Category Specificity In Brain & Mind

Brain Damage, Behaviour & Cognition Series

CHAPTER TWELVE

Animates and other separably moveable objects

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INTRODUCTION

We hold that the origin and development of the animate-inanimate distinction benefits from principled, domain-specific considerations about causality (Gelman, 1990; Gelman, Durgin, & Kaufman, 1995; Gelman & Spelke, 1981; Williams, 2000; Williams & Gelman, 1995). We share with Caramazza (Chapter 1 and Caramazza & Shelton, 1998) the view that the animate–inanimate distinction is domain-specific, universal, and at least as much conceptual as it is perceptual. Our position is consistent with Heider and Simmel's (1944) argument that the motion paths of objects and their interactions are interpreted with schemas (see also Goffman, 1974; Hochberg, 1978). It also dovetails with Keil's ideas about mental devices that resonate to domain-relevant inputs (Keil, 1995; Keil, Kim, & Greif, Chapter 13) and Leslie's (1995) assumptions that animate objects have agency and are goal-directed. Our perspective differs from ones that attribute the acquisition of the animate inanimate distinction to either general information perceptual and semantic processes (Warrington & Shallice, 1984), the sensory and/or perceptual detection of different kinds of motion variables, and/or the subsequent abstraction of various kinds of motion schemes for animate and inanimate objects (Oakes & Cohen, 1995; Mandler, 1992 and Chapter 11; Premack, 1995).

To develop our position we start with a general point. There is no question that various perceptual characteristics of trajectories, photographs, and other replicas of animate and inanimate objects can influence decisions about their identity. Although perceptual characteristics of animate and inanimate objects are relevant, it is an open question as to what perceptual information an observer will use for a given item. Perceptual cues that might seem salient to us need not be so from the observer's perspective; conversely, observers might focus on what we consider irrelevant or neutral characteristics. Such problems of stimulus indeterminacy contribute significantly to our move to say that the issue of relevance is informed by conceptual as well as perceptual matters (Gelman & Williams, 1998).

ON THE PROBLEM OF SELECTIVE ATTENTION

Massey and Gelman (1988; Massey, 1988) showed 3- and 4-year-old children photographs of novel objects like those in Figure 12.1 and asked them whether each could move itself both up and down a hill. The children did rather well and even could justify many of their responses. On the one hand, they might claim the echidna could accomplish the actions because it had feet and "was walking"—even though no feet can be seen and it is still. On the other hand, they said the statue could not move up and down a hill because its feet were "not real", "pertend", "too shiny", or part of a "furniture–animal". Some children even pointed to the very thin antennae on the "bug" to justify their claim that a mainly shiny, hard-surfaced object could move itself. These kinds of answers are hardly what one expects from young children who often are described as "perception bound". Instead, they reveal an active tendency to attend selectively, sometimes to minute aspects, and even misinterpret aspects of photographs with respect to causal considerations. For us, this means that the children were attending to information that could indicate whether the photographed item had movement enabling parts that were intrinsic to animate objects. They also seemed interested in clues about whether an object was made out of the kind of stuff that goes along with the capacity for self-generated actions. Hence, in the words of some children, the material had to be "real" or "not pretend", or from our point of view, biological stuff.

These results are one kind of selective attention or interpretative focus that encourages us to assume that young children, as well as adults, use a domain-specific set of principles to learn about animate and inanimate objects. Data from experiments on how individuals use motion path information provide another major reason for us to favour our position, because it turns out that motion path information is neither necessary nor sufficient for the identification of animate and inanimate objects and events (Gelman et al., 1995; Williams, 2000). Such findings are problematic for those who assume that

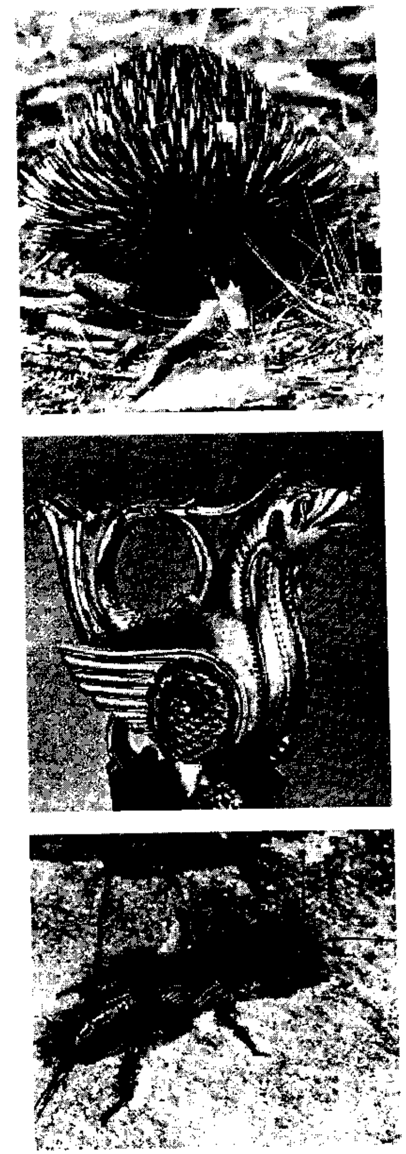


Figure 12.1. Scans of three photographs based on Massey and Gelman (1998). From top to bottom, these are an echidna, a statue, and a "bug".

animacy is grounded on perceptions of particular kinds of complex movement paths and that these, can, on their own, yield veridical animate or inanimate attributions (Bassili, 1976; Mandler, 1992 and Chapter 11; Morris, Nisbett, & Peng, 1995; Premack, 1995; Stewart, 1984).

Stewart (1982, 1984) proposes that we perceive a moving object as inanimate when its motion path is consistent with Newtonian laws of motion. If the motion path violates Newtonian principles, then we perceive animacy and attributions like intentions desires, hunger, affection, etc. To obtain evidence for her theory, Stewart showed college students a computer-generated dot moving on the screen in ways that were either consistent or were not consistent with Newtonian mechanics. Gelman et al.'s (1995) additional analyses of Stewart's data, in combination with new studies, yielded a number of results that represent departures from Stewart's predictions. For example, the perception of a path curving upwards on the screen lent itself to a wide range of perspectives and causal interpretations, including "... a bicyclist going around a corner"; "... a balloon and the wind was blowing and it went like this, this, like a helium balloon. It got caught up in the air"; "... a horse climbing a mountain"; "... some kind of magnetic ball that encountered a field that pushed it away".

The above descriptions are revealing on another level. They embed within them an account of how the "object" might have moved along the path in question. The "hows" were all about unseen causal factors that could support the way the object moved, including wind blowing, a horse climbing, and a magnetic ball in a field. These kinds of answer provide especially compelling evidence for our argument that the displays were fodder for causal principles—ones that encouraged interpretation of the motion paths in terms of the possible agents and conditions that generated the trajectories. What was perceived was interpreted with reference to the conditions that can cause the seen trajectory, even if this means inventing invisible forces, mountains, or magnetic fields.

One might hold that the preceding argument is reasonable, but only for adults who have had a chance to learn about different causal variables. Surely, the argument would continue, young children will not have such knowledge at their disposal to embellish their perceptions. If so, there is an interesting developmental prediction. This is that young children will be more likely than adults to rely on the surface information given in a motion path. It turns out that, if anything, 3- and 4-year-olds are more likely to "import" unseen or unheard information about energy sources when they decide whether a motion of an unidentified object was that of an animate or inanimate object moving in the dark, in a particular setting. Williams' (2000) dissertation provides a lovely demonstration of this. He showed groups of adults, 3- and 4-year-olds a series of dots moving along various trajectories, having first presented priming material that gave information about settings and the physical forces therein.

The setting information for each trajectory was comprised of a still (frozen) clip from a video of a scene, for example, a high cliff dropping into a moving stream that had some trees along its banks. On some trials, there also was the sound of running water or a wind. Williams ended the presentation of a given setting by rendering the screen completely dark. Next, a pinpoint of light appeared somewhere on the screen. Pretest training encouraged people to think that the light was attached to an object that was now moving in the darkened scene. This contributed to the impression of a particular object that was moving in the just-shown, but now pitch-black, environment. For example, the light on the body of an object seemed to move along the top of the cliff, drop straight down from the cliff, smoothly or not, in silence or not, in or just above the river, and so on. After viewing each event sequence, subjects were shown pairs of photographs, one each of an animate and an inanimate object (e.g. a duck and a leaf) and asked which one they had just watched move in the dark. Williams expected subjects to choose inanimate objects when the just-seen motion paths were force-consistent and animate objects with paths that were force-inconsistent. So, for example, he predicted that a dot that stopped and started, and even changed direction, as it moved along the silent river scene, would be paired with the duck.

Adults were especially likely to pair pictures of the animate and inanimate choices in response to whether the setting events were or were not force-consistent. Children's judgements were more variable, but this variability was not due to a failure of the children to use the trajectory information. Both children and adults were especially inclined to give motion explanations that were consistent with their judgements. The difference between the children and adults was due to the youngsters' tendencies to import force conditions that were not part of the setting display! For example, children who paired the leaf, and not the duck, with the trajectory that just moved in a force-inconsistent manner, "imported" a relevant force. They said that "the wind blowed it around", even though there was no sound of wind during the stimulus presentation. Thus, the use of motion path information was only part of the information they used to construct a coherent account of the event and related causal sources of energy. Once again, we see that the trajectories were an important, but not determining, source of relevant information for the assignment of animacy.

To repeat, we are not claiming that perceptual information is irrelevant to the animate–inanimate distinction. Rather, our point is that the definition of what is relevant is deeply related to the causal knowledge structures that individuals bring to the tasks of learning: (i) which separably moving objects are animate and which are not; and (ii) how to categorise exemplars of each class (Wilson & Sperber, 1986). Surface perceptual similarity regarding the parts and shape of objects surely provides some relevant information. Many animals do have parts in common (Carey, 1985; Tversky & Hemenway, 1984). However, such information is neither sufficient, nor necessary. The echidna in Figure 12.1 has almost no parts/features that overlap with those of commonly encountered animals. In contrast, the statue has a considerable number of animal-like parts. When children are encouraged to adopt a causal frame of reference, this influences what they take to be salient. Seemingly subtle cues for material kind become salient because they are relevant for deciding whether something is animate or not (see Massey [1988] for further details). Putting matters this way, it is less surprising that young children say that a statue cannot engage in self-motion because its feet are "not real", because it is not enough to have parts that look like those of a living animal—they have to be composed of the right kind of stuff and it is important to attend to clues that are relevant as regards material composition. In a similar way, it is not enough for an object to move on its own; again, it has to be composed of the right stuff. Why?

The fact that animate objects can cause themselves to move or change and that inanimate objects cannot goes hand in hand with the fact that inanimate and animate objects are composed of different kinds of matter. Animate objects are composed of biological matter; inanimate objects are not. Although all objects obey the laws of physics, animate objects also obey biochemical ones. In fact, the cause of animate motion and change comes from the channelled release of internally stored chemical energy that is characteristic of biological entities. Animate motions have a quality of function (purpose or goal-directedness). This is a direct consequence of their governance by biological control mechanisms. These enable adjustments of, and coordination of, component actions, both as a whole and as separate components. These adjustments can be to social as well as non-social environments. The effect is an ability to adapt to unforeseeable changes in circumstances and interact with social and non-social environments. The cause of inanimate motion is an external force, and there is always a transfer of energy from one object to another or a conversion of potential energy to kinetic energy. This is true even when a person serves as an agent.

Although most people do not have articulate scientific knowledge about the connection between biological matter and animate motion, even young children have relevant intuitions (see Williams [2000] for a recent review). They know that the source of animate action is intrinsic to the object. We think this is because of domain-specific causal principles that serve to encourage attention to, and separate categorisation of, objects as a joint function of whether they are capable of self-generated motion or not *and* made of biological stuff or not. Our thesis is that domain-specific casual principles organise attention to and learning about separably moveable things. Of course, we do not assume that young children are endowed with a rich,

scientific understanding of the biological world. Indeed, the fact that plants do not move as a whole is one key reason we think individuals treat plants and animates differently. At a later point in the chapter we will add evidence to the growing view that young children do not know that plants and animals share deep biological characteristics (Carey, 1985; see also Chapter 11).

MORE ON THE NOTION OF SPECIFIC DOMAINS

Gelman defines a domain of knowledge by appealing to the notion of a set of interrelated principles (Gelman, 1990; Gelman & Williams, 1998). A given set of principles, the rules of their application, and the entities to which they apply together constitute a domain. Different structures are defined by different sets of principles. Therefore, we can say that a body of knowledge constitutes a domain of knowledge if we can show that a set of interrelated principles organises its rules of operation and entities. Sets of principles carve the psychological world at its joints, producing distinctions that guide and organise our differential reasoning about entities in one domain versus another. In this way, available domain-specific structures encourage attention to data that has the potential to nurture learning about that domain; they help learners find inputs that are relevant for knowledge acquisition and problem solving within that domain.

A specific domain of knowledge might or might not be part of our human endowment. Clearly, one mark of human intelligence is the ability of individuals to acquire new domains of knowledge, including ones about cognitive neuroscience, chess, computer programming, or even sushi making. It is necessary to distinguish between those specific domains whose skeletal structures outline and enable domain-relevant learning by all normal human beings and those that do not. The latter depend on learners' interests and take a great deal of time and effort to mount (Bransford, Brown, & Cocking, 1999). This is in no small part due to the fact that learners have to acquire both the new structure and the domain-relevant knowledge. Although the innate domain-specific principles that support learning in a given domain are exceedingly skeletal to start with, they nevertheless constitute a structure. Whenever a structure is available, learning is facilitated. This is why some acquisition moves rather quickly, and seemingly on the fly, in some domains, but not in others.

Gelman (1990, 1994) proposed that attention to, and learning about, relevant characteristics of separately moveable objects benefits from domain-relevant processing mechanisms that are informed by first causal principles. As already discussed, these correspond to deep and fundamental distinctions about the fact that animate and inanimate objects differ in terms of their material, structural composition, potential for interaction, and their energy sources of motion or transformations. Animate objects are made of biological matter, a kind of matter for which the cause of growth, self-initiated movement, and other transformations are intrinsic to the objects themselves. The cause of inanimate motion is an external force (the external agent principle), and there is always a transfer of energy from one object to another or a conversion of potential energy to kinetic energy. It is important to the causal principle argument that these differences go hand in hand with the fact that animate objects are composed of biological matter and honour biological principles, whereas inanimate objects are composed of non-biological material and honour principles of inanimate causation. In addition, animate motions have a quality of directedness or purpose, and biological control mechanisms make it possible for animates to respond (or adjust) to environments -be these social or non-social—and adapt to unforeseeable changes in circumstances (Gallistel, 1990; Gelman et al., 1995).

These distinctions are captured in Gelman's animate causal principle, "the innards principle" and in her inanimate causal principle, "the external-agent principle". The argument is that higher-order causal principles direct attention to a combination of information, including kind of matter, source of energy, and trajectories. As regards objects obeying the innards principle, the energy source for movements, transformations, perceptions, and interactions is intrinsic to biological objects and thus is contained within the objects themselves. As regards objects obeying the external-agent principle, the movements, transformations, and interactions of non-biological objects are caused by agents and forces of nature that are external to the objects themselves. We do not assume that, early in development, one necessarily has an explanation system of intrinsic energy sources and exchange, or even of what it means to say the source of energy is embodied in the object (see also Williams, 2000). Similarly, we do not assume that there is a universal explanation system of external energy sources and exchange. But we do assume that high-level causal principles organise the uptake of data that contribute to the causal explanation system of a culture. This distinction between causal principles and explanatory systems is expanded in a further section.

Why do we postulate the innards and external-agent principles if we do not assume that one has a theoretical understanding of them? A key reason has to do with the need to achieve a solution to the problem of attention to, and coherent learning about, examples of animate versus inanimate objects. We have already presented several sets of results that illustrate the need to have an account of the constructivist aspects of attention. The innards principle offers one such account because it serves to draw attention to that constellation of perceptual information about those natural objects that move and interact on their own. Even infants are sensitive to cues for biomechanical motions and intentionality (Bertenthal, 1993; Gergely, Gergely, Szilvia, & Orsolya, 1999; Poulin-Dubois, 2000; Premack, 1995) and the differential role of contact in the movement of animate and inanimate

objects (Spelke, Phillips, & Woodward, 1995). A second reason is that, given that the innards principle serves as a domain-relevant organising device, it provides young children with a way to sort and then correctly assimilate mental-state predicates such as think, want, and so on. To be sure, it is one thing to assimilate such inputs and quite another thing to understand them. But it does help to accumulate relevant data in some coherent way. Otherwise, it is extremely hard to acquire understanding. Similarly, the external agent principle supports the processing and interpretation of data about objects that move as a function of external energy sources (e.g. from collisions, wind, moving water) as well as details about its size, smoothness or roughness, rigidity, etc. (Baillargeon, 1998; Williams, 2000).

If we are right, then even very young children will not confuse machines with animate objects. A major aim of this chapter is to update and relate our "first-principles" position to other worldly things, especially different kinds of machine (e.g. computers, televisions). After we expand on our general prediction about machines, we present data that we have collected about children's and adults' ideas about a wide variety of things, including animates, simple artefacts (e.g. chairs, spoons), machines and even a plant.

THE CASE OF MACHINES

Machines are made of the wrong stuff to meet the domain-specific criteria that outline the equivalence class of separably moveable animate things. True, a machine can seem to move on its own but, in the absence of some animate agent, it does not anticipate and intentionally adjust to unexpected environments. Further and critically, from a novice's point of view, it is made out of non-biological stuff, stuff that is rigid, hard, and so on. Thus, the information as to whether a novel object is animate or inanimate either is indeterminate, inconsistent, or even internally contradictory. Which of these characterisations apply to a given example depends on the kind of machine in question.

Whereas some machines, like cars, appear to move on their own, others, like computers, appear to think and communicate, do not exhibit bio-mechanical motions, and do not adjust especially well to local environmental problems (Gelman et al., 1995). For example, robots are not especially good at adjusting their motions to local perturbations in the environment and are at risk of falling into holes or toppling over protuberances. In contrast, so predictable is the animate world's ability to deal with unanticipated holes, bodies of water, oil-slicks, branches that come below the head, sun in one's eyes, weather changes, and so on, that we almost forget how remarkable are the action abilities of the animate world. Aside from these fundamental differences regarding sources of energy, movement patterns, and reactions to environments, machines are made of the wrong stuff. Because we assume that causal principles yoke information about objects' composition to their motion trajectories, we predict that children and adults will assume that machines lack the animate, domain-specific capacities of growth, nutrient consumption, reproduction, respiration, and perception. Therefore, machines will not be classified as either clear cases of animates or clear cases of inanimates. Instead, they will be assigned to a separate category.

As machines are man-made artefacts, knowledge of particular kinds of machines depends on opportunities to encounter and learn about them (see Chapter 13). Still, if causal principles direct attention to concerns about the source of motion of an object, children should be inclined to ask about or make up external–agent accounts. Further, there should be little, if any, tendency for young children to endow machines with animate properties. These predictions might surprise those familiar with the Piagetian tradition, within which there has been a longstanding tendency to assume that young children will confuse machines with animate objects and therefore imbue them with animistic attributes. Piaget's (1929) claim that children were animistic was based on his finding that young children sometimes said that inanimate objects such as the sun, the wind, cars, bicycles, clocks, watches, ovens, and fires are alive. According to him, children progress from attributing life to any moving, active object to eventually attributing life only to animals and plants.

There are several problems with Piaget's conclusions. First, young children do not have a clear understanding of the word "alive", even for animals and plants (Carey, 1985). Second, children were classified as animists if they gave only one such explanation during a long interview, hardly the kind of criterion that merits the attribution of a worldview. Third, even adults have murky notions about the nature of the sun, fire, and wind, items that were used frequently by Piaget. Finally, several lines of research show that preschool children are not universal animists, and there now is some research that focuses on the question of whether young children classify machines together with animates. The indications are that they do not.

Simons and Keil (1995) report that, by about 4 years, children consistently choose natural-kind objects (animal insides or rocks) as potential insides for animals, and artefacts (machine insides or blocks) as potential insides for machines. They conclude that children expect the insides of animals and machines to differ, although they lack knowledge about the specific physical appearance of those insides. Rosengren, Gelman, Kalish, and McCormick (1991) report that children believe that animals, but not artefacts (such as a light bulb or telephone), get larger over time. Finally, Backesheider, Shatz, and Gelman (1993) found that 3- and 4-year-old children believe that objects such as a television or a car cannot regrow if damaged, but must be fixed by human intervention.

These findings begin to show that children do not confuse animates and machines. Still, important questions about how they conceptualise these hybrid objects remain unanswered. First, machines are not a homogeneous

category. There are some machines that move, such as cars and aeroplanes. There are other machines that have sentient and "intelligent" properties but were not designed to move, for example, computers and robots. Still other machines mimic communicative functions, for example, televisions and radios. Our informal observations of adults' interactions with these various kinds of machines led us to conjecture that it is the adult, not the young child, who adopts an animistic stance when using or interacting with certain machines. We might say "My car's engine just died" or "How dare you behave so badly when you're supposed to be printing my important manuscript?". These particular animistic statements are surely dependent on our knowledge and experience with objects that "mimic" some aspect of animate objects. One has to learn about both the machine and the relevant animate properties of humans or animals.

FURTHER THEORETICAL ISSUES

Although we might attribute knowledge to computers, it is unlikely that we would do the same with vacuum cleaners. The attributions are selective and depend on the kind of machine in question. Given the preceding discussion, we expected that adults would be more likely than young children to attribute some animate properties to machines. Scaife and Van Duuren (1995) present evidence that is consistent with this conjecture. They reported that, although 5-year-olds attributed a brain to a person, they were not willing to do so for a computer or robot. By about 11 years of age, not only were children more inclined to grant a computer and robot a brain, they knew a great deal more about the relevant variables. They could assign the CPU box correctly and identify the composition of real brains (nerve cells and neurons versus blood, bones, and meat).

Our argument that many animistic answers depend on knowledge of both the animate and inanimate objects in question serves to highlight a theme of our work on domain-specific principles. Although innate principles in a domain facilitate some kinds of domain-relevant learning, they do not guarantee mastery of advanced levels of understanding in that domain. For example, although principles of counting and arithmetic support some early learning about adding and subtracting with the count numbers, they do not do the same for subsequent learning about rational numbers and their relevant operations (Gelman & Hartnett, 1998). Similarly, the way young children make use of abstract causal principles to assign objects to either the animate or inanimate category need not be sophisticated. Given these principles, one can know machines are not animate because they are made of the wrong stuff—even though they might move on their own. However, it is one thing to be able to place a given object in the right memory-filedrawer and quite another to know great deal about it. First principles about causality can help learners move onto and stay on relevant learning paths. They can serve to encourage attention to those aspects in the environment that are relevant to learning about the in's and out's of animate and inanimate objects. They do not, however, determine the particular explanations that learners achieve. Indeed, they do not guarantee that ideas about mechanisms will be congruent with those held by experts. As Keil et al. (Chapter 13) show, many adults fail to achieve a correct understanding of scientific accounts of mechanisms.

In the following section we present results from new studies we have done. These bear on our ideas about clear cases of animates and inanimates, as well as machines. As we also ask about simple artefacts and a plant, the findings offer an opportunity to consider a number of different accounts of the animate and inanimate distinction. These include accounts that grant preschool children biological theories (Hatano & Inagaki, 1994; Keil, 1994; Wellman, 1990) and ones that favour domain-general perceptual and semantic processes (Warrington & Shallice, 1984). For the reasons covered earlier, we expected that young children would falter on questions about mental phenomena, such as thinking and remembering.

Although we contend that young children know that animate actions are due to energy sources within the actor, we have no reason to assume that young children are prone to develop explanation systems that parallel modern, Western philosophical theories of mind. We share Carey's (1985) view that early knowledge about biological entities is naive and limited. Indeed, we anticipated that children would treat plants as belonging to yet another separate category. Plants are in the biological world, insofar as they are composed of biological matter, and share some quintessential animate properties, such as breathing, growing, and food consumption. Yet, they do not move as a whole, do not interact, and do not have a capacity for communication. Therefore, young children should place plants in a category that is separate from animals and artefacts.

These various considerations motivated our studies with young children and adults, where we questioned them about a variety of attributes in different categories. In the first study (The Picture Sorting Study), we used a picture sorting task in which we asked children and adults to sort through photographs of different kinds of items based on whether or not they showed a range of animate attributes. For example, they had to sort pictures of worldly objects into two piles—one pile consisting of objects that can talk and one consisting of objects that cannot talk. In the second study (The Interview Study), we did not use photographs but rather asked target questions about different animals, simple artefacts, machines, and plants. Our questions centered on different animate attributes, such as moving, breathing, and remembering; we also asked the subjects to provide justifications for their answers.

Our studies bear on the Warrington and Shallice (1984) hypothesis that

the animate-inanimate distinction is grounded in a semantic system, such that visual information is relevant to animates but functional information is relevant to inanimates. If we assume that the visual processing system is active when visual stimuli are present (as in the picture sorting task) then, on the Warrington and Shallice hypothesis, children should do better on the animate items in the picture sorting task than on the interview task. If visual information is not relevant to the inanimate items, the visual–verbal variable should have little effect for inanimate items and machines.

THE STUDIES

We begin by describing the materials and procedures of the studies. We organise the findings with reference to different kinds of questions one might ask about children's understanding of animates, inanimates, and other worldly things.

The picture sorting study

Three- and 4-year-old children (mean age = 3.6 years and 4.4 years for the 3- and 4-year-olds, respectively) and adults participated in this study. There were twelve individuals in each age group. They were shown twenty black and white photographs of 3-dimensional objects and were asked to sort them into two piles, with one pile made up of items that displayed a particular animate property and the other pile made up of items that did not display that property. This sorting was done several times, once each for the animate properties of "can move by itself", "needs to eat", "can talk", "can think and remember", and "can feel happy and sad" (Table 12.1). The pictured items included animates (person, dog, cat, elephant, and bug), simple artefacts (chair/stool,

TABLE 12.1
Questions and *post-hoc* comparisons for the picture sorting study

What X *does/does not do*	*Significant interactions**
Eat	Adults more likely than children to attribute to bug and plant
Move	3- and 4-year olds said "yes" to self-motion for aeroplanes and cars (these are not examples of childhood animism; see text)
Talk	Adults and 4-year-olds more likely to attribute to robots
Be happy and sad	4-year-olds and adults more likely to attribute happy and sad to a cat, dog, and elephant
Think and remember	Adults more likely to attribute remember to an elephant

* All main effects and interactions were assessed by ANOVA and Tukey *post-hoc* comparisons (HSD = .43, $p < .01$).

spoon, keys, and lamp), machines (vacuum cleaner, radio, television, aeroplane, car, computer, and robot), a plant, and filler items (apple, rock, and doll).

For the children, we used a cover story involving the penguin puppet, "Pokey",[1] who was visiting Los Angeles from the North Pole. A child was told that Pokey was confused about things found here in Los Angeles because it was so different from the North Pole. Pokey thus had questions about things found in Los Angeles, and wanted the child to answer them. For each question, the child was told that some things exhibited a particular animate attribute, whereas others did not. For example, for the Move question, the tester told the child, "Some things move by themselves, whereas some things do not". The child was then shown the photographs and told that Pokey wanted to find all the things that could move by themselves.

The tester then presented the photographs, one at a time, said the name of the object in the picture, and asked the child whether or not the item possessed the attribute in question. For example, the tester would say "Can a person move by itself? Yes it can? or No it cannot?". If the child said "Yes", the tester placed the card in the "can move by itself" pile close to Pokey; if the child said "No", the tester placed the card in the "cannot move by itself" pile further away from Pokey. After all twenty photographs had been shown for each target question,[2] the experimenter noted the items that had been placed in the "yes" pile. The procedure was identical for the adults, except that they were informed that the task was originally designed for children.

The interview study

In this study, we talked to 4- and 5-year-old children (mean age = 4.5 years and 5.2 years, respectively) and adults. There were twelve individuals in each age group. We asked them eight questions about each of nineteen items. Six questions dealt with various animate properties, including action properties (move and talk), anatomical/physiological properties (brain and breathe), and mental/sentient properties (think and remember). These questions were

[1] Past research has found that use of a puppet greatly enhances preschool children's performance on experimental tasks, where the experimenter is often in the pragmatically odd situation of asking the child for information that he/she would clearly know as an adult. By getting the puppet to ask the question instead, the task becomes more realistic and can elicit a higher and more accurate rate of responding.

[2] All twenty photographs were shown for a property before proceeding to the next one. Two random orders were used to present the properties, with Move being the first in one order, and Eat being the first in the other. For each property, the photograph of the person was always shown first, followed by the other pictures in random order, with different random orders being used for the different properties.

similar in format. For example, "Does a plant move? If yes, how does it move? If not, why not?". The other two questions dealt with the inside and outside and origin of each item. For example, "What is on the inside of a dog? What is on the outside of a dog?" and "Where does a car come from? Does it come from a mommy or does some one make it?".

For a given question, we asked them about the nineteen items in successive order. Table 12.2 presents the format of the questions. The items were similar to those used in the Picture Sorting Study, and included animates (person, dog, elephant, and bug), simple artefacts (chair/stool, spoon, and clock), machines (vacuum cleaner, radio, television, aeroplane, car, computer, and

TABLE 12.2
Questions and resulting reliable *post-hoc* comparisons for the Interview Study

1st question	*2nd question*	*Kind of results*
Does X move?	If yes, how does it move? If not, why not?	Adults more likely to attribute move to a plant compared to 4- and 5-year-olds; Adults more likely to attribute move to clock compared to 4-year-olds
Does X talk?	If yes, how does it talk? If not, why not?	All subjects attributed talk to person; Only adults attributed talk to a bug, dog, and a radio
Does X breathe?	If yes, how does it breathe? If not, why not?	Adults attribute breathe more often to a bug and a plant compared to the 4- and 5-year-olds; Adults and 5-year-olds attribute breathe more often to an elephant compared to the 4-year-olds
Does X have a brain?	If yes, why does it have a brain? If not, why not?	Adults more likely to attribute a brain to a bug and an elephant compared to the 4- and 5-year-olds
Does X remember?	If yes, how does it remember? If not, why not?	Adults more likely to attribute remember to a bug, elephant, and a computer
Does X think?	If yes, how does it think? If not, why not?	Adults more likely to attribute think to a bug compared to the 4- and 5-year-olds; Adults more likely to attribute think to an elephant compared to the 5-year-olds
Where does a X come from?	Does it come from a mommy, or does some one make it?	
What is on the inside of X?	What is on the outside?	

Post-hoc comparisons (Tukey's HSD = 0.43, $p < .05$)*.

robot), a plant, and filler items (apple, rock, sun, and doll).[3] As there were eight questions about nineteen items, the entire interview took between 30 and 45 minutes; whereas most children finished the interview in one session, we administered the interview over two sessions for a few of the younger children.

QUESTIONS ADDRESSED BY THE STUDIES

1. Do children and adults distinguish between animates and machines?

Across both studies, we found evidence that the children[4] consistently and clearly distinguished between animate and other kinds of things, notably machines (we deal with their categorisation of simple artefacts and plants in questions 4 and 5). There are several lines of evidence for this conclusion.

First, analysis of the number of "yes" responses to the categories of different items (Table 12.3) revealed that the children were more likely to attribute the animate properties to the animates than to the simple artefacts or machines.[5] As can be seen, they sometimes granted an animate property to a machine; this usually happened for the question about moving for a car, aeroplane, and robot. The ability to talk also was attributed to a robot. This attribution of the action properties to the machines was decidedly selective. For example, they allowed that a radio could talk but not move, and that a car could move but not talk. Only occasionally did they attribute the anatomical/physiological properties (brain and breathe) or the sentient properties (think

[3]The items were presented in one of two quasi-random orders. For both orders we started with the following items: person, dog, plant, apple, and rock; the rest of the items were then presented in one of two random orders.

[4]As there were no reliable age effects for the children, we collapsed the data from the 3- and 4-year-olds in study 1 and the 4- and 5-year-olds in study 2.

[5]For study 1, "Yes" and "No" responses to each item were analysed by an overall repeated measures analysis of variance with item (20) and property (5) as the within-subjects factors, and age (3) as the between-subjects factor. The overall analysis yielded an interaction of age and item $F(38, 627) = 5.34$, $p < .01$ as well as an interaction of age, item, and property $F(152, 2508) = 1.98$, $p < .01$. The three-way interaction of age, item, and property was analysed by separate mixed ANOVAs for each of the five properties. Each of these analyses had item (20) as the within-subjects factor and age (3) as a between-subjects factor. For study 2, a preliminary omnibus mixed analysis of variance was done with item (19) and property (6) as the within-subjects factors, and age (3) as the between-subjects factor. There were no main effects, but we obtained a reliable interaction of age and item $F(36, 576) = 5.06$, $p < .01$ which was modulated by a three-way-interaction of age, item, and property $F(180, 2880) = 1.45$, $p < .01$. The three-way interaction was analysed by separate mixed ANOVAs for each of the six properties; each of these analyses was done with item (19) as a within-subjects factor and age (3) as a between-subjects factor. Results of the *post-hoc* comparisons are reported in Table 12.1 for the Picture Sorting Study and Table 12.2 for the Interview Study.

TABLE 12.3
Percent "yes" answers given by children and adults for each predicate

	Predicate					
Age/item *	*Move*	*Talk*	*Breathe*	*Brain*	*Think*	*Remember*
Child						
Person	100	100	100	95	95	86
Dog	95	28	92	68	59	45
Elephant	95	32	67	55	41	41
Bug	95	9	50	45	27	41
Plant	9	0	33	0	14	5
Rock	9	0	0	5	9	5
Spoon	9	0	0	9	5	0
Clock	50	0	0	9	5	14
Vacuum	50	5	8	14	5	9
Car	72	5	0	0	5	9
Aeroplane	72	0	0	9	0	5
Robot	90	59	17	23	36	36
TV	0	14	8	5	14	14
Computer	0	9	8	14	9	18
Doll	36	5	17	18	23	36
Adult						
Person	100	100	100	100	100	100
Dog	100	67	100	100	92	92
Elephant	100	58	100	100	83	92
Bug	100	42	100	92	83	92
Plant	58	0	83	8	0	0
Rock	17	0	8	0	0	0
Spoon	25	0	0	0	0	0
Clock	100	8	0	0	0	0
Vacuum	83	8	0	0	0	0
Car	75	8	17	0	0	0
Aeroplane	92	17	0	0	0	8
Robot	92	75	0	0	25	50
TV	33	42	0	0	0	0
Computer	33	42	0	8	0	67
Doll	50	42	0	0	0	0

* The item doll is shown at the end of the machine cluster of items. Adults were more inclined to say dolls move and talk, justifying their "yes" by appealing to the mechanisms of talking and walking dolls. Data for apple, chair, and radio are not shown because they do not change any patterns. Radios were treated like TVs.

and remember) to an inanimate object. The only machine that was given the capacity to think and remember was a robot, presumably because of subjects' knowledge about this category.

Thus, the attribution of potential animate properties to machines was selective in a way that we expected. It was consistent with the proposal that animates and machines are treated as different kinds of things. The same conclusion holds when we look at the explanations accompanying the "yes" or "no" attributions. An explanation was coded as correct if it was appropriate for a given item. For example, the response "a computer moves" was scored as correct if the participant explained that the motion was caused by an agent outside the computer; in contrast, it was scored as incorrect if the participant said the computer moved by itself. Table 12.4 shows sample protocols of correct and incorrect responses for selected items. The responses

TABLE 12.4
Examples of children's and adults' answers in the interview study

Property/capability and item	*Age group*	*Answer*
Correct answers		
Move – Elephant	Child	Yes, it walks
Move – Car	Child	Yes, when driven
Move – Plant	Adult	No, no legs
Talk – Vacuum	Child	No, no mouth
Talk – Plant	Child	No, no lips
Talk – Radio	Adult	No, inanimate object
Talk – Bug	Adult	No, no language
Breathe – Dog	Child	Yes, has lungs
Breathe – Plant	Child	Yes, with its leaves
Breathe – Radio	Adult	No, it's a machine
Breathe – Car	Adult	No, no lungs
Think – Person	Child	Yes, it has a brain
Think – Vacuum	Child	No, not alive
Think – Computer	Adult	No, it's man-made
Think – Plant	Adult	No, doesn't have a mind
Remember – Person	Child	Yes, coz he has a mind
Remember – Car	Child	No, coz it doesn't have a brain
Remember – Robot	Adult	No, not living, unknown
Remember – Plant	Adult	No, doesn't have a brain
Brain – Person	Child	Yes, to think
Brain – Computer	Adult	No, it's not living.
Brain – Plant	Adult	No, it doesn't think
Incorrect answers		
Move – Dog	Child	No, animals don't move
Move – Chair	Adult	Yes, can change states like rot
Talk – Doll	Child	Yes, with mouth
Talk – Radio	Adult	Yes, with speakers
Breathe – Bug	Child	No, because it stings people
Breathe – Car	Adult	Yes, turn fan on
Think – Dog	Child	No, no brain
Remember – Elephant	Child	No, no brain
Remember – Elephant	Adult	No, not by self, usually train
Brain – Robot	Adult	No, no control centre

TABLE 12.5
Percentage of correct answers

Property and age	*Correct (%)*
Move	
Children	92.3
Adults	95.6
Talk	
Children	90.2
Adults	94.3
Breathe	
Children	75.4
Adults	96.9
Think	
Children	73.7
Adults	94.7
Remember	
Children	72.0
Adults	95.6
Brain	
Children	66.0
Adults	98.7

were coded jointly by the authors and checked by the collaborator. Table 12.5 shows the percentage of correct answers offered by the children and adults for the different properties summed across different item kinds. Overall, children offered 92.3% of correct answers for move, 90.2% for talk, 75.4% for breathe, 73.7% for think, 72% for remember, and 66.0% for brain.[6] Chi-square goodness-of-fit tests confirmed that the number of correct answers (versus incorrect, don't know, and other responses collapsed together) was above chance for all properties for both the children and adult samples (all $p < .01$). Not only did children offer correct justifications, they were just as likely to do so as the adults (all $p < .01$).

Further evidence that children, like adults, distinguish between animates and machines comes from a qualitative code of children's explanations (Table 12.6). As shown in Figure 12.2, the children consistently used different explanations to justify their responses for the different item kinds. For animates, they appealed to the presence of animate parts (e.g. bones, muscles, blood), causes (e.g. wants to move), and notions (e.g. alive, living) to justify their attributions. For the machines, they invoked the absence of animate

[6] We discuss the fact that children were more accurate on some as against other properties in a subsequent section.

TABLE 12.6
Qualitative code of explanations

Category code and description	*Examples*
I Presence/absence of animate (+/–A) including:	
1. Animate parts (innards/external)	1. Bones, muscle, blood, legs, mouth
2. Animate motion	2. Flies, walks, takes in air
3. Animate causes	3. Wants to move
4. Life terms	4. Alive, living
5. Other animate features	5. Ability, perception
II. Presence/absence of inanimate (+/–I)	
1. Inanimate parts and mechanisms	1. Batteries, wheels, engines
2. Inanimate materials	2. Plastic, metal
3. Inanimate motion	3. Flies, when an aeroplane
III. External causes (E)	
1. Action of a person (EM)	1. Someone drives it, flies it, programmes it
2. Forces of nature (EN)	2. Wind, earthquake, gravity
IV. Plant properties (+ P)	
1. Plant parts, plant features	1. Leaves, stem
2. Plant mechanisms	2. Stationary, leaves move toward sun, photosynthesis
V. Tautology (TA)	
1. Re-statement as to whether item displays property	1. Doesn't, doesn't talk, just does,
2. Statement of the item's category, etc.	2. Just an apple
VI. Causal essence/origin (C)	Comes with it, built with it, not meant to, DNA, genetics, needs one, supposed to, instinct
VII. Function (F)	
1. Function or use of the item	1. For eating, for sitting on, we watch TV
VIII. Attributes (T)	
1. Perceptual and other properties and attributes (surface similarity)	1. Stays in kitchen, makes noise
IX. Other + Bizarre (O)	He is my friend
X. Don't know (DK)	I don't know; because

features and/or the presence of inanimate parts (wheels), inanimate mechanisms (batteries, engines), inanimate materials (plastic, metal), and external sources of energy to explain their attributions.

Children's answers to the inside/outside question provide additional support that they distinguished between the insides and outsides of animates and machines. Both children and adults appealed to animate 'innards' (blood, bones) and animate externals (wings, eyes) for the animates, but appealed to inanimate materials (plastic, glass), constituent parts (buttons, knobs), and inanimate mechanisms (electricity) for the machines. Children, like adults, think that animate objects can have blood and bones on their insides, but not wires and batteries. Again, we see that the children used different explanations when responding to the different kind of objects.

In sum, young children know that when machines mimic an animate property, they do so because they obey the external-agent principle. Thus, they know that moving machines move because of energy extrinsic to the object, such as the energy from a battery or an agent, whereas animates move as a result of intrinsic variables. Even though children attributed an potentially animate property, such as move, to a machine, they did not behave as general animists. Their projection of animate attributes was suitable and selective. Children flexibly switched their item attribution of a property and their accompanying explanation for their attribution based upon the question. It is clear that children place animates and machines in separate categories. So, what do young children think about animate objects?

2. What are children's concepts about animates like?

Some hold that young children's ideas about animate objects are organised by a content-rich theory of biology (Hatanao & Inagaki, 1994; Keil, 1994; Wellman & Gelman, 1998; Williams, 2000). Our findings encourage us to favour the conclusion that early knowledge is embedded in a more skeletal set of causal principles and beliefs about the actions and reactions of animates and other worldly things (Gelman, 1990). Indeed, our findings converge on ones Carey (1985) presented when she concluded young children do not have a biological theory.

Recall the results from the ANOVAs on the "yes" attributions reported earlier in question 1. As reported in Tables 12.1 and 12.2, children did not treat all animate objects alike. Like the adults, they consistently attributed the animate properties to a person. But unlike the adults, they were reluctant to attribute particular animate properties to other animates, such as bug, dog, or elephant. To give some examples, in study 1 they were less likely than the adults to attribute "eat" to a bug and plant, and "feels happy" to a cat, dog, and elephant. Similarly, in study 2, they were again less likely to attribute "breathe" to a bug and a plant, and "think" and "remember" to a bug. The only exception was "move," which children generally attributed to all animate items in both studies. Following Carey (1985), on a theory-rich biological account of animate concepts, children should generalize all properties relevant to one animate kind (here, a person) to other objects belonging to the same ontological category (e.g. an elephant and a bug). But they did not consistently generalise animate properties. This was so even for the property

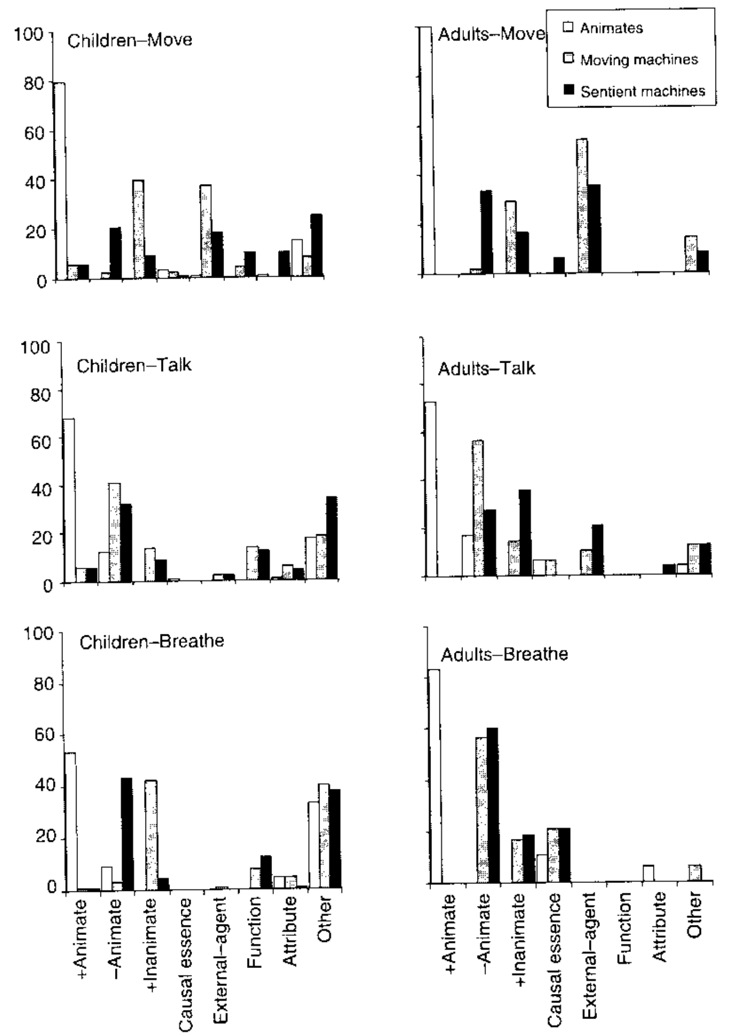
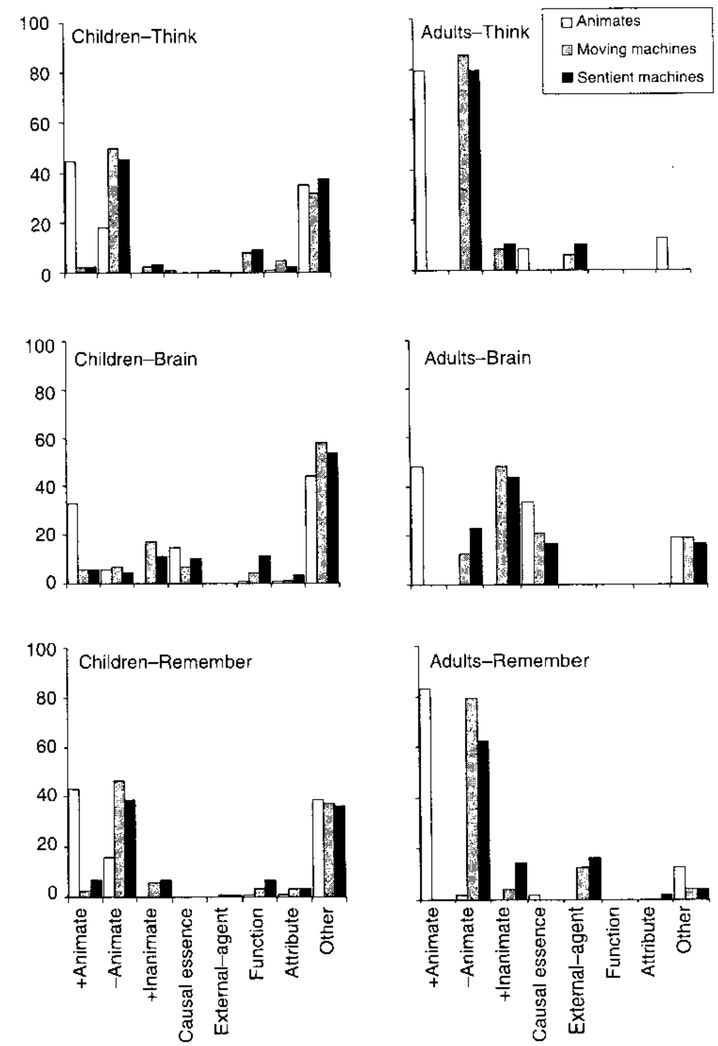


Figure 12.2. Percentage of subjects who offered different kinds of explanations for animates versus machines for the six animate properties.

"breathe". Our results are similar to those of Carey (1985), who holds that young children do not have a biological theory.

Converging evidence for the Carey position comes from data on the



accuracy of children's attributions and explanations/justifications. Table 12.7 presents the mean number of correct answers offered by the children for the animates (person, elephant, dog, and bug), moving machines (car, aeroplane, robot, and vacuum cleaner), and sentient machines (computer, robot, radio,

TABLE 12.7
Mean number of correct answers offered by the children and adults for the animates, moving machines, and sentient machines*

Property	*Age*	*Animates*	*Moving machines*	*Sentient machines*
Move	Children	**3.59**	**3.64**	**3.50**
	Adults	**3.83**	**4.00**	**3.92**
Talk	Children	2.96	**3.55**	**3.27**
	Adults	**3.33**	**3.67**	**3.58**
Breathe	Children	2.27	**3.00**	**3.23**
	Adults	**3.83**	**3.75**	**4.00**
Think	Children	2.00	**3.18**	**3.05**
	Adults	**3.50**	**4.00**	**4.00**
Remember	Children	1.82	**3.05**	2.91
	Adults	**3.33**	**3.83**	**4.00**
Brain	Children	2.32	2.55	2.73
	Adults	**3.92**	**3.75**	**3.67**

*As there are 4 items in each group the maximum possible in each cell is 4. Mean values greater than 3 are shown in bold.

and television) collapsed together. The children were equally accurate for the animates and machines when explaining responses for "move". However, for the other animate properties they were considerably more accurate on the machines than on the animates. Children had much more difficulty providing correct explanations when asked about animates than when asked about machines. They could articulate why machines lack animate properties but not why animates possess what are fundamental animate, biological, properties.

We also examined whether the children offered sophisticated explanations when invoking animate causes for their attribution (or lack of attribution) of a property. Responses such as "alive", "not alive", "living", "not living", "having the ability", and "no ability", were coded as ones that reflected a biological interpretation of the animate category. Answers that simply alluded to animate parts (e.g. an elephant breathes with its trunk) or animate mechanisms were treated as simple explanations that did not originate in a theory-rich notion of animates as biological/physiological entities. Among the children, all 85 of the sophisticated explanations (total possible = 2508) came from just 3 out of 24 children, with 83.5% coming from one 5-year old! In contrast, all the adults offered some sophisticated responses. Still, even their tendency to provide theoretical-type explanations was not overwhelming. There were only 254 such explanations out of a possible number of 1368. The percentage of such explanations from individual subjects ranged from 0.4% to 18.5%, and many of these "sophisticated explanations" sounded like bits of information that students had memorised in a high school or introductory level college biology course. These included "because it is a living thing", "to perform motor and sensory functions", and "born with it—part of biological processes".

Finally, the data from the "origin" question are relevant here. The "Where does *X* come from?" question was a forced-choice question, with one option referring to biological origin (does it come from a mommy and daddy?) and the other option referring to non-biological origin (does someone make it?). Children responded at chance, and only about 50% of their responses were correct. When asked for an explanation, they mostly appealed to agents (e.g. parents, mommy) and not to core biological mechanisms such as sex and eggs. A few even appealed to environmental niches (both natural ones, such as forest and ocean, and man-made ones, such as store and zoo), God, and man-made production processes (e.g. someone made it).

To sum up, although the children attributed all the animate properties to a person, their attribution of these to other animals was selective. Further, their explanations, although reasonable, rarely alluded to complex, theory-driven notions of being animate or alive. Thus, it is hard to maintain that the young children in our studies were calling on a biological organisation of the animate category. This conclusion places us closer to Carey (1985) than researchers who grant young children intuitive biological theories. Nevertheless, there are some key ways in which we differ from Carey.

Carey favours a "person-first" account or young children's knowledge and development of the nature of items in the animate category. That is, she argues that young children's generalisations of animate predicates are a function of the extent to which other objects are similar to people. Accordingly, items that share person-like characteristics are more likely to be treated as animate. This is true whether or not they are animate. Thus, a robot or walking doll is about as good a candidate for inclusion in the animate category as a dog. In contrast, an invertebrate should be an especially poor case of animate, given how little it looks like a person or even a vertebrate. But, as we have seen, these predictions about the conceptual similarity space are not supported. First, Massey and Gelman (1998) found that preschoolers say that invertebrates can move themselves up and down a hill by themselves but statues cannot. Second, young children are less inclined than adults to attribute animate predicates to robots. That is, they are not especially animistic about machines, at least when they think about them in the context of clear cases of animates and non-machine inanimates.

3. Who are the animists?

The percentage of adult "yes" responses to whether machines possess animate properties suggests that, if anyone, it is the adults who are the animists.

Most adults told us that machines move and talk.[7] Furthermore, many adults indicated that a robot thinks and that a robot and computer can remember. Very rarely did they say that artefacts and machines breathe and have a brain. This trend of selective animistic attributions, particularly of the action properties, supports our prediction that it is knowledge of, and experience with, machines that encourages animism in adults. It is not uncommon for us to talk to our computer while working on it and say something like "Why are you doing this to me today?". Similarly, most of us would say that computers have a memory and thus can remember; however, few of us would say that they think in the sense that humans do.

The nature of adults' explanations make it clear that they are not really animists. It is not as if we have reason to believe that they think machines have real brains and intentionally move or talk. Instead, their accounts are metaphorical and dependent on the result of their past experience with such objects. When we consider the kind of explanations they gave for "move" and "talk" (see Figure 12.2), we see that they appealed to animate parts (e.g. bones, muscles, blood), animate causes (e.g. wants to move), and animate predicates (e.g. alive, living) for the "real" animates. In contrast, for the machines, they noted the absence of animate parts and causes and went on to talk about, inanimate parts (wings, wheels), mechanisms (batteries, engines), materials (plastic, metal), and external energy sources (e.g. the actions of a person). So, although the adults attributed "move" and "talk" to the machines, they made it clear that they did not think of these as actions that are due to an intrinsic capacity for self-generated motion. Most importantly, they appealed to external causal sources of energy when asked to justify their answers. For us, this kind of selective attribution of animate properties is cultivated. It requires understanding about both the animate properties and the nature of the machine. Hence, we say that it is metaphorical animism.

4. Do children distinguish between different kinds of inanimate artefacts?

We asked about only two simple artefacts, chair and spoon. Nevertheless, the children's responses for these inanimate objects are revealing. Analyses of the number of "yes" responses (see Tables 12.1, 12.2 and 12.3) revealed that children not only distinguished between simple artefacts and animates, but also between simple artefacts and machines. No child thought that a chair could move, and less than 10% replied that a spoon could move. Furthermore, the same children said that machines, particularly the ones designed by people to do so, were the ones that could move. Not only do

[7] Note that their attribution of "move" was weaker for the sentient machines and their attribution of "talk" was weaker for the moving machines.

young children distinguish between animates and inanimates, they also discriminate between different kinds of inanimates.

5. Do adults and children treat plants as a separate category?

There is no doubt that adults treat plants as a biological category that is both like and different from animals. About 83% of the adults said that plants breathe (or show respiration, as many referred to it); 58% said that plants move; and a few even said plants possess other animate properties (Table 12.3). Although many of the adults said that plants move, it would be a mistake to conclude that they used this predicate in the same way that they do with animals. When they were asked to explain their attributions, they talked about parts (i.e. leaves) moving in response to the wind, the sun, or a person moving a potted plant. For them, a plant is not self-moveable, as a whole, and therefore not animate. Additionally, when asked about the origin of a plant, they appealed to seeds and the ground; in contrast, they appealed to man-made processes (e.g., someone made it, made in a factory) for the machines but to biological agents (e.g., mother, parents) for the animates.[8]

The children showed a similar, albeit less strong, pattern of responses. About 33% said that a plant can breathe, compared to 14% for think, 9% for move, 5% for remember, and 0% for talk and has a brain. While they attributed the property of breathe to a plant, they did not attribute a brain to it. Neither did they attribute the sentient animate properties of think and remember nor the action/communication property of talk to plants. Again, there was a selective uptake of our test list of " animate" properties. This restricted pattern of attribution went along with different answers about the insides and outsides of a plant. When asked about the insides of a plant, children talked about seeds and "plant stuff". When asked about the outsides, they talked about leaves, petals, and even dirt.

Perhaps the best evidence that plants were considered members of separate categories from animates and machines is the fact that we had to create a separate code to score explanations about a plant. Plant-specific responses were never given in connection with animates or machines. Thus, for the six questions dealing with move, talk, breathe, think, remember, and brain, we developed the category of "plant properties" (e.g. moving towards the sun, growing, photosynthesis). For the question on insides and outsides, we developed the categories of "plant internals" (e.g. seed, xylem) and "plant externals" (leaves, petals). Finally, for the origin question, we developed the category of "gardening activities" to include answers appealing to planting

[8] Adults occasionally referred to the animate mechanism of sex when talking about the origin of animates.

and watering. Thus, we were forced to recognise that questions about plants tapped a different categorical system compared to ones about animates and machines. In other words, terms such as breathe or move are better thought of as homonyms with different meanings, depending on whether they refer to an example of an animal or a plant (Keil, 1979).

6. Do children have a rich theory of mind?

Children's responses to questions about think, remember, and brain are relevant to discussions about a theory of mind. First, as seen in Table 12.3, children did not do very well on these questions compared to questions on move, talk, and breathe. This is especially true of the non-human animates—many of the children said that bugs and elephants might have a brain but could not remember or think.

Second, children had difficulty talking about mental phenomena (see Table 12.5, which shows the percentage of correct answers). Overall, children were much better at explaining why an object can move, talk, and breathe. In contrast, they were less accurate when responding about remember, think, and brain and had considerable difficulty explaining why animates can think, remember, and have a brain (see Table 12.7, which shows the mean number of correct and appropriate answers for the animates, moving machines, and sentient machines). Perhaps this stems from a reluctance to attribute such mental phenomena to non-human animates. It therefore is possible that young children's theory of mind is restricted to humans.

ON HOW THE ANIMATE–INANIMATE DISTINCTION IS ORGANISED

Overall, our results are consistent with the Caramazza and Shelton (1998) hypothesis that the general distinction between animate and inanimate is domain-specific. Children and adults answer questions about animals and inanimates in qualitatively different ways. Their explanations about the motion of separably moveable objects, be they animate or inanimate, were conceptually based. Motion by separably moveable animate objects was generally attributed to intrinsic causes, such as the presence of animal parts (legs, muscles), animate causes (e.g. wants to move), and animate notions of living and life. The potential for the movement of inanimates was attributed to extrinsic causes such as transport by an agent, wind, gravity, and collision with barriers. Children clearly knew that a plant as a whole does not move on its own; only parts move, and then in response to external forces. When talking about motion they did not confuse either plants or machines with animals, even though these latter objects can appear to "move" on their own. Children, like adults, seem to interpret the predicate "move" with respect to

the kind of category they are asked about and then the energy sources that pertain to that category.

Such explanatory coherence about the motion of a kind (self-induced versus other-induced) supports our view that the animate–inanimate distinctions has its origins in both principled conceptual and perceptual processes. There is no question that perceptions about motion are relevant to the build-up of knowledge about particular animate and inanimate objects. However, motion paths by themselves can be ambiguous (see the earlier discussion). That is, a similarity function that is based on kinds of motion paths does not lead to the assignment of all and only one class of motion paths to the abstraction "animate", and all and only a different class of motion paths to the abstraction "inanimate". This is our main difficulty with the Mandler hypothesis (1992 and Chapter 11) that infants first develop image schemas of self-motion and caused motion through domain-general processes of perceptual analysis of spatiotemporal differences between different kinds of motion events, because we do not see what motivates the modification of these schemas to form "self-moving animate" and "caused-to-move inanimate" schemas, which then provide a foundation for conceptualisation about animate and inanimate things—there is no account of why cause becomes a relevant conceptual framework. These kinds of consideration link conceptual principles about causality to problem of classification. A major function of the principles is to draw attention to those perceptual inputs that are relevant to learning about the animate–inanimate distinction and ones within these.

Support for our domain-specific account of the animate–inanimate distinction is provided by children's and adults' abilities to pair their answers about an object's possible motion with relevant comments about their material composition and the inside of these objects. Children's answers about the insides and outsides of objects were again conceptually driven. Animate objects were said to have animate "innards" (blood and bones) and animate externals (wings and eyes), whereas inanimate objects were said to have inanimate parts and materials (plastic and glass) for their insides and outsides. Children switched their category of answers depending on which conceptual category the item belonged to.

A "THEORY" OF ACTION

Overall, children were good at questions about motion and communication (talk), leading us to believe that knowledge about the difference between animate and inanimate objects reflects the acquisition of a theory about actions, interactions, and reactions of objects. This line of explanation also helps explain why even young children quickly learn about environmental conditions that are relevant to the different ways that animates and inanimates move and do not treat machines as if they were new examples of animate objects. For example, they know that a leaf can move if there is a wind (Williams, 2000), that a young animal might need help from an adult to move up a large hill (Massey & Gelman, 1988), and that dolls can walk if they have a battery (Gelman, Spelke, & Meck, 1983). In contrast, children were not very knowledgeable about mental phenomena and had difficulty talking about mental phenomena, such as thinking and remembering.

Our results bear on the Warrington and Shallice (1984) position that the animate–inanimate distinction is grounded in domain-general sensory and functional processes. First, the theory of action was not more or less important for animate as opposed to inanimate objects. Even when children seemed to be appealing to visible parts to justify their attribution of a property to an item (e.g. a dog walks with its legs), they tended to focus on the parts most functionally relevant, such as legs for movement or mouths for breathing. Hence, it is hard to argue that visual information is more relevant to the animate category or that functional information is not relevant to the animate category. This would seem to be a problem for the Warrington and Shallice (1984) position. So too is the fact that the young children in our studies did as well on the task without pictures as the one with pictures.

Children in our studies were not significantly different from the adults in terms of their ability to distinguish between animates and inanimates. Although they gave fewer sophisticated explanations than the adults for the presence of animate properties, even the adults did not offer them consistently. The finding that the adults did not respond very differently from the children is consistent with our position that first principles encourage learners to attend to relevant information (in this case, about animates and inanimates). Ours is a theory about everyday knowledge that is learned on the fly. It is not about the problem of how people come to share ideas about mechanisms that are held by experts. Clearly, for the adults in our study, like those in other studies (see Chapter 13), the animate–inanimate distinction was not grounded in modern-day scientific theory. This would require conceptual change of the kind proposed by Carey and Spelke (1994), one that presumably occurs as a result of formal scientific training.

If young children do benefit from the availability of causal principles that focus on the causal conditions of the motions and interactions of objects in the world, this helps explain why they classify plants and animals differently. It also offers an account of children's selective uptake of the predicate "talk" for animates and machines that mimic communication, and thus their very limited tendency towards animism. Whether this conceptual foundation develops into richer theories or metaphorical interpretations of worldly objects is then very much a matter of experience and education. How domain-specific or domain-general these kinds of learning are remains an open question.

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