.001$) and between item and Age ($F(14,266)=2616$, $p<.002$). There was also a 3-way interaction between item, Answer type and Age, ($F(14,266)=3.069$, $p<.001$). These interactions were not found to be interpretable.

Insert Figure 3 about here

Four-year-olds

A 2 (Question type: DO, FOR) x 2 (Answer type : Function, Activity) Analysis of Variance was performed on the 4-year-old data. There were main effects of both question type, $F(1,19)=6.394$, $p<.03$ and Answer type, $F(1,19)=36.173$ $p<.001$: 4-year-olds found more good responses to the DO questions than to the FOR questions (89% vs. 80%), and they chose the Function (98%) responses more often than they chose the Activity responses (71%). There was a marginally significant interaction between the two, $F(1,19)=3.408$, $p<.085$: Children's pattern of response to the FOR questions was different from their pattern of response to the DO questions: they found the Function responses equally good for both the DO and the FOR (99% and 96% respectively) questions and they found the Activity responses good responses to the DO questions more often than to the FOR questions (78% vs. 64%).

Eight-year-olds

A 2 (Question type: DO, FOR) X 2 (Answer type : Function, Activity) Analysis of Variance on the number of responses the 8-year-olds judged as good was performed. There were main effects of Question type, $F(1,11)=17.298$, $p<.003$, and Answer type, $F(1,11)=26.523$, $p<.001$. That is, the children judged that there were more good answers for the DO questions (89%) than for the FOR questions (71%), and overall chose the Function responses more than the Activity responses (100% vs. 60%). More importantly, there was an interaction between Answer type and Question type, $F(1,11)=17.298$, $p<.025$. That is, the 8-year-olds' response pattern for the FOR questions was different than their response pattern for the DO questions: they found the Function responses equally good, both for the DO and the FOR questions (100% for both), while they chose the Activity answers significantly more for the DO questions than for the FOR questions (78% vs. 42%).

Adults

A 2 (Question type: DO, FOR) X 2 (Answer type : Function, Activity) Analysis of Variance was performed on the adult data. There were main effects of both Question type, $F(1,11)=2602.600$, $p<.001$, and Answer type, $F(1,11)=1682.627$, $p<.001$, and an interaction between the two, $F(1,11)=2602.600$, $p<.001$: the adults found more good responses to the DO questions than to the FOR questions (99% vs. 52%), they chose the Function responses more often than they chose the Activity responses (100% vs. 51%). In addition, the adults answered the two questions differently: they found the Function responses appropriate for both the DO and the FOR questions (100% for both) while they chose the Activity responses significantly more for the

DO questions (98%) than for the FOR questions (3%). This response pattern was virtually at ceiling.

Comparison of the three age groups

Given the overall interaction between Question type and Answer type and Age, a series of three planned comparisons between each of the 3 age groups was performed. An Analysis of Variance on Age (Four, Eight, Adult), Question Type (DO, FOR) and Answer type (Function, Activity) probed which of the age groups differed from one another with respect to the way they responded to the two questions. The 3-way interactions between Question type, Answer type and Age between the 4-year-olds and the 8-year-olds ($F(1,30)=6.606$, $p<.015$), between the 4-year-olds and the adults ($F(1,30)=122.216$, $p<.001$) and between the 8-year-olds and the adults ($F(1,22)=42.378$, $p<.001$) were all significant indicating that all three age groups performed differently from one another.

Effect of training

In order to examine whether the training had any effect on participants' performance, a 2 (Training :Yes, No) x 2 (Question type: DO, FOR) x 2 (Answer type: Function, Activity) x 3 (Age: 4-year-old, 8-year-old, adult) Analysis of Variance was performed on the number of "good" responses each participant gave. The 4-way interaction was significant $F(2,82)=3.528$, $p<.035$ indicating that training had an effect on participants' responses to the DO and FOR questions. Then, 3 pair-wise comparisons examined for each age group whether the training affected their performance.

Recall that in Experiment 2, the 4-year-olds were influenced by which block of questions they were presented with first. Therefore, a 4-way Analysis of Variance examined the effect of Question Type (DO, FOR), Answer type (Function, Activity), Order (Do_1st, For_1st) and Training (Yes, No) on the number of responses participants judged as good. There were main effects of Question Type ($F(1,36)=11.1174$), $p<.002$), Answer Type ($F(1,36)=77.311$, $p<.001$)

and Order ($F(1,36)=7.283$, $p<.011$). There were also 2-way interactions between Question type and Order ($F(1,36)=7.289$, $p<.015$), Answer type and Order ($F(1,36)=4.403$, $p<.045$) and Answer type and Question type ($F(1,36)=9.243$, $p<.005$). There was a 3-way interaction between Question type, Answer type and Order ($F(1,36)=8.296$, $p<.008$) indicating that participants' choices of Activity responses to the DO and FOR questions differed with respect to which set of questions was presented first: when the FOR questions were presented first they chose the Activity responses more for the DO questions than for the FOR questions (74% and 48% respectively). When the DO questions were presented first, they found the Activity responses equally good for both the DO and FOR questions (79% and 77% respectively). Most importantly, there were no interactions involving training. That is, training was not found to effect the 4-year-olds' pattern of responses.

An Analysis of Variance examined the effects of Question Type (DO, FOR), Answer type (Function, Activity) and Training (Yes, No) on the number of responses 8-year-olds judged as good. There were main effects of Question Type ($F(1,22)=25.544$, $p<.001$) and Answer Type ($F(1,22)=69.824$, $p<.001$). There was also a 2-way interaction between Question type and Answer type ($F(1,22)=22.463$, $p<.001$). There were no interactions with training indicating that there was no evidence that training had an effect on the 8-year-olds' response pattern.

An Analysis of Variance examined the effects of Question Type (DO, FOR), Answer type (Function, Activity) and Training (Yes, No) on the number of responses adults judged "good". There were main effects of Question type ($F(1,22)=215.164$, $p<.001$) and Answer type ($F(1,22)=170.350$, $p<.001$). There were also 2-way interactions between Question type and Training ($F(1,22)=10.554$, $p<.005$) and between Question type and Answer type ($F(1,22)=22.463$, $p<.001$). In addition there was a 3-way interaction between Question Type, Answer type and training ($F(1,22)=10.544$, $p<.005$). That is, the adult pattern of responses changed as a result of the training: without training, they chose the activity responses for the DO questions 88% of the time and for the FOR questions, 27% of the time, whereas after training, they chose the Activity responses 98% percent versus 3%.

Discussion

Experiment 3 demonstrated that the difference between adults' and children's capability of distinguishing between what something does and what something is for more than a simple misunderstanding that "what is x for?" should be interpreted as "what is x made for?" In this experiment participants were explicitly trained that "making noise" is a bad answer to the question "what is x for?" Despite training, children's performance was still significantly different than adult performance. Training effected adult and 8-year-performance: adult performance almost reached ceiling, and even though there was not a statistically significant difference between 8-year-olds' pattern of response before and after training, there was a significant difference between the performance of the 4-year-olds and the 8-year-olds, a difference which was not found in Experiment 2. The training, however, did not affect the 4-year-old's performance. They still claimed 64% of the time that, for example, trains are for going "choo-choo". In addition, they were still influenced by the order in which the questions were presented, making a weak differentiation between the DO and FOR questions when the FOR questions were presented first, but treating them the same when the DO questions were presented first.

General Discussion

Making the distinction between the original intended function of an artifact and its epiphenomenal properties is central to reasoning within the Design Stance. Experiment 1 established that 4- and 6-year-olds know at minimum the use-function of everyday artifacts. In Experiments 2 and 3, children's capability of distinguishing between the original intended function of artifacts and their epiphenomenal properties was assessed by their capability of distinguishing between the questions "what is x for?" and "what can x do?" Although not statistically significant, a developmental progression in children's capability of distinguishing between both questions was observed in Experiment 2: the 4-year-olds and the 6-year-olds revealed a shaky understanding of the distinction between the two questions by the fact that they were influenced by the order in which the questions were presented and that they claimed around 50% of the time (61% for the 4-year-olds and 45% for the 6-year-olds) that e.g. vacuum cleaners were for making noise. The 8-year-olds were no longer influenced by the order in which the questions were presented and judged that vacuum cleaners were for making noise only 35% of the time. However, it was noted that "what is x for?" is actually ambiguous between "what is x made for?" and "what is x used for?", Experiment 3 addressed this ambiguity by explicitly training participants that making noise is not a good answer to what vacuum cleaners are for, because that is not why people made them.

The training was not found to effect the 4-year-olds' judgments. They were still confused by the order in which the questions were presented. Moreover, as in Experiment 2, they still maintained that trains are for going "choo-choo" (64% of the time). There was weak evidence for an effect of training on 8-year-olds' judgments: Unlike Experiment 2, 8-year-olds were now significantly different in their performance from the 4-year-olds. Nonetheless, even the 8-year-olds were still different from adults in their capability to distinguish between what something does and what it is for.

There are a few possible sources for the difference in children's and adults' performance. The first possibility is that children simply do not understand the notion of original intended design. That is, they do not understand that artifacts are made by people for a specific purpose. Even though they know that artifacts are man made (Gelman & Kremer, 1991), they do not know that the original intended design of the artifact is what an artifact is for.

In two different experiments, contrary to her own conclusions, Kelemen (1996) provides evidence supporting this possibility. In one set of experiments, Kelemen provides evidence that 4- and 5-year-olds have difficulties in distinguishing between the original intended function of the artifact and other functions it can fulfill. She told participants about an artifact that was made for a specific purpose and then was used for an altogether different purpose: either once by accident, once intentionally, many times by accident, or many times intentionally. The original function and the subsequent use were depicted in line drawings. Participants were asked to point to the picture that showed what the artifact was for. In all but the many-times-intentionally condition, preschoolers successfully pointed to the picture depicting the original intended function of the artifact. Also in the many-times-intentionally condition preschoolers pointed to the correct picture significantly more than chance. However, although their responses in this condition were significantly different from chance, their responses were also significantly different from the adult responses and from their own responses in the previous conditions, where they predominantly picked the picture depicting the original intended function. In all but the many-times-intentionally condition, it is unclear whether children were indeed invoking the original intent of the creator or just an intent that was desirable: in the accidental stories, children might have made the inference that if the function was accidental, it was not desirable because they were told that it was never meant to happen. Similarly, if a function was intentionally used only once, it also might not be desirable. On the other hand, in the many-times-intentional condition, the function must have been desirable since it was intentionally repeated. Thus, in the condition where there is true conflict between the original intended design and a current function, preschoolers were unsure of their judgments and did not clearly judge the original intended function to be more important than the current intended function in determining what something is for.

In a second set of experiments Kelemen (1996) has evidence suggesting that children do not understand the expression "made for". Kelemen asked 4- and 5-year-olds about both artifacts and natural kinds. She first asked children what things like mountains, tigers and clocks are for. Consistent with Piaget's (1929) findings, 4- and 5-year-olds said that mountains are for walking around, tigers are for scaring and clocks are to tell the time. Kelemen hypothesized that instead of answering the question "what is x made for?" children were answering the question "what is x used for?" Therefore, she trained the children on the distinction between these two expressions. After training the children, Kelemen introduced them to two puppets who were always in disagreement about whether a given item was made for something or wasn't made for anything. At the end of each test trial, children were asked to point to the character that they thought was right. Children judged that artifacts (ring, jeans), biological kinds, (puppy, tiger), and natural objects (mountain, cloud) were all made for something. Kelemen interprets these results as indicative of preschool children having a generalized teleological bias. That is, children see everything to be designed for a purpose. While this might indeed be true, there is another equally plausible interpretation of Kelemen's results, namely children do not understand the expression "made for". The results from the training sessions support this interpretation. In the training session, Kelemen tried to train children that some things are not made for anything. She sharpened a pencil in front of the children, pointed to the tip and the sharpenings, and explained that whereas the tip is made for writing, the pile of sharpenings is not made for anything. She then asked participants whether they thought the shavings or the tip were made for something or not made for anything. Since the task itself was administered in two parts, participants participated in two training sessions, one at the beginning of each session. Almost half of the children (11 out of 24) , insisted in both sessions that the "pile of stuff" was made for something, whereas only 7 demonstrated the adult response of affirming that the pencil tip was made for something whereas the "pile of stuff" was not. Kelemen also found that it was very difficult, if not impossible, to persuade them to the contrary. The children who insisted that the pile of stuff was made for something differed in their performance on the test trials from the children who denied, as adults do, that the "pile of stuff" was made for something. The children who insisted that the pile was made for something were twice as likely to say that natural objects such as clouds or icebergs were made for a purpose than children who denied that statement. In addition, these children were statistically significantly younger than the children who demonstrated the adult-like pattern (4;10 versus 5;5).

Thus, there is evidence suggesting that preschoolers do not understand the notion of original intended design. The question arises whether 8-year-olds are different in their performance from adults for the same reason as 4-year-olds, namely they too do not understand the notion of original intended design. It is difficult to believe that 8-year-olds would insist, in Kelemen's experiment, for example, that the sharpenings were made for something. Or that if asked why people made vacuum cleaners, they would respond "because they wanted something to make noise". Therefore, another source of differences between children and adult performance is that, despite the training, the task was linguistically difficult. As mentioned earlier, the question "what is x for?" may be interpreted as "what is x used for?" Even though Experiment 3 addressed this ambiguity, it is possible that the training was not sufficient to override this interpretation. Also, participants were not completely sure what were the correct answers to the question "what does x do?": in response to the question "what does a vacuum cleaner do?" participants chose "makes noise" slightly less than "picks up dirt". This is probably due to the fact that the functions of the artifacts are more highly associated with the artifact than other properties that it has. Thus, for example, people use candles when they need a source of light, and are less likely to use them for the sake of seeing them melt or for getting candle drippings. The training clarified for adults that both the Function and the Activity responses were appropriate responses to the DO questions: they chose, for example, "giving light" and "melting" almost equally (100% and 98% respectively). However the 8-year-olds were still unsure of how to interpret the DO questions and still found "giving light" to be a better response than "melting" (78% versus 42%) to the question "what do candles do?"

Thus, both the DO and FOR questions have more than one possible interpretation, which may be the reason for the difference between the 8-year-old and adult performance. This may also be a possible source of the 4- and 6-year-olds' failure. However, it is unlikely that these difficulties were the only source of their failure, given Piaget's (1929) and Kelemen's (1996) work which supports the interpretation under which preschoolers may not understand the notion of original intended design. Despite having all the necessary components to distinguish between the originally intended function and other properties, the evidence suggests that preschoolers cannot combine these components to do so. This is not surprising if preschoolers do not have the concept of original intended design, namely that people create artifacts for a specific purpose. If preschoolers do not understand this notion, they cannot be said to have the Design Stance, given that this is the most basic component of this mode of explanation. Further research will address preschoolers' understanding of this basic notion: in Chapter 2 children will be asked to create an item on their own and answer the simple question "what did you make this for?" If children cannot answer this question, it will provide evidence that preschoolers do not understand the notion of original intended design. In Chapter 3 we will explore whether 4- and 6-year-olds, like adults, base their artifact categorization judgments on the original intended design of the artifact. Failure to do so would lend further support to the claim that children do not understand the notion of original intended design.

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Figure Captions

Figure 1. Experiment 2: Percent of “good” answers chosen for DO and FOR questions

Figure 2. Experiment 2: Percent of Function and Activity responses for each item.

Figure 3. Experiment 3: Percent of “good” answers chosen for DO and For questions

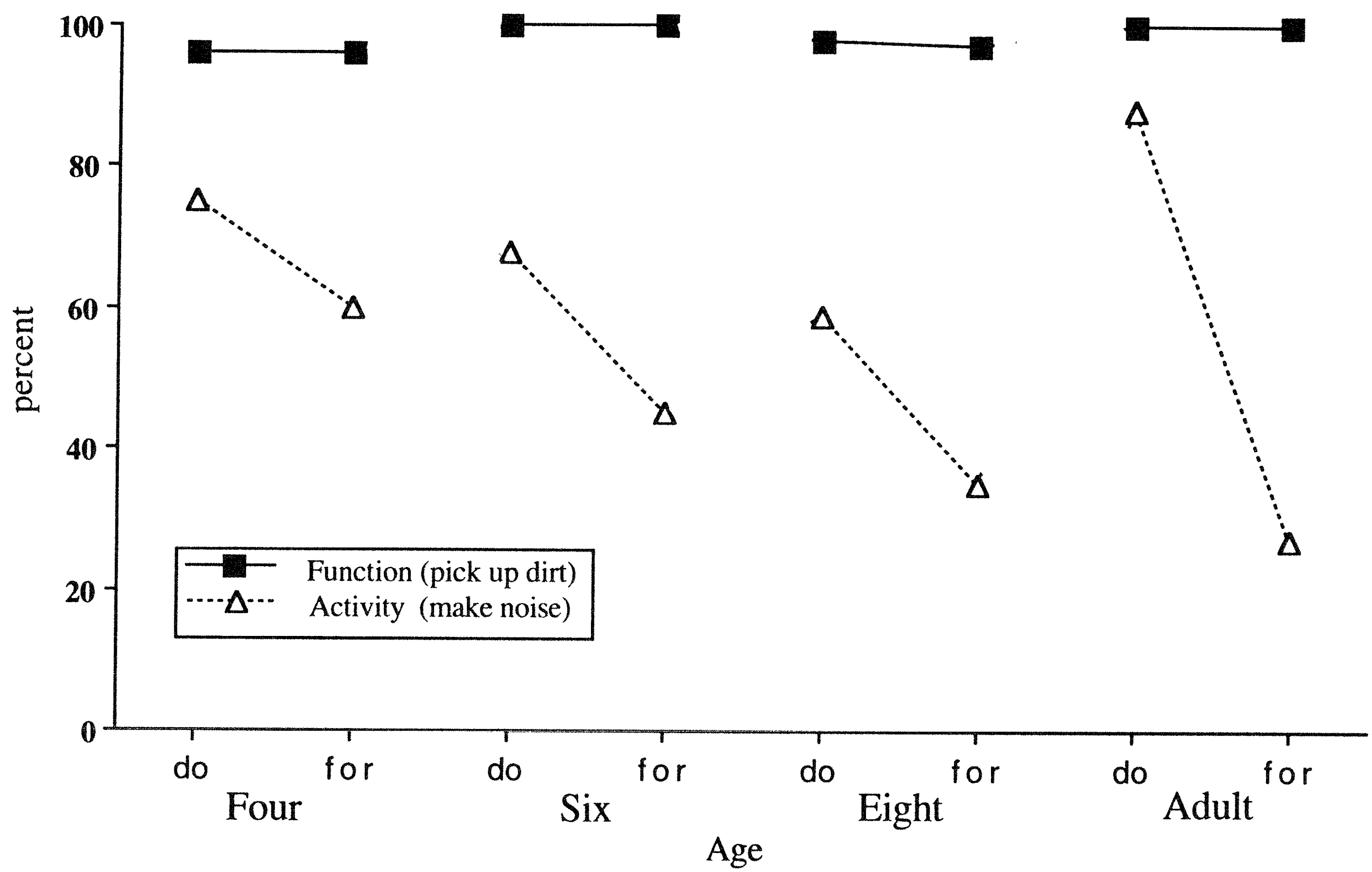
100
80
60
40
20
0
percent
Function (pick up dirt)
Activity (make noise)
do
for
Four
Six
Eight
Adult
Age

Figure 1

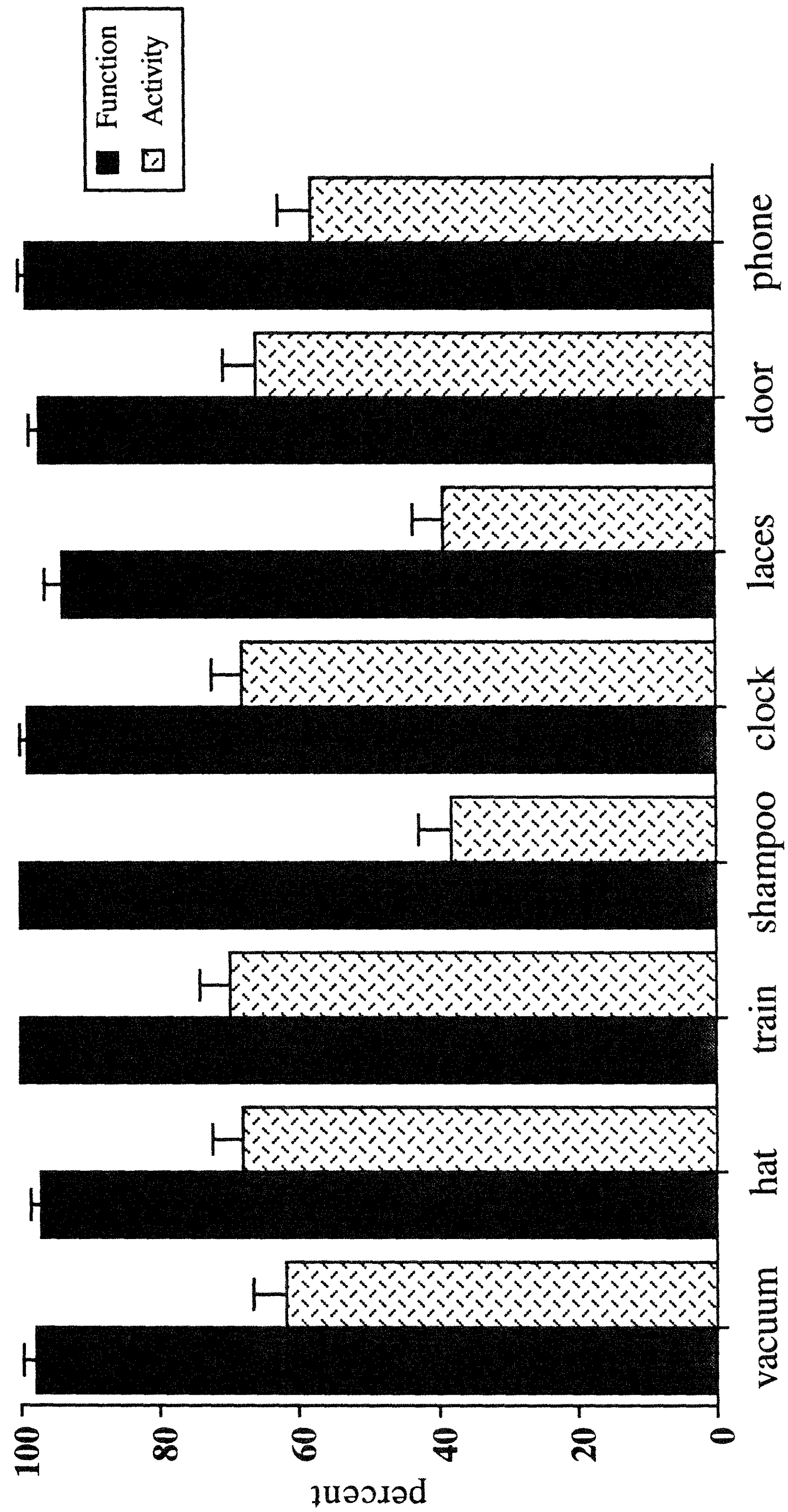
Function
Activity
percent
100
80
60
40
20
0
vacuum
hat
train
shampoo
clock
laces
door
phone

Figure 2

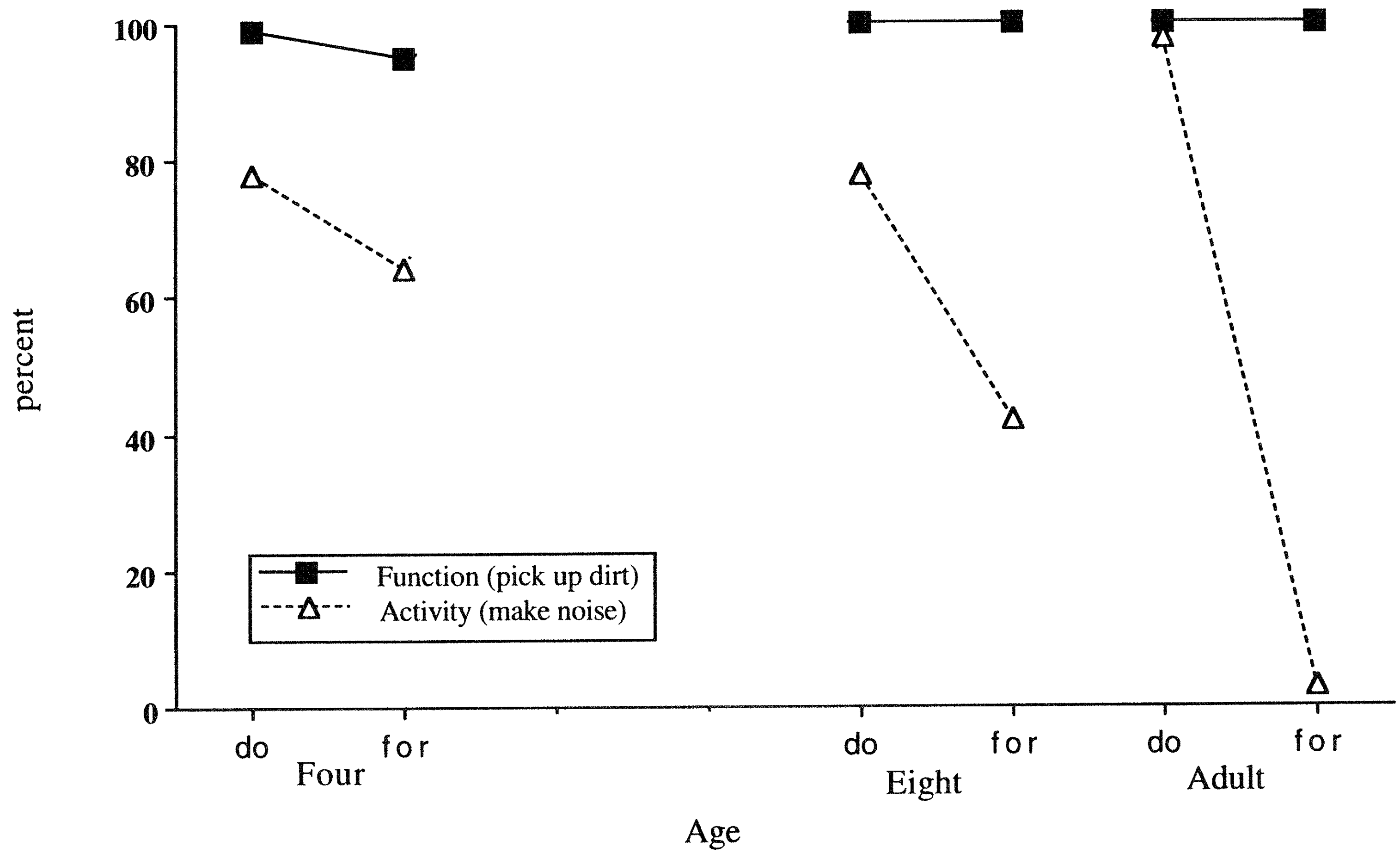
100
80
60
40
20
0
percent
Function (pick up dirt)
Activity (make noise)
do
for
Four
do
for
Eight
do
for
Adult
Age

Figure 3

Appendix A. Experiment 1 - Four test items with their potential answers

1) vacuum cleaners : [a] this one picks up dirt but doesn't make noise; [b] this one makes noise but doesn't pick up dirt.

2) cars: [a] this one can take people from place to place but it doesn't go "vroom vroom"; [b] this one goes "vroom vroom" but it can't take people from place to place

3) umbrellas: [a] this one keeps you dry, but doesn't open and close; [b] this one opens and closes, but doesn't keep you dry.

4) candles: [a] this one gives light but doesn't melt ; [b]. this one melts but it doesn't give light.

Appendix B. Experiment 2 - Eight test items with their potential answers

1) What does a Vacuum Cleaner do/What is a vacuum cleaner for ? It picks up dirt from the floor [F]; It makes a loud noise [A]; It washes the dishes [D]

(2) What does a hat do/What is a hat for? It keeps your head warm [F]; It sits on your head [A]; It holds your soup [D].

(3)What does a train do/What is a train for? It takes people from place to place [F]; It goes "choo choo"[A]; It makes candy[D].

(4) What does shampoo do/What is shampoo for? It makes your hair clean[F]; It makes your eyes burn [A]; It makes you grow tall [D].

(5) What do the hands of a clock do/What are the hands of a clock for ?They tell us the time [F]; They go around inside the clock [A]; They help us brush our teeth [D].

(6) What do shoe laces do/What are shoe laces for? They make the shoe fit tightly [F] ; They trip people [A]; They play the piano [D].

(7) What does the door of a house do/What is the door of a house for ? It lets people in and out F]; It moves back and forth [A]; It plays baseball [D].

(8) What do the buttons on the phone do/What are the buttons on the phone for? They dial a number [F];They make sounds when you touch them[A];They make the fridge open[D].

Appendix C. Training items of Experiment 2

What do birds do?

a. write books
b. they sing
c. they fly
d. they live in fridges

What are pencils for ?

a. for eating soup
b.for writing with
c. for drawing with
d. for combing your hair

Chapter 2

Four-year-olds' understanding of the notion of original intended design

One of the goals of cognitive science is to account for the human capacity to reason about the vast array of phenomena in the world. Humans represent a variety of explanatory schemata in their reasoning, two of which have been the focus of much developmental research. It is well established that by preschool age, children draw on both the "Intentional Stance" and the "Physical Stance" (Dennett, 1987) to reason about sentient beings and physical objects respectively (Carey,1985;Wellman & Gelman 1992). A third stance, which Dennett calls the "Design Stance" has received less attention in the developmental literature. When we adopt the Design Stance, we account for the existence of entities (e.g. a chair) or their properties (e.g. the sharpness of a knife) by referring to the original intended function of the entity. Given the fact that the notion of function is an integral part of reasoning within the Design Stance, explanations of this type are also called functional explanations[5].

Recent developmental work has addressed the question of whether and when children have at their disposal the Design Stance, or functional explanations, to reason about natural and non-natural kinds (Keil 1992, Kelemen 1996, Matan, 1995). Keil claims that the Design Stance is an innate, or at least early developing mode of explanation. Understanding the Design Stance includes an understanding of the existence of a *creator*, who *intentionally* created something to achieve a *goal* or a *purpose*. Indeed, there is evidence for preschoolers' understanding of each of these components of the Design Stance. Gelman and Kremer (1991) have shown that young children know that artifacts are man-made. They posed preschoolers questions about origins of artifacts

[5]Some researchers speak of functional explanations and teleological explanations interchangeably (Keil 1992; 1994, Kelemen, 1996). There is a distinciion to be made between these two types of explanations. Teleolgoical explanations explain the existence of entities or events in terms of the goals that they fulfill. Functional explanations explain the existence of entities or events in terms of their original intended function. Thus, functional explanations have the additional component of intention or design which is not part of teleological explanations.

(cup, hammer, doll, shoe, television) and natural kinds. First, children were asked directly whether they thought people made those things. Four-year-old children clearly knew that people made artifacts and that natural kinds such as clouds or the moon were not made by people. Second, a different group of preschoolers were asked in an open-ended format where such items came from. Again, children demonstrated a clear understanding of artifact origins by citing a human cause (made by people, machines or factories) 80% of the time. Thus, there is clear evidence that preschoolers understand the origins of artifacts, namely that they were made by people.

As young as one year of age, children understand goal directedness and aspects of human intentionality (Woodward, 1995; Gergly, Nadasdy, Csibra, & Biro, 1995). By the end of their second year, they become aware of their own goals and their achievement of these goals (Bullock and Lutkenhaus, 1988) and by the age of three they can demonstrate an understanding that other people act upon their goals (Wellman & Woolley, 1990). For example, Wellman and Woolley (1990) showed that preschool children can predict a protagonist's behaviour when they have information about her desires. Children were told about a boy who wanted to take his rabbit to school. The rabbit, however, was hiding in one of two locations. The boy looked for the rabbit in one of the locations, and depending on the conditions, either found it, did not find it, or found something else. Children were then asked what the boy would do next, would he look in the other location or would he go to school? Three year-olds were already able to predict that child would go to school if his goal was achieved and he found the rabbit, or that he would continue to search if he had not achieved his goal (for example, if he found nothing or some other animal).

Thus there is ample evidence that by the age of four children know that artifacts originate with people, and there is evidence that they can attend to intentions and goals. In this paper we ask whether children have put these components together in the domain of artifacts. That is, do children understand not just that people make artifacts but that they design them with a purpose in mind.

In an attempt to assess children's understanding of functional explanations, researchers have asked children what they thought certain things were for. Piaget (1929) asked children what mountains are for, Kelemen (1996) asked children what women are for and in Chapter 1 children were asked what vacuum cleaners are for. Preschoolers think that mountains are for climbing, women are for walking and vacuum cleaners are for making noise. The assumption made in most of this work is that asking "what is x for?" is equivalent to asking "what is x made for" and that these questions refer to the notion of intended design. The above responses given by preschoolers cast some doubt on their understanding of this concept.

In Experiment 3 of the previous chapter, children were trained on the distinction between "what something does" and "what something is for." Using vacuum cleaners as an example, it was explained that picking up dirt is a good response to both of these questions, whereas making noise is only a good answer to the former question. Thus, children were told that vacuum cleaners are not made for making noise, that making noise is not the purpose of a vacuum cleaner and not what vacuum cleaners are meant for. After training, four-year-olds were as likely to respond that, for example, trains are for going "choo-choo" (well over 60% of the time) as before training. One interpretation of the ineffectiveness of the training is that preschool children do not really understand the notion of original intended design; they do not understand that artifacts were created by people for a specific purpose.

Kelemen (1996), contrary to her own conclusions, provides evidence which clearly questions children's understanding of original intended function and the expression "made for". Kelemen asked 4- and 5-year-olds both about artifacts and natural kinds. She first asked children what things like mountains, tigers and clocks are for. Consistent with Piaget's findings, 4- and 5-year-olds said that mountains are for walking around, tigers are for scaring and clocks are to tell the time. Kelemen hypothesized that instead of answering the question, "What x is made for?", children were responding to the question, "What x is used for?". Therefore, she trained the children on the distinction between these two expressions. After training the children, Kelemen introduced them to two puppets, who were always in disagreement about whether a given item was made for something or wasn't made for anything. At the end of each test trial, children were asked to point to the character that they thought was right. Children judged that artifacts, biological kinds, (puppy, tiger), and natural objects (mountain, cloud) were all made for something. Kelemen interprets these results as indicative of pre-school children having a generalized teleological bias, that is children see everything to be designed for a purpose. While this might indeed be true, there is another plausible interpretation of Kelemen's results. Children may not in fact understand the expression "made for", interpreting it as "used for" or "can be used for". The results from the training sessions are most telling. In the training session, Kelemen sharpened a pencil in front of the children and pointed to the tip and the sharpenings in turn and said - "This is the tip of the pencil. The pencil tip is made for writing with. That is what it is made for...But some things aren't made for anything. See this pile of stuff. It isn't made for anything, it's just something that is there. Maybe somebody could use it for something but it isn't made for anything. So even though the tip of my pencil is for writing with, this stuff is not made for anything". She then asked participants whether they thought the shavings or the tip were made for something or not made for anything. Since the task itself was administered in two parts, participants participated in two training sessions, one at the beginning of each session. Almost half of the children (11 out of 24) , insisted in both sessions that the "pile of stuff" was made for something, whereas only 7 demonstrated the adult response of affirming that the pencil tip was made for something whereas the "pile of stuff" was not. Kelemen also found that it was very difficult, and often impossible, to persuade them to the contrary. The children who insisted that the pile of stuff was made for something differed in their performance on the test trials from the children who denied, as adults do, that the "pile of stuff" was made for something . Those who insisted that the pile was made for something were twice as likely to say that natural objects such as clouds or icebergs were made for a purpose than children who denied that statement. In addition, these children were statistically significantly younger than the children who demonstrated the adult-like pattern (4;10 versus 5;5). These data suggest that it is sometime during their fifth year that children construct an understanding of the notion of original intended design.

In sum, although 4-year-olds seem to have all the components necessary for understanding the notion of original intended design, there is evidence suggesting that they may not understand this concept. A possible explanation of some of the above results n Chapter 1 is that even though the children are aware that artifacts are made by people they may not have been completely aware of the initial design of the artifacts. That is, even though the artifacts used by Kelemen and in Chapter 1 (jeans, vacuum cleaners, etc.) were familiar to the preschoolers, they were not privy to the design process and may not have been aware what such artifacts were designed for. In the present experiment (Experiment 1a), children are asked to create the artifacts on their own, ensuring that they indeed know what the artifacts are created for. The artifacts are then used for the original intended function and a serendipitous function which was not part of the original intended design. The children are then asked what they made the artifact for.

This task may be used as training experiment for the DO/FOR experiments (Studies 2 and 3 of Chapter 1) in which participants were asked to distinguish between properties of artifacts which are part of the original intended design and properties which are epiphenomenal. Participants' grasp of this distinction was assessed by their understanding that, for example, "picking up dirt" is a good answer to both "What does a vacuum cleaner do? (DO question) and to "What is a vacuum cleaner for?" (FOR question) whereas "making noise" is only a good answer to the former question. In the Original DO/FOR experiment (Experiment 2 of Chapter 1) 4-year-olds revealed a shaky grasp of this distinction. It was hypothesized that the children did not understand that "What is x for?" means "What is x made for?" Therefore, in the DO/FOR Training experiment (Experiment 3 of the Chapter 1) participants were trained on the distinction between these two questions. However, the training did not affect 4-year-olds' performance. In the current experiment, children will have first-hand experience of the origins of the artifact and will go through the process of creating the artifact on their own. It is possible that the experience of making something on their own will cause the notion of original intended function to become more salient in children's minds, and will make the distinction between the DO and the FOR questions to become clearer. Experiment 1a can be considered a more extensive training procedure for the DO/FOR experiments of Chapter 1. It's effectiveness as such is tested in Experiment 1b. In addition, by administering both Experiment 1a and 1b on the same children we will be able to look at within child consistency on both tasks.

In Experiment 1a, after having created an artifact on their own, 4-year-olds will be asked the simple question "what did you make this for?" If children understand that people make things for a purpose, they should be able to answer this question with no difficulty. If they are not capable of doing so, this would call into question preschoolers' understanding of the Design Stance.

Experiment 1a

Method

Participants

Twenty 4-year-olds (M=4;6, range 4;0 to 5;0), ten boys and ten girls, participated in this experiment. They were recruited from local day care centres. They were all native speakers of English and from multi-ethnic middle, upper-middle class populations.

Stimuli and procedure

Children were asked to perform two separate tasks in which they had to create an artifact in order to satisfy a goal. Each artifact they created was then used both for its original intended purpose and for another, unrelated purpose. At the end of each scenario, the children were asked which of the purposes the artifact was made for.

For example, in the first scenario (see Appendix A) participants were asked to create from a piece of construction paper something which would aid them in pouring lentils from a bowl into a narrow-mouthed bottle, without spilling any of the lentils. The children were given a piece of paper and were asked if they could use it to make something which would help them fulfill the task. The children invariably thought they could. The experimenter held the paper in place and the children taped it to create a cone-shaped object. The children were then encouraged to use the artifact they created to fulfill its original intended function. Just after using it to pour lentils, the experimenter pointed to the artifact and asked the following comprehension question: "what are you using this for now ?" Then, everything save the artifact was put away and the experimenter brought out a prefabricated item which was mostly blue with a protruding yellow part. This item was designed such that the artifact that the children created could be placed over it covering the blue parts, leaving only the yellow part visible. The experimenter told the children that she only wanted to see the yellow part, and asked them whether they thought that the artifact they had created could be used for that purpose. All the children thought it could and they all succeeded in covering the blue parts. Immediately after using it for this purpose, children were asked "what are you using this for now?". The experimenter then brought out the bowl and the bottle containing the lentils. She pointed to the artifact the child created and said "We did two things with this. Which thing did you make it for?" If the child did not answer, or said both uses, or said s/he didn't know, or gave an uninterpretable answer, s/he was given a forced choice "Did you make it for helping us pour these into the bottle or for covering up the blue parts?"

The second scenario was very similar (see Appendix A), differing only in the artifact to be created and its associated functions. In this case, the artifact to be created was a long object made from a piece of Styrofoam into which a short thin piece of wood was inserted. The task was to push out a piece of newspaper that was stuck in a tube. The task could not be fulfilled by use of either of the components on their own because neither was long enough to push the paper out of the tube. The children were then asked if they could use the artifact to hold up a piece of cloth so that it would not touch the floor.

In both scenarios, the experimenter never named the artifacts and always referred to them by "this" or "it". The order of scenarios was counter balanced, as were the original tasks each of the artifacts was designed to fulfill. Thus, for example, the cone-shaped artifact constructed of paper could be initially designed for helping to pour lentils from a bowl to a narrow-mouthed bottle (as described above) or for covering up the blue parts of an item. Similarly, the long Styrofoam object with the piece of wood could be initially designed to push a piece of paper out of a tube (as described above) or for keeping a piece of cloth from touching the floor.

Results and Discussion

Children were virtually perfect on the comprehension probes: out of 80 probes overall, only 1 response was incorrect.

In response to the test question "we did two things with this, which thing did you make it for?" children gave three types of responses: they gave the original function 57.5% of the time, they gave both the original function and the serendipitous function as responses 27.5% of the time, and they gave the serendipitous function as a response 15% of the time[6]. Thus, the 4-year-olds gave incorrect responses over 40% of the time. In the cases that children said that the object was made for both functions, they were asked to choose which they thought was a better answer. Overall, the four-year-olds chose the original function 75% of the time and the serendipitous function 25% of the time, $\underline{t}(19)=2.932$, $\underline{p}<.009$.

We also looked at children's individual response patterns to see whether the results were distributed between children who understood the expression and those who did not. Half the children consistently gave the original function as a response in both scenarios, whereas the other half either never gave it as a response or gave it as a response at most one time (see Table 1). This

[6]In a few cases, children needed to be prompted and were asked, for example, "Did you make it for helping us pour these in the bottle or for covering this up?" (7 cases out of 40 overall responses).

distribution is significantly different than the expected adult distribution of giving the original intended function as the response in both cases, chi-square (2)=13.34, $p<.01$ (To verify this assumed adult distribution, we will test adults in Experiment 2).

Four-year-olds showed considerable confusion in their responses. Over 40% of their free responses were incorrect (said either the serendipitous function or both the serendipitous and the original function were the answer to what the item was made for), and only half of them gave the original function as a response on both scenarios. That is, overall, 4-year-olds were not capable of consistently answering the simple question "what did you make it for?" by naming the purpose for which they, themselves, created the artifact.

Nonetheless, the original function was given as a response more often than the serendipitous function and ten of the children gave the original function as their answer in both scenarios. This performance may be indicative that some preschoolers grasp the notion of original intended function, or alternatively, perhaps the first function is merely the more salient one. If correct responding reflects understanding, these ten 4-year-olds should show better performance in the DO/FOR procedure than their counterparts, who gave the original function as a response at most one time in Experiment 1a. In addition, we might expect these 4-year-olds, as a group, to perform better on the DO/FOR procedure than the 4-year-olds in Chapter 1, given that the origins of the artifact were highlighted by having the children create the artifact on their own.

Experiment 1b

Method

Participants

Same as in previous experiment.

Stimuli and Procedure

The stimuli and procedure for this experiment were identical to that of Experiment 3 in Chapter 1, the DO/FOR training task (see Appendix B). Children were tested within two weeks of participating in Experiment 1a.

Results

An analysis of Variance examined the effects of Question type (DO, FOR), Answer type[7] (Function, Activity) and Order (DO_1st, FOR_1st) on the number of responses judged as "good". There were main effects of Question type $F(1,15)=18.646$, $p<.002$ and of Answer type $F(1,15)=44.866$, $p<.001$: overall there were more "good" responses to the DO questions (85%) than to the FOR questions (71%) and the Function responses (94%) were judged as good more often than the Activity responses (62%). There were no main effects or interactions due to Order. In addition, there was a 2-way interaction between Question type and Answer type $F(1,15)=10.300$, $p<.007$, indicating that the children's pattern of response to the FOR questions was different than their pattern of response to the DO questions. Participants found the Function responses equally good for the DO and the FOR questions (95% and 93% respectively) and chose the Activity responses more for the DO questions (74%) than for the FOR questions (46%).

The pattern of results observed for 4-year-olds in the present experiment closely replicated those found in Chapter 1 (See Figure 1). An Anova on Experiment (Previous, Current), Question type (DO,FOR) and Answer type (Function, Activity) explored whether there were any effects of experiment on the 4-year-olds' capacity to differentiate between the DO and the FOR questions. No main effects or interactions with Experiment were found. Only main effects of Question type $F(1,38)=22.533$, $p<.001$, of Answer type $F(1,38)=92.478$, $p<.001$ and an interaction between

[7] Since the distractor items were chosen only 2% of the time, we excluded them from the analysis, as in the analyses in the previous chapter.

Question type and Answer type $\underline{F}(1,38)=14.488$, $\underline{p}<.001$, as reported above, emerged as significant in this overall analysis. In conclusion, participation in Experiment 1a did not improve performance on the DO/FOR procedure.

The two groups of children (those who gave the original function as a response on both scenarios, and those who gave the original function as a response on one or fewer scenarios in Experiment 1a) were compared with respect to their performance in Experiment 1b. Each participant received a difference of difference scores between his/her responses to the FOR questions and his/her responses to the DO questions. The difference between the Function and Activity responses on the DO questions was subtracted from the difference between the Function and Activity responses on the FOR questions. Scores could range from -8 to 8. A high score is indicative of the fact that a stronger differentiation is being made between the Function and Activity responses on the FOR questions than on the DO questions. The adult score would be +8 since both the Function and the Activity responses are good responses to the DO questions and only the Function responses are good responses to the FOR questions. A t-test between the two sets of scores was not significant ($\underline{F}(1,18)=.226$, $\underline{p}>.6$). That is, the children who consistently gave the original function as a response on both scenarios in Experiment 1a were not better at distinguishing between what something does and what something is for than children who gave the original function as a response at most one time (see Table 2).

Discussion

Overall, 4-year-olds were far short of perfect in answering the simple question of "what did you make this for?" after having creating an artifact by themselves. Two considerations suggest that correct responding may not reflect true understanding. First, participating in the Experiment 1a had no effect on children's capability, as a group, of making the distinction between what something does and what something is for. Second, there was no relation between high performance in Experiment 1a and high performance in the DO/FOR procedure. It is possible that these children understand the notion of original intended design, but this does not help them in making the distinction between what something does and what something is for because they have not mapped the question "what is x for" onto "what is x made for". This is unlikely given that the training in Experiment 1b explicitly stresses that mapping.

Rather than reflecting an understanding of the concept of original intended function, perhaps success is due to the fact that the original intended function of the artifact was the most salient choice. To assess this possibility, in Experiment 2, the first function to be successfully carried out with the item will not be the correct response. As in Experiment 1a, participants are asked to create an artifact by themselves. However unlike Experiment 1a, the artifact will not be able to fulfill the function that it was designed to fulfill. The first function that will successfully be carried out with the artifact will be some other, serendipitous function.

In addition to eliciting free responses by asking "What did you make this for?" participants will also participate in a judgment task. Participants will be asked to judge for each of three responses -- the original function, a serendipitous function and a distractor response -- whether the response is right or wrong. Using a judgment task is more informative than open-ended or forced-choice tasks. An open-ended question, especially in a task like this, is implicitly a forced choice task - which of the two uses is the best answer to the question. Thus, if one of the options is more salient, they will choose it as an answer even if they consider the other answer to also be a good one. The judgment paradigm permits participants to evaluate each response on its own merit. Even though participants might think that the original intended function is a better answer to the question of what the artifact was made for, they might also genuinely believe that the serendipitous function is also an acceptable response. In addition, a judgment task forces participants to consider answers that otherwise they might not have considered on their own.

In judgment tasks, one needs to guard against "yes-biases". The distractor items were introduced for that purpose. They were plausible answers but incorrect in the context of the task.

If not chosen by the children, this demonstrates that the children are not willing to accept any answer as correct.

There are many ways in which children could fail in the judgment task. Barring cases in which children choose the distractor items, revealing failures will be cases in which children choose the serendipitous function or both the serendipitous function and the original function as correct answers. However, if the results of Experiment 1a indeed reflect an understanding of the notion of original intended design, children should succeed on the judgment task and choose only the origin function as a good response.

Given the fact that children's responses in Experiment 1a were so different than the expected adult response, a group of adults were included in Experiment 2 to confirm that adults indeed provide the expected adult response.

Experiment 2

Method

Participants

Thirty-four 4-year-olds (M=4;7, range 4;3 to 5;0), twenty girls and fourteen boys, participated in this experiment. They were recruited from Greater-Boston day-care centres. They were all native speakers of English and from multi-ethnic middle, upper-middle class populations. Seventeen of the 4-year-olds were excluded from the analysis because they did not pass a training item. Fourteen adults, MIT staff, neighbours and friends also participated.

Stimuli and Procedure

A practice scenario was introduced at the beginning of the test session to familiarize participants with the judgment paradigm. The training scenario was taken from Jaakkola & Carey (1996). Participants were introduced to three characters (51/2 inch plastic Cookie Monster, Big Bird, Mickey Mouse) and were told that they would be hearing a story or playing a game, after which they would be asked a question. The experimenter explained that she was first going to ask the participant a question, and then she was going to ask the characters the same question. The participant had to judge for each of the characters responses whether they were right or wrong. For that purpose, two 7-inch plastic buckets were used as the "right" and "wrong" buckets. If the answer was right, they would put the character in the "right" bucket, and if it was wrong, in the "wrong" bucket. If participants judged more than one answer to be right, they were asked to pick the best answer. The question was then repeated and the participant was reminded what each of the characters said. If the participants judged all three responses as correct, they were asked to choose the best answer between two of the items, and then to choose the best between the item they chose and the remaining item.

In the practice scenario participants were told a story about John and Mary who were climbing a tree, and how John fell because the branch he was sitting on broke (See Appendix C). Participants were first asked why John fell and then were asked to judge whether each of the following answers was a good answer: a) because the branch broke (correct answer); b) because Mary pushed him (a possible reason for John to have fallen, but incorrect in context of story); c) because John has blue eyes (distractor).

The practice scenario drew on children's knowledge of the physical stance, which is well established by the age of four, and is not related to their understanding of function or design. Thus, it was a true test of their understanding of the judgment task.

After the practice scenario, participants were presented with two tasks in which they had to create an artifact to fulfill a specific purpose. However, in this experiment, as opposed to the previous one, the materials participants were given were crafted such that the artifact that the participants created would not be able to fulfill its original intended function. Participants first made an artifact and then tried to use it to fulfill the function it was designed for. When that failed, the participant used it to fulfill a serendipitous function. Participants were then asked an open-ended question "What did you make this for?" Then they were presented with three potential answers which they were asked to judge as “right” or “wrong”. The three possibilities were (a) the original intended function that the artifact was designed for but could not fulfill (e.g.- “we made it to help pour the lentils into the bottle”); (b) the serendipitous function that the item successfully fulfilled (e.g.-“we made it to cover up the blue part”); (c) a distractor response which was not a function (e.g.-“we made it because we wanted something green[8]”). This response was introduced to avoid creating an “all-correct” bias, in the case that the children found both previous answers correct, and as a further check on the suitability of the method for 4-year-olds. If more than one answer was judged correct, participants were asked to pick which one they thought was the best.

There were two tasks using the same materials we used in Experiment 1a. As in Experiment 1a, one of the tasks required participants to create something to transfer the contents of a bowl of lentils into an extremely narrow-mouthed bottle, without spilling any of the lentils on the floor. Participants were given a piece of paper and were asked if they could use it to make something which would help them fulfill the task. Participants invariably thought they could. The experimenter held the paper in place and participants taped it to create a cone-shaped object. Participants were then encouraged to use the artifact they created to fulfill its original intended function. Unbeknownst to participants, the piece of paper they were given was crafted in a way that the item they created could not successfully fulfill its original intended function (in this case, when taped together, the mouth of the funnel-like object that the children created was too big to fit into the mouth the of the bottle). The experimenter expressed dismay, to reinforce the fact that the task was not successfully accomplished. The bottle and the lentils were removed and the

[8] One of the artifacts was made of green construction paper.

experimenter then produced a prefabricated item which was mostly blue with a protruding yellow part. The experimenter said that she wished to only see the yellow part, and asked the child whether he or she thought they could use the artifact that they had created to cover up the blue part of the object. Participants were always able to do so. The experimenter expressed delight that this operation was successful and reintroduced the bowl with the lentils and the narrow-mouthed bottle. For the open-ended question, the experimenter pointed to the item the child had made and asked him/her "What did we make this for?" As in training session, the child was told what each of three characters said in response to the same question and was asked to judge whether each response was right or wrong. (See Appendix D for a sample text).

As in Experiment 1a , the second scenario was similar to the first one, but differed in the artifact that was created and its associated functions. In this scenario, the artifact to be created was a long object made from a piece of Styrofoam into which a small narrow piece of wood was inserted. Participants were asked to create it to push out a piece of newspaper that was stuck in a tube. However, the artifact they created was not long enough to push the paper out of the tube. As described above, the experimenter expressed dismay that the artifact could not fulfill its function. She then brought out a piece of cloth which she said that she didn't want to touch the table. Participants were asked whether the artifact that they had just made could be used to keep it from touching the table. Participants invariably thought it could and were encouraged to use it to do so.

As in Experiment 1a, the artifacts were never named and were always referred to by "this" or "it". Also as in Experiment 1a, the order of scenarios was counterbalanced, as were the original tasks each of the artifacts was designed to fulfill. Thus, for half of the participants, the cone-shaped artifact constructed of paper was originally designed for helping to pour lentils from a bowl to a narrow-mouthed bottle (as described above) and for the other half it was designed for covering up the blue parts of an unfamiliar object. Similarly, for half of the participants, the long Styrofoam object with the piece of wood was initially designed to push a piece of paper out of a tube (as described above) and for the other half, for keeping a piece of cloth from touching the floor. The order of the three possible answers that the characters could give and their pairing with the different plastic characters were also counterbalanced.

Results

We analyzed participants' responses to the open-ended questions and their responses in the judgment task.

Analysis of openended responses

Overall, adults gave the original function as the correct answer 100% of the time and 4-year-olds said the original function is what they made the artifact for 69% of the time. Children also mentioned the serendipitous function (9%), both the original and the serendipitous function (13%) and a few uninterpretable responses (9%) (see Table 3). The percentage of correct responses 4-year-olds gave in Experiment 2 (69%) did not differ from that of Experiment 1a (57.5%), $t(34)=0.630$, $p>.4$.

Children's individual response patterns were also analysed. As in the previous experiment, half of the children consistently gave the original function as a reponse twice, whereas the other half either never gave it as a response or only gave it once as a response (see Table 4). This distribution is significantly different from the adult distribution (chi-square(2)=49.8, $p<.001$).

Analysis of 'good' responses

Initial analyses showed that the children who did not pass the training item chose all three responses (original function 68%, serendipitous function 67%, distractor 53%) to the same extent ($F(2,32)=1.192$, $p>.16$). This confirmed that they could not participate successfully in the judgment task. Therefore only the data of the children who passed the training task is presented.

We performed a 2 (Age: adults, children) X 3 (Response: original function, serendipitous function, distractor) on the number of times participants judged each of the responses as good (See table 5). There were main effects of Response $F(2,56)=70.973$, $p<.001$ and of Age $F(1,28)=15.964$, $p<.001$. That is , overall 4-year-olds judged more responses to be correct than adults (55% versus 40% respectively), and the original function was chosen to be a correct response more often than the serendipitous function (92% versus 42% of the time respectively). The distractor was hardly ever chosen (7%) and only by the children. There was also an interaction between Age and Response $F(2,56)=13.374$, $p<.001$, indicating that the pattern of choices differed across the age groups. Adults predominantly chose the original function (100%) over the serendipitous function (11%) as the correct answer ($F(2,26)=151.098$, $p<.001$). Children chose the original function (84%) and the serendipitous function (69%) to the same extent ($F(1,15)=1.744$, $p>.2$), but chose both answers significantly more than the distractor response ($F(1,15)=35.683$, $p<.001$ and $F(1,15)=19.286$, $p<.001$ respectively).

That children rejected the distractor item shows that they were not participant to a "good" response bias. In addition it demonstrates that they understood that the relevant answers were related to functions, albeit they did not know what the correct response was.

Looking at the dominant response patterns over all three judgments revealed a similar picture: 100% of the adults responses and 87.5% of children's responses included the original function, the serendipitous function or both (see Table 6). (In comparison, these responses only accounted for 44% of the responses of the children who did not pass the training item). Whereas adults' predominant response pattern was to judge only the original function (89%) as a good answer to the question "what did we make it for?", the 4-year-olds judged just the original function as a good answer only 25% of the time, significantly less ($F(1,58)=41.244$, $p<.001$) than the adults. Children predominantly chose both the original function and the serendipitous function as good answers (50%), whereas adults never chose this response pattern. When the children chose only one response, the were equally likely to chose either the original function(25%) or the serendipitous function(12.5%).

The fact that the 4-year-olds considered both the original intended function and the serendipitous functions good answers to the question "what did we make it for?" is also revealed in the analysis of individual response patterns over both scenarios. Only one child out of sixteen restricted his/her "good" responses to the original function on both scenarios, whereas twelve out of fourteen adults did. On the other hand, eleven out of the sixteen children said both functions were good responses on at least one of the tasks, whereas only one adult did so (see Table 7).

Analysis of 'best' answers

Experiment 1 clearly demonstrated that 4-year-olds do not understand the notion of original intended design. Recall that if a participant said that both the original function and the serendipitous function were correct responses, they were asked to choose which one they thought was the best answer (see Table 8). Thus each participant ended up with one answer which they thought was the best (either it was the only answer they considered good, or it was the result of choosing from 2 or 3 good responses). Overall, adults chose the original function as the best answer 100% of the time. However, consistent with the other analyses, children had no preference for the original function over the serendipitous function (54% and 46 % of the time respectively, not different than chance in a binomial distribution).

Discussion

Experiment 2 provides two different probes into 4-year-olds' understanding of the notion of original intended design. The first measure was an open-ended question "what did we make this for?" and the second measure was a judgment task. Children's responses to the open-ended question in Experiment 2 were no different than their responses to the same question in Experiment 1a. Therefore, the tendency to choose the original intended function in Experiment 1a was not due to the fact that children were choosing the first function that was carried out with the item. In fact, in Experiment 2, children were slightly more likely than in Experiment 1a to give the original function as a response to the open-ended question, although not significantly so. Although not order-of-carrying out effect, this may well be a salience effect. Indeed the fact that the original function could not be realized may have induced a Zeigarnik effect, increasing the salience of the original function. Zeigarnik (1927) reports that in free recall, participants will tend to remember tasks which they failed to complete markedly more than tasks that they accomplished successfully.

The judgment task showed clearly that children found both the original function and the serendipitous function to be good responses to the question of what the artifact was made for. Children's lack of preference for either function was demonstrated a) by the fact that they chose the original function as many times as they chose the serendipitous function; b) in their within scenario response pattern where their dominant response pattern was that both responses were good; c) in their across scenario response pattern, in which only one out of sixteen children consistently chose only the original function as the correct response on both scenarios.

Children's choice of both the original and the serendipitous function is not the result of their not understanding the task, since the children who took part in the experiment passed a training item (they had to correctly choose the correct answer out of 3 possible responses). The training item was taken from a domain (naive physics) which 4-year-olds are highly knowledgeable about, therefore children who could not pass it were simply having difficulties with the task itself. Indeed, most telling to the fact that the judgment task indeed taps into the children's understanding is that the responses of the children who did not pass the training task were qualitatively different than the responses of the children who passed the training task. The former judged all 3 responses (original function, serendipitous function, distractor) to be good answers to the question "what did we make it for?" In contrast, the children who passed the training task hardly ever judged the distractor to be a good response to that question.

General Discussion

This paper examined 4-year-olds' understanding of the notion of original intended design. Children created an artifact on their own and after using it (successfully or unsuccessfully) for its original function and for some other serendipitous function they were asked a very simple question "what did we make this for?". In two experiments children demonstrated that they did not know what the answer to this question was.

In Experiment 1a, after having created the artifact, children successfully used it for its original intended function and for a serendipitous function. When asked what the artifact was made for, over 40% of their responses were incorrect -- they either named the serendipitous function or both the original and the serendipitous function. In addition, children's individual response patterns were bimodally distributed -- half of the children consistently gave correct answers, whereas the other half gave only one or no correct answers. The children who were consistently gave the original function as a response on both scenarios a) could have adopted a response strategy of choosing the most salient function that was carried out with the item, which also happened to be the correct answer; b) or may genuinely understand the expression *made for*. To bring data to bear on this question we tested the same group of children who participated in Experiment 1a on the DO/FOR Training task (Experiment 3 of Chapter 1). In this experiment, children are trained to distinguish between what something *does* and what something is *for*. They are told that whereas artifacts (for example, vacuum cleaners) can do various things (pick up dirt, make noise), the original function of the artifact (picking up dirt) is the only thing they were made for. If children who received high scores on Experiment 1a genuinely understood the notion of original intended design, they should be better at the DO/FOR task, since original intended design accounts for the fact that picking up dirt is a good answer to both questions whereas making noise is only a good response to the question "what is a vacuum cleaner for?" We found no such relationship. That is, the children who gave the original function as a response in both scenarios in

Experiment 1 were not better than their counterparts in distinguishing between these two questions. This is not to say that the children who received high scores in Experiment 1 do not understand the expression "made for," but rather, that the reason for their apparent success is unclear. Therefore, we addressed a second possible interpretation: children were simply choosing the first function that was carried out with the item, which also happened to be the correct response. In Experiment 2, this interpretation was addressed by having the first function that the artifact successfully filled be the serendipitous function. In addition to this change in the task, Experiment 2 also included a judgment task which was administered after the open-ended question "what did you make this for?". In this task participants were asked to judge if each of three responses (original function, serendipitous function, distractor) was a good response to that same question "what did you make it for?" In contrast to adults who only chose the original function as the correct answer, children chose both the original and the serendipitous function as correct.

However, on the open-ended question of Experiment 2, children gave the original function as the correct response almost 70% of the time. This was surprising given the clear results from the judgment task which showed that 4-year-olds had no preference for the original function or the serendipitous function as a response to the question "what did you make it for?" Given these results on the judgment task, the fact that children preferred the original function in their free responses is best interpreted as salience effect, perhaps a reflection of the Zeigarnik effect.

In sum, despite the fact that children made an artifact on their own, giving them first hand knowledge about the artifact's origins and why it was created, 4-year-olds do not understand the expression "made for", they do not understand that the original intended function of an artifact is what it was made for, regardless of whether it can or cannot successfully fulfill its original intended function or whether it can serendipitously fill any others.

There is evidence that children do not understand the notion of original intended design until between the ages of four and five from studies of children's drawings (Gardener, 1980, Lowenfeld & Brittain 1970) . Lowenfeld and Brittain (1970) observe that until the age of 4 to 5, when a child has just begun his drawing, he might proclaim that it is of a tree, but by the time the drawing is completed, it may end up having a different name. Artistic license aside, this shows that the original intent of the drawer can change, suggesting that its role is no more important than the role of other intentions. Or a 4-year-old may draw a picture, without having anything in particular in mind, but when asked by others what she drew, she may simply name it as whatever occurred to her at that moment (Gardner, 1980). These observations from a different domain of inquiry are consistent with the interpretation under which children do not have, or are only just beginning to acquire the concept of original intended design. Or at minimum, these results suggest another domain in which original intended design is not important to children. Thus, in two separate domains of designed entities (artifacts and drawings), it is only at the end of the preschool years that children demonstrate an understanding of original intended design.

It is possible that children understand the notion of original intended design, but have not mapped it onto the expression "made for". A simple change in the procedure of Experiment 2 might address this possibility: instead of asking "what did you make this for?" participants can be asked "why did you make it?" If children correctly point out the original function of the artifact, this would suggest that they have the concept of original intended design but have not mapped it onto the expression "made for". However, further failure would provide further support for the claim that children indeed do not understand the notion of original intended design.

The more plausible interpretation, we find, is that 4-year-old children genuinely do not understand the notion of original intended design. If children understood this notion, they would not claim that mountains are for climbing (Piaget, 1929), since they know that mountains are not made by people and they have no clear idea how mountains originated (Gelman & Kremer, 1991). Kelemen's (1996) inability to convince some of the preschoolers in her experiment that certain things are not made for anything, despite explicit training, also lends support to the fact that young children do not understand the notion of original intended design. These 4-year-olds' insistence that pencil sharpening are made for something, together with Piaget's findings, and the fact that both in Chapter 1 and in Experiment 1b children claimed that vacuum cleaners are for picking up dirt, suggest that children cannot distinguish between the different possible uses that entities can be put to. That is, if the child can imagine a possible function for pencil-sharpenings, or for noise-making vacuum cleaners, she will be willing to accept that function as an answer to the question "what was it made for?".

Additional support for children's lack of preference for original function over other functions in determining what something is made for is provided by the fact that 4-year-olds do not attend to the original function of an artifact in their categorization judgments. In Chapter 3, it was shown that unlike 6-year-olds and adults, 4-year-old children do not use the original intended function of an artifact to determine category membership. For example, when told that someone is watering their flowers with an object which was originally designed to make tea in, 4-year-olds were agnostic as to whether it was a teapot or a watering can. Just as preschoolers do not attend to origins to determine artifact kind membership, there is also evidence that unlike older children and adults, they do not attend to origins of animals in determining animal kind (Johnson & Solomon, 1996, Keil, 1989,1992). In one experiment, for example, preschoolers were told a story about an animal that looked like a zebra, but scientists found out that its parents were horses and its babies were horses. Whereas adults say that the animal must be a horse, preschoolers disregard the information about the animals origins and judge it to be a zebra (Keil, 1989).

The notion of original intended design is the basic component of the Design Stance. Four-year-olds do not seem to have this basic understanding. Thus, contrary to Keil's claims, this stance is neither innate nor early developing. Keil reports several experiments to support his claim. In one experiment he contrasts biological kinds, such as plants, with non-biological natural kinds, such as emeralds. The task is to answer the question why the plants or emeralds are green. Five- and seven-year-olds are given two possible answers to choose from: (a) that it is better for plants/emeralds to be green and it helps there to be more plants/emeralds; (b) that there are tiny parts in the plant/emerald which cause it to be green. Keil found that preschoolers to second-graders preferred the first type of explanation for the plants and the second kind for the emeralds. In a second experiment Keil contrasted a prickly plant with a prickly mineral and told the children that only one is prickly because it is good for it. The children were asked to pick which one was prickly because it was good for it. Keil reports that preschoolers chose the plant over the mineral.

While providing further evidence for children's understanding of function, these results are inconclusive with respect to children's understanding of the notion of original intended design and functional explanations. In his experiments, Keil takes children's use of the expressions "good for it" "better for it" as indicative of having the Design Stance. However, being able to say what something is good for is not indicative of understanding functional explanations. For example, chairs are good for standing on to water the plants, but that was not what they were originally designed for. Thus, the fact that children use these expressions with respect to artifacts can only be taken as an understanding of functions. In addition, it is probably the case that the expressions "good for it", "better for it" are rarely used with minerals/emeralds or barbed wire. They are more commonly used in conjunction with plants, and might have been chosen by the children on this basis.

Kelmen (1996) also suggests that preschoolers can take into account the original intended function of an artifact when judging what it is for. Kelemen told participants about an artifact that was made for a specific purpose and then was used for an altogether different purpose: Either once by accident, once intentionally, many times by accident, or many times intentionally. The original function and the subsequent use were depicted in line drawings. Participants were asked to point to the picture that showed what the artifact was for. In all but the many-times-intentionally condition, preschoolers successfully pointed to the picture depicting the original intended function of the artifact. In the many-times-intentionally condition preschoolers pointed to the correct picture significantly more than chance. However, even though their responses in this condition were significantly different from chance, they were also significantly different than the adult responses and from their own responses in the previous conditions, where they predominately picked the picture depicting the original intended function. In all but the many-times-intentionally condition, it is unclear whether children were invoking the original intent of the creator or just an intent that was desirable : in the accidental stories, children might have made the inference that if the function was accidental, it was not desirable because they were told that function never happened again. Similarly, if a function was intentionally used only once, it also might not be desirable. On the other hand, in the many-times-intentional condition, the function must have been desirable since it was intentionally repeated. Thus, in the condition where there is true conflict between original intended design and current function, preschoolers were unsure of their judgments and did not clearly judge the original intended function to be more important than the current intended function in determining what something is for. We take this as consistent with the weight of evidence that preschool children do not understand the notion of original intended function.

Thus, despite having all the requisites necessary for the understanding the notion of original intended design: the understanding of functions (Brown, 1989; Keil, 1989); of goals and intentions (Bullock and Lutkenhaus, 1988; Wellman & Woolley, 1990; Woodward, 1995); of the origins of artifacts (Gelman & Kremer, 1991), 4-year-old children do not understand the notion of original intended design. This is in fact, not surprising. When one encounters an artifact, the first thing one needs to know is how it can be used for one's benefit, what can be done with it. This is the information that we are exposed to in our day to day encounters with artifacts. This information usually coincides with what the artifact was originally made for. But not always. Apparently, this is what children are beginning to figure out.

Children have yet to learn how attending to the original design of an artifact can be beneficial. They have yet to figure out that original intended design is at the core of our understanding of artifacts. It is the basic feature which supports our reasoning about them and enables us to individuate them and predict their properties. Thus, a chair can be successfully used as a ladder, but that use will not explain why it has arm rests. However, knowing that the chair was originally designed to sit on, provides, for example, an explanation for the existence of the different properties of the chair, in this case of the arm rests.

Already at the age of six, children use the original intended design of an artifact to determine category membership (see Chapter 3). Around the same age children begin to attend to the origin of animals in determining animal kind membership (Johnson & Solomon, 1996; Keil, 1989). It is possible that preschoolers attention to origins in the domain of artifacts is prompted by children's attention to origins in the domain of biology. It is also possible that it is the other way around : children's attention to original design in the domain of artifacts pushes children to pay attention to the origins of animals. Whichever is the case, children see that attending to the origins of these entities gives them more explanatory power. Thus, in the case of biological kinds, the origin of an animal enables the child to predict what it will be. In the case of artifacts, the original design of the artifact enables the child to predict what the artifact is and what is for. These are things that the 4-year-old has yet to figure out.

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Appendix A - Text for Experiment 1a

First Scenario
Look at these. I don't want them to be in this bowl. I want to put them in the bottle, without spilling any on the floor. I have an idea. Why don't we make something out of this piece of paper to help us pour them into the bottle? Do you think you can do that? Great job! Why don't you pour them in? Look, it's working!

Control question: What are you using this for now?

Look, here is this thing. I only want to see the yellow part, so we want to cover up the rest. I have an idea. Can we use this to cover up the rest? Do you think you can do that? Great job! Look's it working!

Control question: What are you using this for now?

Now listen carefully: We did 2 things with this. Which did you MAKE it for?

If forced-choice was needed: Did we make it for pouring the lentils into the bottle or for covering up the blue part?

Second Scenario

Look at this. Can you look inside? I want to get the paper out of the roll. I have an idea. Why don't you make something so that we can push the paper out of the roll? Do you think you can do that? Great job! Can you push the paper out? Look, it's working!

Control question: What are you using this for now?

Look here is a piece of cloth. I don't want it to be on the floor. I have an idea. Can you use this to put the cloth on top, so it won't be on the floor? Do you think you can do that? Great job! Look, it's working!

Control question: What are we using this for now?

Now listen carefully: We did 2 things with this. Which did you MAKE it for?

If forced-choice was needed: For putting the cloth on top or for pushing the paper out of the roll?

Appendix B - Text of Experiment 1b

1) What does a vacuum cleaner do/What is a vacuum cleaner for ? It picks up dirt from the floor [F]; It makes a loud noise [A]; It washes the dishes [D]

(2) What does a hat do/What is a hat for? It keeps your head warm [F] It sits on your head [A]; It holds your soup [D].

(3)What does a train do/What is a train for? It takes people from place to place [F]; It goes "choo choo"[A]; It makes candy[D].

(4) (1) What does soap do/What is soap for? It makes you clean [F]; It makes bubbles [A]; It sings songs [D].

(5) What do the hands of a clock do/What are the hands of a clock for ?They tell us the time [F]; They go around inside the clock [A]; They help us brush our teeth [D].

(6) What does a candle do/What is a candle for ? It gives light [F]; It melts [A]; It helps you comb your hair.[D]

(7) What does the door of a house do/What is the door of a house for ? It lets people in and out F]; It moves back and forth [A]; It plays baseball [D].

(8) What do the buttons on the phone do/What are the buttons on the phone for? They dial a number [F];They make sounds when you touch them[A];They make the fridge open[D].

Appendix C - Text of training item in Experiment 2

John and Mary were climbing a tree. All of a sudden the branch John was sitting on broke, and he fell to the ground. Why did John fall down ?

1. Because Mary pushed him.
2. Because the branch broke.
3. Because john has blue eyes.

Appendix D - Text of Experiment 2

First Scenario

Look at these lentils. I don't want them to be in this bowl. I want to put them in the bottle, without spilling any on the floor. I have an idea. Why don't we make something from this piece of paper to help us pour them into the bottle. Do you think you can do that? Great job. Do you want to see if it works? Oh no! It's not working, the lentils are spilling all over the floor. What a shame. Never mind. Let's see what else I have here.

Look, here is this thing. I only want to see the yellow part, so we want to cover up the rest. I have an idea. Do you think we can use this to cover up the blue part ? Do you think you can do that? Great job!

Remember we played will all of these. Can you tell me : What did we make this for ?

a. We made it for pouring the lentils into the bottle

b. We made it because we wanted something green

c. We made it for covering up the blue part .

Second Scenario

Look at this. Can you look inside? I want to get the paper out of the roll. I have an idea. Why don't you make something so that we can push the paper out of the roll? Great job! Do you want to see if it works ? Oh no, it's not working, the paper is still stuck. What a shame. Never mind. let's see what else I have here.

Look here is a piece of cloth. I don't want it to be on the floor. I have an idea. Do you think you can use this to put the cloth on top, so it won't be on the floor? Great job! Look, it's working.

Remember we played with all of these. Can you tell me: What did we make this for ?

a. We made it for keeping the cloth off the floor.

b. We made it because we wanted something with yellow stripes.

c. We made it for pushing the paper out of the roll.

Table 1. Experiment 1a - Distribution of Participants' Responses.

Number of times participant gave the original function as response	0	1	2
4-year-olds	7	3	10
Expected adults	0	0	20

Table 2. Relation between performance on Experiments 1a and 1b.

Numbers of correct responses in Experiment 1a	0,1	2
Mean difference of differences score in Experiment 1b	1.29	1.80

Table 3. Experiment 2 - Distribution of open-ended responses

	4-year-olds	Adults
Original function	69%	100%
Serendipitous function	9%	0%
Both	13%	0%
Other	9%	0%

Table 4 . Experiment 2 - Distribution of participants' responses

Number of times participants gave the original function as response	0	1	2
4-year-olds	2	6	8
Adults	0	0	14

Table 5. Experiment 2 - Percentage of 'good' responses in the judgment task

	Children	Adults
Original function	84%	100%
Serendipitous function	69%	11%
Distractor	13%	0%

Table 6. Experiment 2 - Distribution of individual patterns of response - within scenarios

Original fn	Serendipitous fn	distractor	4-year-olds	Adults
+	-	-	25%	89%
-	+	-	12.5%	11%
+	+	-	50%	0%
other			12.5%	0%

Table 7. Distribution of individual patterns of response -across scenarios

Scenario A	Scenario B	Number of children	Adults
+--	+--	1	12
++-	++-	5	1
++-	+--	5	1
-+-	-+-	1	0
+--	-+-	1	0
++-	-+-	1	0
other		2	0

Table 8. Experiment 2 - Distribution of 'best' responses

	Children	Adults
Original function	56%	100%
Serendipitous function	44%	0%

Chapter 3

Children's use of original intended design in artifact categorization.

What criteria do we use to categorize an entity? Determining what these criteria are and what they reveal about the structure of concepts has long been a question for debate (Murphy & Medin, 1985; Smith & Medin, 1981). The criteria adults use to determine which category an entity belongs to vary according to whether the category is a naturally occurring one or a man-made one. It has been suggested that adults believe that natural kinds such as tigers and bears have deep underlying essences which determine their category membership (Kripke, 1972; Putnam, 1977; Keil, 1986; Gelman & Coley, 1994, Medin & Ortony, 1989). On the other hand, category membership for man-made objects is considered to be more superficial, involving the correlated features of perceptual form and original function (Bruner, Olver, & Greenfield et al., 1966; Miller & Johnson-Laird, 1976; Schwartz, 1980). Of these two factors the latter, function, is considered to be the more important for several reasons: It is usually the case that original function determines the form of the artifact. Thus for example, both teapots and watering cans have long narrow spouts because of the need to pour water in a focused stream. Also, the function of artifacts of a single kind seems to vary less than their form. Consider a dial telephone and a banana shaped telephone - where the function of the objects is the same but the perceptual form is strikingly different. Yet both are categorized as telephones.

Several empirical studies confirm the philosophical claims about the importance of function in adult categorization judgments (Rips, 1989; Keil, 1989; Barton & Komatsu, 1989; Sera, Reittinger, & Pintado, 1991; see Malt & Johnson, 1992, for counter-examples). However in the discussion of the relative importance of function in artifact kind judgment, two different notions of function have been conflated, namely the difference between *original* function and *current* function (Hall, 1995). The original intended function of an artifact is the function for which it was intentionally created. The current intended function of an artifact is the function which its current user is intending it to fulfill. These two notions are distinct from one another, although in most cases they coincide. If you see someone eating dinner off an object, it is very likely that object is a plate[9]. However, consider the case of my coffee mug. Coffee mugs are used to drink coffee and were intentionally made for that purpose. However, the coffee mug on my desk has never contained any liquids, let alone coffee. It does, however, contain an assortment of pens and pencils, has since I bought it, and will probably continue to do so until it breaks, therefore never really fulfilling its true calling of containing coffee. This example is a case where the original function and current function do not coincide.

The psychological relevance of the distinction between original intended function and current function is seen from the fact that information about the original intended function can cause the categorization judgment of an artifact to change. Imagine for example an object that looks like a chair. If it turned out, however, that it was created as the result of workman dumping out debris from a window, we would no longer categorize it as a chair because it was not intentionally created for sitting on. To take another example, an archeologist might discover that a hat-shaped straw object is actually a sieve for washing rice because she found evidence that it was intentionally made for that purpose. Thus, for adults, the causal principle which determines artifact kind, is the intended function of its creator (Keil, 1986). Indeed, the Design stance (Dennett, 1987) which explains the existence of entities in terms of their original intended design, has been suggested as one of the major explanatory principles available to adults in reasoning about artifacts and biological kinds.

Rips (1989), for example, distinguishes between original and current function. He presented adult participants with stories at the end of which they were requested to categorize the described object . In one story, participants heard about an object with the perceptual features of an umbrella, without being told about its current or original function. In the second scenario, participants heard about an object which had the perceptual features of an umbrella but whose creator intended it to be used as a lamp shade. In the first scenario, participants judged the item

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[9]In addition, note that perceptual features help here: if it is being used as a plate *and* it looks like a plate, then in all likelihood, it probably is a plate.

according to its perceptual features, namely they judged it to be an umbrella. In the second scenario, participants judged the item to be a lamp shade, even though it had the same perceptual features as the object in the first scenario.

In his studies of the relative roles of characterizing and defining features in artifact categorization, Keil (1989) described objects which looked like certain artifacts (for example, a screwdriver) but were used for some other function (for example, to clean the grooves in the top of screws) and objects which did not look like the target artifact (for example, looked like a round, pink plastic ball with a little edge sticking out) but could be used to fulfill the function of the target artifact (e.g. - the little edge fit into screws to turn them). Keil, like other researchers, makes the assumption that current function is indicative of original function. He found that adults denied that the former were screwdrivers whereas they accepted that the latter were.

In the developmental literature, it has been claimed that preschoolers, as opposed to adults, rely on perceptual features in their categorization judgments of artifact kinds, and only around the age of six or seven do their judgments begin to become adult-like in their reliance on functional features (Keil, 1988; Gentner, 1978, Landau, Smith & Jones, 1995, Tomikawa & Dodd, 1980).

For example, Gentner (1978) has shown that when asked to name a newly encountered artifact, three- to 5-year-olds will select the artifact name in accordance with the appearance of the artifact. Gentner showed children two novel objects which were perceptually distinct and had different functions. The "Ziggy" was a colorful box with a face on it. When participants pulled the lever, the face changed its expression. When participants pulled the lever of the "Zimbo", which was a modified gumball machine, jelly beans poured from it. Two- to 5- year-olds were presented with a hybrid object which looked like the Ziggy but dispersed gumballs, and were asked to name it. Children mainly responded on the basis of form and called it a Ziggy, despite the fact that they were all very surprised that jelly-beans poured from the object, in Zimbo-like fashion. After the age of five, children begin to rely on function in their judgments. Gentner's data suggests that preschool children use perceptual features as a basis for categorization of artifacts into namable kinds.

In the same series of experiments mentioned earlier, Keil (1989) asked kindergartners whether an object that looks like a screwdriver (has the perceptual features of the target item) and is used to clean the grooves on tops of screws (does not fulfill the function of the target item) could still be a screw driver. Kindergartners judged that it could be a screwdriver. Children's judgments on these tasks begin to change around second grade, and are adult-like by fourth grade.

To sum, most of the adult literature suggests that adults rely on functional information in making artifact categorization judgments, whereas most of the developmental literature suggests that young children rely on perceptual information in making their categorization judgments. However, these studies have not contrasted the notions of original intended function and *current* function to determine which is more important in artifact kind judgments. In the first experiment pitting the two against each other, Hall (1995) found that, indeed, the original function of an artifact is more important than the current function in adult determination of the category of an artifact.

Hall (1995) presented subjects with three scenarios in which he held constant the current function of an artifact and he varied the information about their original design. Thus, for example, subjects were told about an object which was being used to water flowers. This is the "current function" of the artifact. There were three conditions for the "original function": In the matching condition, subjects were told that the object was made with the original intended function of being used to water flowers. In the unknown origin condition subjects were told that the objects' original intended function was not known. In the mismatching condition, subjects are told that the artifact was made by a company for the original intended function of making tea. Subjects were asked to rate their answers to the question "Is that a watering can?" on a scale from 1 to 10 . Hall found that original function determined subjects' judgments. That is, when there was a mismatch between current function and original function, subjects relied on the original function for their judgments. When subjects did not know the origin of the object, they were unsure of their judgments. Hall suggests, therefore, that any claims made about the role of function in adult category judgments of artifact kinds should be interpreted as claims about *original* intended function

In the developmental literature, as in the adult literature, the distinction between original function and current function has not been systematically brought to bear on the question of artifact categorization. However, the research in Chapter 2 suggests that 4-year-olds do not understand the notion of original intended function, since children could not distinguish between the original function of an artifact and a current function of an artifact to determine what the artifact was made for. Therefore, if children do not understand the notion of original intended function, it is unlikely that they will be able to rely on this notion to determine what an artifact *is*. It is also the case that children do not attach importance to origins when reasoning about biological kinds until at least the second or fourth grade (Johnson & Solomon, 1996; Keil, 1989). For example, when told that a certain animal looks likes a skunk but actually has raccoons for parents, only by fourth grade will children judge, as adults, that the animal is a raccoon (Keil, 1989). Given this common disregard for origins in determining what an animal is and in determining what an artifact is for, we predict that preschoolers will have a similar disregard for the origins of artifacts in determining artifact kinds. We predict that 4-year-olds will not base their categorization judgments on the original intended function of the artifact, whereas 6-year-olds will already be able to do so.

To test these predictions, Hall's (1996) procedure was adapted so that it would be suitable for young children. To shorten it, only the mismatched scenarios were included (e.g. - this artifact was made to make tea in and is currently being used to water flowers in the garden with), since there is every reason to believe that even 4-year-olds would judge that an object that was originally made to water flowers in the garden and was being used to water flowers in the garden is a watering can, as did adults. Children were shown a picture that occluded most of the object, leaving only a part that provided no differentiating information as to the objects' kind, and their responses were probed in a forced-choice format. The descriptions were read out loud to the children. Given all these changes from Hall's (1996) procedure, Experiment 1 established whether

Hall's results with adults would be replicated under these conditions. But first, a pretest established a set of items that 4-year-olds could identify by description.

Pretest

Four pairs of items were required that met the following criteria: four-year-old children had to be able to identify them from descriptions, and each of the items in the pair could be used to fulfill the function of the other item in the pair (e.g., a teapot could feasibly be used as a watering can and vice versa). Twelve 4-year-olds were provided with descriptions of 6 pairs of items: plate/frisbee, watering can/teapot, stroller/shopping cart, belt/tie, bowl/helmet, rolling pin/baseball bat. For each item we described, we asked children to judge which category it belonged to. For example: "I have a picture of something in my hand. People use it to pour water on the flowers in the garden. Is it a tea pot or a watering can?" The items that more than two children failed to identify were not included in final materials. The final list consisted of the following pairs of items (number of children failing to identify each object from the description is given in parentheses: teapot(1)/watering can(0), plate(1)/frisbee(1), bowl(0)/helmet(0), shopping cart(1)/stroller(0).

Experiment 1

This experiment attempted to replicate Hall's (1995) results with adults using the version adapted for young children.

Method

Participants

Eight adults participated in this experiment. They were all from the MIT community - undergraduates and staff.

Stimuli

Each participant was presented with four scenarios in which information about the original intended function of an artifact and information about its current function were provided. The items were taken from the list created in the pretest. Participants were then asked to categorize the artifacts.

In each scenario, participants were shown a picture of a wall with an ambiguous unidentifiable object protruding from behind it. For example, the participants saw a spout which could be interpreted as either belonging to a tea pot or to a watering can, sticking out from behind a wall (see Appendix A for a sample picture). Participants were then shown two pictures of women. They were told that one of the women made the item for some specific purpose (e.g. - watering the flowers in her garden - this is the original intended function) whereas the other woman was using it for something else (e.g. - for making tea in - this is the current function). Participants were then asked two comprehension questions in order to ensure that they indeed remembered the information they were presented with. Pointing to each of the women in turn, the experimenter asked "Why did this woman make this?" and "What was this woman doing with it?". Finally, participants were asked to categorize the item. The following are the four scenarios with the two comprehension and test questions:

(1) See this woman, she made this [experimenter points to protruding item]. She made it so people could put food on it at dinner time. And see this woman, she's using it. She's using it to throw back and forth in an outdoor game. So why did this woman make it? And what is this woman doing with it? So can you tell me what this is ? Is it a Frisbee or a plate ?

(2) See this woman, she made this. She made it so that people could water flowers in their garden with it. And see this woman, she's using it. She's using it to make tea in. So why did this woman make it? And what is this woman doing with it? So can you tell me what this is ? Is it a tea pot or a watering can ?

(3) See this woman, she made this. She made it so that people can eat soup in it. And see this woman. She's using it. She's wearing it on her head so she won't get hurt. So why did this woman make it? And what is this woman doing with it? So can you tell me what this is ? Is it a bowl or a helmet?

(4) See this woman, she made this. She made it for putting babies in when you take them for a walk. And see this woman. She's using it. She's at the supermarket and she's using it to put food in. So why did this woman make it? And what is this woman doing with it? So can you tell me what this is ? Is it a stroller or a shopping cart ?

The order in which the two kinds of function were mentioned (original function first or current function first), was counterbalanced between participants. Also counter-balanced were the original intended design of the item (that is, whether it was made as a frisbee or as a plate); and the order of mention of the two choices in the test question (for example, "Is this a plate or a frisbee?"). Comprehension questions were presented in the same order of mention as were the two functions.

Procedure

To familiarize the participants with the items and the descriptions of their functions, participants were shown Polaroid pictures of the items in the experiment prior to the testing session. They were asked to identify the object in the photograph ("What is this?") and to tell the experimenter what can be done with the artifact ("What do you do with X?"). The experimenter reinforced and corrected the participants' responses using the same wording for the items that would be used in the test trials. For example, after a participant told the experimenter that teapots are for pouring tea into cups, the experimenter would say "Oh, so people make tea in them".

A practice pair of items (baseball bat/rolling pin) was then used to introduce participants to the experiment itself, with the help of a puppet. The experimenter played out the game with the puppet and profusely praised the puppet when it answered the comprehension questions correctly. When asked to categorize the object, the puppet whispered its judgment into the experimenter's ear so as not to bias the participants' response. The puppet then "went to sleep" leaving the experimenter and the participant to play the game. After this familiarization procedure, the test portion was carried out, as described above.

Results and discussion

Participants received a score of 1 if they categorized the object with its original function, and 0 otherwise. Since there were four items, scores could range from 0 to 4. Overall, 78% of adults categorization judgments were based on the original intended function and their performance was significantly above a chance level of 2, $t(7)=3.813$, $p<.007$, two-tailed. Out of the 8 adults, six of them categorized at most one, or no items with the current function, and two participants categorized two of the items with the original function and the other two with the current function. Grouping participants who made three or four judgments based on the original function together (n=6), and participants who made one or two judgments based on the current function together (n=6), this distribution was significantly different than chance (chi-square(2)=7.733, $p<.05$). As in Hall (1996) adults clearly use the original intended function of the artifact as the determinant of their categorization judgments.

The condition in Hall (1996) most comparable to the present experiment was that in which no picture was provided (recall the picture presented in Experiment 1 provided no information) and the description of the original intended function conflicted with that of the current function. In this condition, 83% of participants categorization judgments were based on the original intended function, which is comparable to the 78% obtained in Experiment 1. Thus, Hall's findings were replicated on our modified task. In Experiment 2, we turn to the question of interest: whether 4 and 6-year-olds are like adults in basing artifact categorization judgments on original intended function.

Experiment 2

Method

Participants

24 4-year-olds (M=4;6, range 4;1 to 4;11), eleven girls and nine boys, and 16 6-year-olds (M=6;6, range 6;0 to 7;0), ten girls and six boys, participated in this experiment. They were recruited from Greater-Boston day-cares and schools. They were all native speakers of English and from multi-ethnic middle to upper-middle class populations.

Stimuli and Procedure

The same as in Experiment 1.

Results

As in Experiment 1, participants received a score of 1 if they categorized the artifact according to its original function and 0 otherwise, such that scores could range from 0 to 4. Overall, 86% of 6-year-olds' categorization judgments were based on original function (mean response 3.4) which is significantly above chance, $t(15)=7.064$, $p<.001$, two-tailed. Overall, 54% of 4-year-olds' categorization judgments were based on original function (mean response 2.2), and their performance was no different from chance, $t(23)=.678$ $p>.5$, two-tailed (See Figure 1).

Separate Anovas at each age examined the effects of the order in which functions were described (Original-Fn-1st, Current-Fn-1st); the order in which the forced choices were given (Following-order-of-presentation, Not-following-order-of-presentation) and item (item: teapot/watering can, plate/frisbee; bowl/helmet; stroller/shopping cart). For neither age group were there any main effects or interactions involving these variables.

The individual response patterns revealed a similar picture to the overall analysis (see Table 1). The majority of 6-year-olds (81%) categorized the artifacts 3 or 4 times with the original function, a pattern of response which was significantly different than chance, chi-square(4)=88.91, $p<.001$. Four-year-olds' response pattern, however, was not found to be different than chance, chi-square(4)=4.0, $p>.05$.

In sum, 6-year-olds performed as did the adults in this task, relying on original intended function in their categorization judgments.

There were some indications of difficulty on the part of the 4-year-olds in responding to the comprehension questions (52% of the time, as opposed to 30% for the 6-year-olds). Children sometimes mixed up the function they were told the object was made for and the function they were told the object was being used for, and they sometimes responded that they didn't know the answers to the comprehension probes. Thus, a possible explanation for the 4-year-old's random responses might be that they simply cannot remember what the artifact was made for. If they cannot remember what the object was originally made for, we would not expect them to base their categorization decision on original intended function. However if the reason for children's failure is that they simply cannot remember the information, 4-year-olds with few problems with the comprehension probes should perform better than those who readily remembered the information presented in the scenarios. Two separate analyses were performed to assess this possibility.

First, ten 4-year-olds who needed the information repeated on at most one item were identified and their categorization judgments analyzed. Their performance was no different than chance (mean score 2.5), $t(9)=1.342$, $p>.2$, two-tailed. Second, 14 4-year-olds who responded to

Table 1. Distribution of individual response patterns

Number of judgments based on original intended function	0	1	2	3	4	
4-year-olds	2	6	5	8	3	(n=24)
6-year-olds	0	0	2	3	10	(n=16)

all of the comprehension probes correctly (sometimes needing many repetitions of the information) were identified. Their categorization judgments did not differ from chance (mean score 2.4), $t(13)=1.249$, $p>2$, two-tailed. Thus even those 4-year-olds who remembered which function the object was originally made for and which it was currently used for failed to categorize on the basis of original intended function. These data fail to support the suggestion that the random responding of the 4-year-olds is due simply to their inability to remember the information presented in the scenario.

In comparison, eleven 6-year-olds met the criterion of the first analysis and fourteen met the criterion of the second analysis. In both cases, the 6-year-olds performance was significantly above chance ($t(10)=8.05$, $p<.0001$, and $t(13)=6.032$, $p<.0001$ respectively). Thus, the 6-year-olds did not have problems remembering the information.

Discussion

Like adults, 6-year-olds are clearly using the original intended function of the artifact as the determining factor in their categorization judgments. The 4-year-olds, however, responded randomly, basing their categorization judgments neither on original function nor current function.

In addition, 4-year-olds as a group found it difficult to remember the information presented in the scenarios; they sometimes mixed up the function they were told the object was made for and the function they were told the object was being used for, and they sometimes responded that they didn't know the answers to the comprehension probes. However, it seems unlikely that the random responding to the test questions was due to a memory failure, since the subset of 4-year-olds who remembered the information also failed to base their categorization judgments on the original function. Experiment 3 will address further the possibility that memory limitations explain the failure of the 4-year-olds to categorize these objects in the same way as the 6-year-olds or adults.

It is likely that the memory problems of the 4-year-olds stem from the same conceptual difference between them and the 6-year-olds, as does the difference in categorization judgments. If the 4-year-olds cannot differentiate between original and intended function, they have no other resource available to them to remember which of the protagonists made the artifact and which one was using it, because both of the protagonists were women and no other feature distinguished between them. In addition Chapter 2 showed that 4-year-olds fail to distinguish between original and current function with respect to what an artifact was made for. Therefore, it would not be surprising that 4-year-olds will also fail to find that distinction meaningful or salient in the context of artifact categorization.

Chi (1976) provides independent support that the difference between the performance of 4 and 6-year-olds is conceptual in nature. She suggests that memory span for materials on which adults and children are matched for knowledge does not change after the age of four.

Experiment 3 adopts a slightly different procedure, designed to make the information about original function and current function more salient and to eliminate memory demands. If 4-year-olds do not consider this distinction relevant to artifact categorization, they should still fail to categorize the artifacts according to the intent of the original maker. The scenarios were elaborated, made more story-like, and colorful drawings which were associated with the items were added. Given the 6-year-olds' adult-like performance in Experiment 2, only 4-year-olds were included in Experiment 3.

Experiment 3

Method

Participants

24 4-year-olds (M=4;6 range 4;0 to 4;11), ten girls and fourteen boys, participated in this experiment. They were recruited from Greater-Boston day-cares and schools. They were all native speakers of English and from multi-ethnic middle and upper-middle class populations. Three additional participants participated in this experiment but were excluded from the analysis. Two participants were excluded because they could not answer three or more of the comprehension questions correctly, and the additional participant was excluded due to an experimenter error.

Stimuli and Procedure

As in the previous experiment, each participant was presented with four scenarios in which contrasting information about the original function and the current use of the items was described. The children were then asked to categorize the items.

The two major differences between Experiment 2 and Experiment 3 were the colorful drawings and the level of detail in the stories presented. As in the previous experiment, the items in each pair were chosen such that each item could plausibly be used in the capacity of the other item in the pair. Three of the pairs of items were the same as in the previous experiment. We replaced the stroller/shopping cart pair with the baseball/rolling pin pair[10]. In each scenario the children were shown an object occluded by a wall and two pictures of people, a man and a woman. They were told that one of two people had made the item for a certain purpose whereas the other

[10] We replaced the stroller/supermarket cart pair, because as one child pointed out during the previous experiment - supermarket carts have a seat which was specifically designed for putting young children in them. Thus the function of "putting babies in them and taking them for a walk" could apply to both the supermarket cart and the stroller, even though the primary function of shopping cart is for putting food in when at the supermarket. Note that in Experiment 1, subjects did not demonstrate a preference for choosing the stroller interpretation for this pair of items. However given the possiblity of confusion, we replaced this item with the baseball bat/rolling pin which served as the familiarization item in Experiment 1.

one was using it in a different capacity. In the scenarios of Experiment 3, general traits of the artifacts were described (for example, long and smooth for baseball bats) and the desires of the protagonists (for example, this woman wanted something to hit baseballs with, and this man needed something to roll out cookie dough with). In addition, the process of creating the artifact was described at length to highlight the importance of the original function of the artifact, thus giving the children a better chance of succeeding on the task. The stories were also accompanied by colorful drawings that were associated with the original function of the artifact being described and with its current use. Thus, when hearing the story about a something that was made to hit baseballs with and was being used to roll out cookie dough - a picture of a baseball cap and a baseball was shown next to the character that created the artifact, and a picture of some cookie dough and a cookie cutter was shown next to the character who used it. All the drawings were left in full view of the children throught the session. After the respective stories were told, the experimenter briefly repeated why a given character made the item and what the other character was using it for. The child was then asked to categorize the item. After the child gave her response, the experimenter asked two comprehension questions to see whether the children indeed remembered the information that was presented. The comprehension questions were placed at the end in order to avoid adding to the complexity of the task by placing them before the test question. Following is a sample scenario with the test and comprehension questions: (the entire set of scenarios is given in Appendix B).

"See this woman? She made this thing [experimenter points to protruding object] Now this woman wanted something to hit baseballs with in the park. But she didn't have anything to do that with. So you know what - she decided to make something. So she went to the store and bought all the materials she needed so she could make something to hit baseballs with. She then went home and she spent the whole day carefully making something that was long and smooth. She said to herself "this is going to perfect for hitting baseballs with". She then went to the park. But you know what, she forgot this thing on the table.

But you know what, see this man? He's her brother. Now this man found this thing [experimenter points to protruding object] on the table. He had been looking for something to roll out cookie dough with for a long time. He walked up to this bench and said "hey look what I found on this bench: it's exactly what I needed for rolling out cookie dough - it's long and smooth and it's just the right size". So he picked it up and took it to his kitchen and he rolled out cookie dough with it"

"So remember, - this woman made this to hit base balls with, and this man was using to roll out cookie dough.

So can you tell me what this: is it a baseball bat or a rolling pin?

Now can you tell me why this woman made this?

And what was this man doing with it?"

As in Experiment 2, participants were shown Polaroid pictures of the items in the experiment prior to the test session in order to familiarize them with the items and the descriptions of their functions. The participants were asked to identify the artifact in the photograph ("What is this?") and to tell the experimenter what can be done with the artifact ("What do you do with X?"). The experimenter reinforced and corrected the children's responses using the same wording for the items that would be used in the test trials. For example, after a child told the experimenter that teapots are for pouring tea into cups, the experimenter would say "Oh, so people make tea in them"

The same counter balancing measures that were used in Experiment 2 were used in Experiment 3. In addition, whether the man or the woman made the item was counter balanced across scenarios.

Results

In this experiment the need to rely on memory when making the categorization judgments was indeed eliminated. This was demonstrated by the small number of errors on the comprehension probes. There were a total of eight comprehension probes for each participant. Two participants who made mistakes on more than 3 were not included in the analyses. Out of a total of 192 comprehension probes, only 6 were not the exact answer we were looking for, and were mostly of the nature "Why did he make it? Because he needed to".

As in the previous experiments children received a score of 1 if they categorized the artifact according to its original intended function and 0 otherwise. Therefore, given that there were four scenarios, scores ranged from 0 to 4. Sixty-one percent of the 4-year-olds' categorization judgments were based on the original function (mean score 2.5), and their performance was no different from chance, $\underline{t}(23)=1.6$, $\underline{p}=.118$, two-tailed (See Figure 1).

An Analysis of variance examined the effects of order in which the functions were described (Original-Fn-1st, Current-Fn-1st), the order of the forced choices and item (teapot/watering can, plate/frisbee; bowl/helmet; stroller/shopping cart) on childrens' categorization judgments. There was a main effect of order $\underline{F}(1,22)=5.037$, $\underline{p}<.04$, indicating that children's response pattern varied according to whether the original intended function of the artifact was mentioned first in the scenario or whether the current function was mentioned first in the scenario. There was no main effect of item, nor any interaction between the two factors.

Insert Figure 1 about here

The main effect of order was due to the fact that the preschoolers tended to categorize the item according to the first mentioned function in the scenario. Those who heard the original function of the item mentioned first received an mean score of 3.17, significantly above chance $\underline{t}(11)=3.386$, $\underline{p}<.007$, two-tailed. Those who heard the current function first received a mean score of 1.75, below chance but not significantly so. Whereas the responses of the children who heard the current function first are not significantly different than chance, the mean of their responses is in the opposite direction than the responses of the children who heard the original function first (3.17 is greater than 2 whereas 1.7 is less than 2).

An analysis of the individual pattern of responses underlines the effect of order of mention on the children's categorization judgments. For this analysis, children were grouped into those who made 3 or 4 judgments consistent with the original function, those who made 2 such judgments, and those who made 0 or 1 such judgments(See Table 2). The response pattern of the children who heard the original function first was significantly different than the children who heard the current function first (chi-square(2)=7.9, $p<.02$). Nine out of the 12 children who heard the original function first based their categorization judgments on the original function significantly more than chance (chi-square(2)=15.16, $p<.001$). The children who heard the current function first relied neither on original function nor on current function and their distribution was no different than chance.

Discussion

The methodological differences between Experiment 2 and Experiment 3 eliminated the need to rely on memory in making the categorization judgments. Children could rely on several cues to remember which protagonist made the item and which one was using it: the gender of the protagonists was different (one was a man, the other a woman) and a drawing associated with the original or current function was left next to the appropriate protagonist. These cues were left in full view of the children while they were asked to categorize the artifact. Indeed, the virtually perfect responses on the comprehension probes showed the children were able to rely on these cues to remember why the artifact was made and what it was being used for.

Nonetheless, despite having all the information at hand, the results of Experiment 2 were replicated. Namely, 4-year-olds still did not categorize the artifacts according to their original function and their overall distribution was no different than chance. This substantiates the claim that the reason for the 4-year-olds' failure in Experiment 2 was not due to the fact that they could

Table 2. Number of children basing categorization on original function 0/1, 2 or 3/4 times as a function of order of mention of function type.

Number of original function choices	0/1	2	3/4
Original Function 1st	2	1	9
Current Function 1st	5	4	3

not remember the information. Moreover, the fact that they could not remember the information lends further support to the suggestion that 4-year-olds do not have the distinction between original and intended function. In Experiment 2, the only way to distinguish between the protagonists was on the basis of original versus current function, since the protagonists were both women and there were no facilitating visual cues. However, if children do not differentiate between these two notions of function, they have no tools to distinguish between the protagonists, and therefore cannot remember who created the artifact and who was using it.

We did however find an order effect, namely children who heard the *original* function first in the scenario, categorized the artifact according to its original function. The children who heard the current function first were random in their response patterns, although they had a tendency to rely on current function as a basis for categorization. However, even if some preschool children are beginning to recognize that intended function determines artifact kind, as a group they clearly differ from 6-year-olds and adults in not taking original intended function as the basis for artifact categorization.

General Discussion

Unlike 6-year-olds and adults, 4-year-olds do not rely on the original intent of the creator in their artifact kind judgments. In Experiment 2 and 3 children were told about two protagonists, one of whom made an item for a certain purpose, and another who was using it in a capacity other than its original purpose. In Experiment 2, the 4-year-olds had difficulties in remembering why the artifacts were made and what they were being used for and overall showed no reliance on original or current function in their categorization judgments. It is unlikely that their chance responding on the categorization judgments was due to memory problems. First, the categorization judgments of the children with few memory problems were also random. Second, in Experiment 3 the need to rely on memory in categorizing the artifacts was eliminated by having visual cues continuously present. Nonetheless, as a group, the 4-year-olds did not use the original intended function of the artifact as the basis for their categorization judgments. Thus, either preschool children simply do not find the distinction between the original and current function of the artifacts relevant to artifact categorization, or they do not understand the distinction between these two notions. In Chapter 2 it was shown that 4-year-olds cannot make the distinction between original intended function and current function in determining what something is made for. This strongly suggests that 4-year-old children do not understand the notion of original intended design. The results from the present experiments also suggest that preschool children do not grasp this concept. Indeed, lack of clarity as to the distinction between original intended function and current function might also explain why children were having difficulties in remembering the information in Experiment 2: in that experiment, the only cue to distinguishing between the two protagonists was on the basis of these two types of function. If children do not have this distinction they will not be able to remember the information.

Just as preschoolers do not attend to origins to determine artifact kind membership, there is also evidence that they differ from older children and adults in not attending to origins of animals in determining animal kind (Keil, 1992; Johnson & Solomon,1996). Keil (1992) reports a experiment where not until fourth grade are children willing to infer that two animals of different origins and different developmental histories belong to two different kinds. For example, one animal is born alive with no hair, the other hatched from an egg with lots of long fur. Children are asked whether the animals are the same kind of animal. Five- and seven-year-olds are willing to accept that they are the same kind of animal. Keil suggests that these results show that children do not attach much importance to origins when individuating species kinds, which is interesting given how basic origins are to adult concepts in biology.

Johnson and Solomon (1996) have shown that although by the age of five children know the factual information that cats give birth to cats, it is not until they are about seven that they realize that the origins of the animal are causally related to their kind. That is , they do not understand that a cat *is* a cat *because* a cat gave birth to it. In the same vein, 4-year-olds do not understand that a teapot is a teapot because it was intentionally created to be one

In a different set of studies, Keil (1989) showed that, unlike adults, preschoolers will not change their categorization judgment of an animal when confronted with information about its origins. For example, he told a story about an animal which looked like a raccoon but scientists found out that its parent were skunks and its babies are skunks. Whereas adults will say that the animal must be a skunk, preschoolers do not find such information about the animal's origins compelling and judge the animal to be a raccoon.

All these studies suggest that until children understand the causal relationship between the origin of an artifact or an animal and what it is, namely that it is what it is because of its origins, they will not attach much importance to that factor. We propose that when children understand the power that this causal relationship gives them in predicting the kind (e.g. - teapot, skunk) or the different properties (e.g. - has a spout, has baby skunks) of these entities, only then will they begin to rely on this information in their categorization judgments.

In fact, Nelson (1995) has evidence that suggests that when children understand the causal relationship between the form of the artifact and the function that it can fulfill, children as young as three will categorize it according to its function and not its form. For example, Nelson showed 3-, 4- and 5-year-olds an object that could be dipped into paint and used to paint with and called it a "stennet". She then presented the children with a novel object that was perceptually similar to the test object but could not be used to perform the same function of painting (because, for example, strings of small coloured beads replaced the brushes). She asked children if the novel object was also a stennet. Children as young as three, responded that it was not. In addition, an object that looked perceptually dissimilar but still afforded the same function as the original object, was categorized by these children as a stennet. In most other research, claims Nelson, children do not clearly understand the structural properties or physical principles that mediate between the perceptual properties and the intended function of the items. Nelson proposes that the reason she finds success with such young children is because the children understand the causal principles that relate the perceptual form of the object with its function. Nelson's data show that even at an age when children cannot distinguish between original and current function, let alone rely on original function in their artifact categorization judgments, children will rely on functional information when they understand that it is causally important to the existence of certain features of an artifact.

Six-year-olds already understand the importance of origins with respect to artifact categorization and base their judgments on the original intent of the creator of the artifact. As predicted, this understanding coincides with the same age in which children are beginning to rely on functional information as opposed to perceptual information in their categorization judgments. These two shifts may be occurring at the same time because the children have begun to understand that the original function is the element which has the most explanatory power with respect to artifacts. This is the element that will explicate why the artifact has the features that it has, and which will allow them to make futher predications about it. Thus, for example, if we are told that a certain company has a product which is designed to enable people to boil water on their stoves, we will be able to make many inferences regarding the properties of this product. We will be able to predict that it does not have holes in it, that it is made from material that does not melt or explode when brought into contact with fire, that it will be of a relatively small dimensions etc.

All of the above mentioned shifts suggest that at around the age of six children have already acquired much information which is not yet organized around causal explanatory principles. Looking at the origins of entities paves the way to acquiring some of these principles: looking at the origins of animals provides an insight into the understanding of what makes a cat a cat and into the biological explanatory principle of inheritance; looking at the origins of artifacts provides an insight into what makes a teapot a teapot and into the understanding of the Design stance. These explanatory principles are late developing, because it takes time until children acquire a body of knowledge that would require or would benefit from reorganization around deeper causal relations.

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Figure Captions

Figure 1. Percent of artifact categorization based on original function

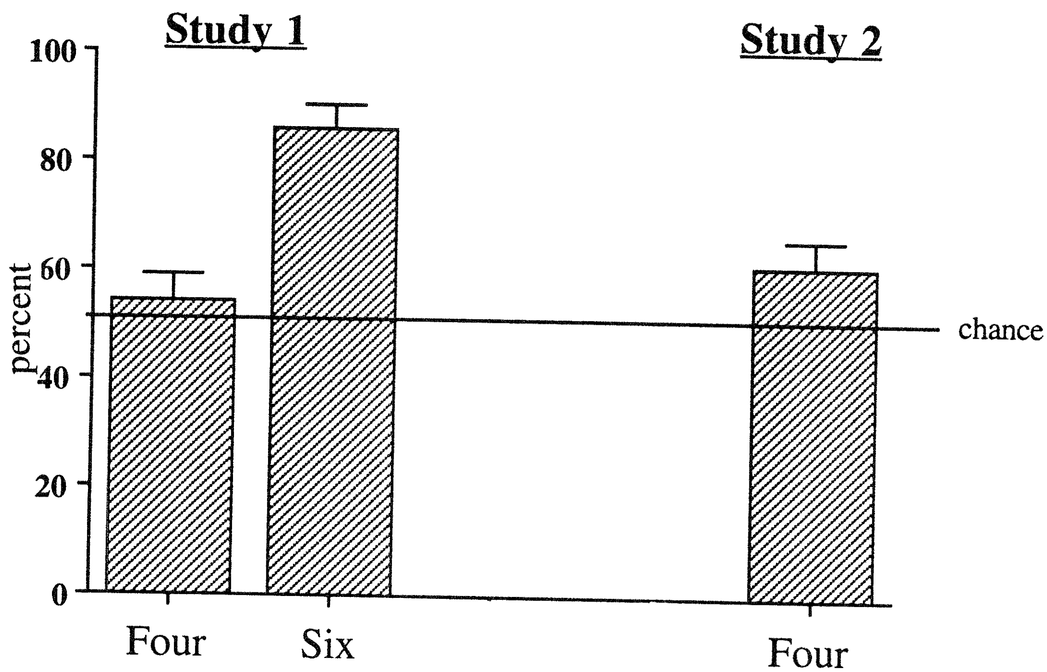
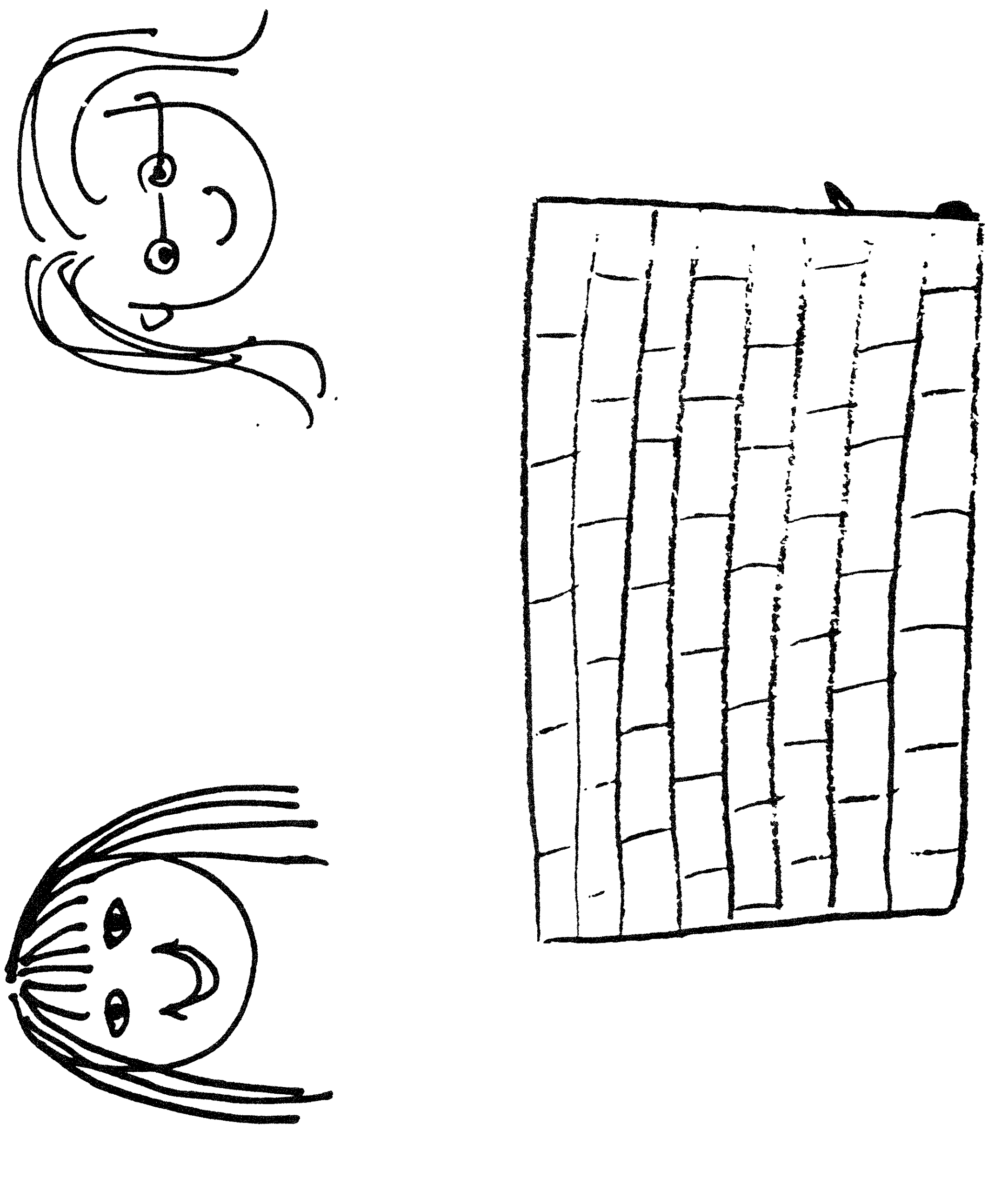


Figure 1

Appendix A. Example of line drawings from Experiment 1



Appendix B. Scenarios from Experiment 2

I'm going to show you some pictures and tell you some stories about them.

Scenario A
See this woman? She made this thing. Now this woman wanted something to hit baseballs with in the park. But she didn't have anything to do that with. So you know what - she decided to make something. So she went to the store and bought all the materials she needed so she could make something to hit baseballs with. She then went home and she spent the whole day carefully making something that was long and smooth. She said to herself "this is going to perfect for hitting baseballs with". She then went to the park. But you know what, she forgot this thing on a bench next to her house.
But you know what, see this man? He's her neighbour. Now this man found this thing on the bench. He had been looking for something to roll out cookie dough with for a long time. He walked up to this bench and said "Hey look what I found on this bench: it's exactly what I needed for rolling out cookie dough - it's long and smooth and just the right size". So he picked it up and took it to his kitchen and he rolled out cookie dough with it
So remember - this woman made this to hit base balls with, and this man used it to roll out cookie dough.
So can you tell me what this: is it a baseball bat or a rolling pin?
Now can you tell me why this woman made this?and what is this man doing with it?

Scenario B
See this man? He made this thing. Now this man wanted something to eat his dinner in the park. But he didn't have anything to eat on. So you know what - he decided to make something. So he went to the store and bought all the materials he needed so he could make something to eat dinner on. So he went home and he spent the whole day carefully making something round and flat. He said to himself "this is going to be perfect for eating dinner on." So he then went to the park. But you know what - he forgot this thing on his kitchen table.

But you know what - see this woman? She's his sister. Now this woman found this thing on the table. She had been looking for something to throw back and forth in outdoor game with her friends for a long time. She walked up to the table and said "Hey, look what I found on this table. Its exactly what I needed for throwing back and forth in an outdoor game. It's round and flat and just the right size." So she picked it up and took it to the park and threw it back and forth with her friends.
So remember - this man made it to eat dinner on and this woman used it to throw back and forth in an outdoor game.
So can you tell me what this is it a plate or a frisbee ?
Now can you tell me why this man made this?and what is this woman doing with it?

Scenario C
See this woman? She made this thing. Now this woman wanted to have tea in her garden. But she didn't have anything to make it in. So you know what - she decided to make something. So she went to the store and bought all the materials she needed so she could make something to make tea in. She then went home and she spent the whole day carefully making something with a spout and handle . She said to herself "this is going to be perfect for making tea in." So she then went outside to garden. And you know what, all of a sudden she had to leave the house so she left this thing on the table outside

But you know what ? see this man? He's her neighbour. Now this man found this thing on the table. He had been looking for something to water flowers in his garden for a long time. He walked up to the table outside and said "Hey look what I found on this table. It's exactly what I

needed for watering the flowers in the garden. It has a spout and a handle and it's just the right size. So he picked it up and watered the flowers in his garden with it.
So remember - this woman made this to have tea in her garden and this man is using it to water flowers in.
So can you tell me what this is: is it a teapot or watering can?
Now can you tell me why this woman made it? and what is this man doing with it?

Scenario D
See this man? He made this thing, Now this man wanted to eat some cereal in his garden. But he didn't have anything he could eat in. So you know what - he decided to make something. So he went to the store and bought all the materials she needed so he could make something he could eat cereal in. He then went home and spent the whole day carefully making something round and deep . He said to himself "this is going to be perfect for eating cereal in." And you know what, all of a sudden he had to leave the house so he left the thing she made on the kitchen table.

But you know what, see his sister here? She found this thing on the table. Now this woman had been looking for something to wear on her head so she wouldn't get hurt when she was riding his bicycle. She walked up to the table and said "hey, look what I found on this table. It's exactly what I needed for wearing on my head to so I don't get hurt. It is deep and round and is just the right size. So she picked it up and wore it on her head while she was riding his bicycle.
So remember, - this man made this to eat cereal in and this woman is wearing it on her head so she won't get hurt.
So can you tell me what it is: is it a bowl or a helmet ?
Now can you tell me why this man made this?and what is this woman doing with it?