



Identifying living and sentient kinds from dynamic information: the case of goal-directed versus aimless autonomous movement in conceptual change

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Abstract

To reason competently about novel entities, people must discover whether the entity is alive and/or sentient. Exactly how people make this discovery is unknown, although past researchers have proposed that young children – unlike adults – rely chiefly on whether the object can move itself. This study examined the effect of goal-directed versus aimless autonomous movement on children's and adults' attributions of biological and psychological capacities in an effort to test whether goal-directedness affects inferences across documented periods of change in biological reasoning. Half of the participants (adults, and 4-, 5-, 7-, and 10-year-olds; $Ns = 32$) were shown videos of unfamiliar blobs moving independently and aimlessly, and the other half were shown videos of identical blobs moving identically but toward a goal. No age group was likely to attribute biological or psychological capacities to the aimless self-moving blobs. However, for 5-year-olds through adults, goal-directed movement reliably elicited life judgments, and it elicited more biological and psychological attributions overall. Adults differed from children in that goal-directed movement affected their attributions of biological properties more than their attributions of psychological properties. The results suggest that both young children and adults consider the capacity for goal-directed movement to be a decisive factor in determining whether something unfamiliar is alive, though other factors may be important in deciding whether the thing is sentient. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Since Piaget (1929), many psychologists have argued that people of various ages identify things as alive or sentient by seeing these things move on their own (Bassili,

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1976; Laurendeau & Pinard, 1962; Mandler, 1992; Poulin-Dubois, Lepage, & Ferland, 1996; Premack, 1990; Reed, 1997; Stewart, 1982). This insight no doubt captures an important phenomenon: a child who sees her once active hamster lying still and unresponsive will be horrified, not because she thinks the inaction to be a temporary state, but because for her it signals that the hamster is now and forever dead and unaware.

Whether something moves by itself, however, may be anything but clear-cut strictly at the perceptual level. Leaves, paper cups, cars, and airplanes often move without any apparent external force, yet adults are not tempted to identify them as living things. For the leaves and paper cups, adults might infer that the wind causes them to move, and for the cars and airplanes, that some inanimate motor does the work. In both cases, adults consider these moving things as inanimate and insentient as a dead hamster.

Adults' interpretations of movement, of course, may be influenced by their prior knowledge: they know that leaves and paper cups have no internal mechanism for locomotion, and they know that cars and airplanes move only because a person starts their motor. If children say otherwise, is it not fair to assume that they merely lack the knowledge that adults possess? That is, if confronted with an *unfamiliar* object moving autonomously, might not children and adults both infer that the self-moving object is a living thing?

Generally, they do not: even when entities are unfamiliar, children and adults do not consider autonomous movement to be a decisive factor in judging something alive or sentient (Gelman, Durgin, & Kaufman, 1995; Poulin-Dubois & Héroux, 1994; Richards & Siegler, 1986). For example, when asked to identify an object that moved with multiple accelerations without any apparent outside force, one adult responded “(long pause) Gosh, I don't know ... let's try just a windblown object. You're in an area where it is swirling and stopping and changing direction...” (Gelman et al., 1995, p. 168). Based on such responses, Gelman et al. (1995) concluded, “Animates cannot be distinguished from inanimates simply on the basis of motion because the cues of motion, like the static cues of color and shape, are ambiguous” (p. 156).

This conclusion raises several important questions, questions that concern not only adults' conceptions of animacy, but also questions about the role of movement in the origin, development, and character of that understanding. First, can animates be distinguished from inanimates simply based on motion? Might not some sort of movement (such as goal-directed movement) independently and unambiguously signal whether a novel object is an animate? Second, does the *meaning* of different types of movement change over the lifespan? For example, do young preschoolers through adults decide whether something is alive by reference to the same standard (such as whether it can move itself toward goals), or do they use incommensurable standards for deciding whether something is alive? Lastly, what exactly is the meaning of different categories of movements? That is, if there are unambiguous motion categories that imply animacy, do they directly signal *life* or something else that implies life (such as *sentience* or *intentionality*, i.e. the capacity to sense, represent, or desire goals)?

The present experiment seeks to address these questions by asking preschoolers through adults about novel entities that move in two distinct ways – ones that move autonomously but aimlessly and ones that move autonomously but toward a goal. Goal-directed movement, I propose, unambiguously signals animacy where autonomous movement fails to do so. I argue that this goal-directed movement is a commensurate standard by which

preschoolers through adults identify novel entities as living things, that its value for identifying living things operates even during periods of profound conceptual change in the biological domain, and that this use of goal-directed movement may make many of these conceptual changes possible.

1.1. The ambiguity of autonomous movement

Autonomous movement is a type of movement in which an entity moves itself, with independent changes in direction and acceleration. Because this movement is so characteristic of living things, many researchers have thought it powerful enough to motivate young children's animacy–inanimacy distinction (see Gelman & Opfer, in press, for review). However, many empirical attempts have failed to confirm this intuition. For familiar entities, autonomous movement has proven incidental to the other sorts of information that children use to identify animates (e.g. natural kind status; Bullock, 1985; Dolgin & Behrend, 1984; Richards & Siegler, 1984). For unfamiliar entities, the movement provides only ambiguous biological information (Gelman et al., 1995; Poulin-Dubois & Héroux, 1994; Richards & Siegler, 1986).

Some of the earliest experiments on the biological interpretation of unfamiliar entities were performed by Stewart (1982, 1984) in a series of unpublished studies with adults. Stewart proposed that any non-Newtonian motion, including autonomous motion, would yield an illusion of animacy. To test her proposal, she generated computer representations of a ball that systematically differed in its movement: (1) the ball moved either as a result of collision with another ball or with no visible source of initiation; (2) either the ball collided with another surface and changed directions or it changed directions before colliding with another surface; and (3) either the ball moved at a constant speed or the ball doubled its speed midpath without any apparent outside force. Gelman et al. (1995) recently repeated Stewart's methodology. For the first pair of movements, participants were more likely to judge the self-propelled ball as alive (25%) than the externally propelled one (0%). For the second pair, the ball that 'avoided' the barrier was also more likely to be judged alive (12.5%) than the ball that 'bounced off' the barrier (0%). For the third pair, both balls were judged not alive by roughly 60% of the participants. In conjunction, these studies show that autonomous motion provides adults with weak but unconvincing animacy cues.

Children's judgments of unfamiliar objects have been similar. For example, Poulin-Dubois and Héroux (1994) presented 5-, 7-, and 9-year-olds with computer displays of unfamiliar, irregularly-shaped stimuli that moved either autonomously or because of an external agent. Children were then asked whether the entity was "alive" and whether it possessed other biological and psychological properties. They found that autonomous motion was more likely than non-autonomous motion to elicit such attributions, but again neither movement elicited more than 4.5 of the 12 possible attributions of animate objects, a level indistinguishable from random guessing. These results led the authors to allow for the same conclusion reached by Gelman et al. (1995): "[E]ven for 5-year-old children, other features must also be involved [in attributing life] as their low scores for the artificial stimuli indicate" (p. 24). Given that autonomous motion seemed an ambiguous animacy cue, it is worth examining what "other features" might provide a stronger cue.

1.2. Goal-directed versus aimless autonomous movement

Another feature that might indicate life (Opfer & Gelman, 2001; Opfer & Siegler, 2001) or sentience (Csibra & Gergely, 1998) is goal-directedness. Goal-directed movement is a type of autonomous movement in which the agent contingently directs its movement toward (or away from) another object, state, or location. ‘Movement’ is used here in the full sense used by Michotte (1963), which includes “changes in shape”, which he classified as the special movement of the “kinaesthetic amoeba” (pp. 204–206). Thus, a plant growing toward the sun or an amoeba engulfing a paramecium would equally count as movements. ‘Goal’ refers here to any object, state, or location toward which an entity *contingently* directs its self-movement. Thus, a ceiling fan (say) would not be the goal of a plant’s growth (even if a plant grew toward it) because the plant would not grow toward the ceiling fan were it moved elsewhere; in this case, the growth is only accidentally directed toward the ceiling fan. In contrast, the goal of a plant’s growth could be a stream of sunlight. For example, imagine that sunlight is streaming from the left and right sides of a shaded window. Place a plant on the right side of the window and it will consistently grow leftward (i.e. toward the sunlight); move the plant to the left side of the window, and it does not continue to grow leftward (i.e. away from the sunlight) but instead changes the direction of its growth to the right (i.e. toward the sunlight). The difference between accidental self-movement toward objects (such as ceiling fans) and contingent self-movement toward objects (such as sunlight) is the difference that ‘goal-directed movement’ is meant to convey.

Goal-directed movement is superficially similar to two types of contingent, object-directed movement that are not autonomous – being pushed toward a goal and getting pulled by another object. An object (O) is readily perceived as pushed by another object (S) when there is contact between S and O, when the speed of S is at least half as great as the post-contact speed of O, when the movement of O immediately occurs upon contact, and when the direction of the post-contact movement of O is similar to the direction of the pre-contact movement of S (Michotte, 1963). Thus, if O moves to a goal (G) following Michotte-like pushing, the movement of O cannot be classified as goal-directed (though it might result from the goal-directed movement of S). For example, if Michael Jordan consistently hits his baskets, we would say that the movements of Michael Jordan were goal-directed, but we would not say that the movement of the basketball itself was goal-directed. Indeed, 3- and 5-year-olds reliably see the difference between being pushed toward a goal and moving there autonomously, and 5-year-olds do not claim that a person pushed toward a goal actually desires it (Montgomery, 1996).

A similar type of object-directed (though not goal-directed) movement is pulling (White & Milne, 1997). Adults’ impression of pulling arises from seeing one object following another, even when there is no visible connection between the pulling and pulled objects and the two objects move in different planes. Their impression of pulling, however, is decreased (and their impression of autonomy increased) by two factors: (1) *delay before movement*, wherein a delay precedes one object following a second object; and (2) *change in direction*, wherein the first object moves in the opposite direction as the second object moves, and only then follows the second object (White & Milne, 1997).

Although no studies have systematically varied the factors that give rise to impressions

of goal-directedness, it seems plausible that the features that attenuate impressions of pushing and pulling amplify impressions of goal-directedness if for no other reason than that they also signal autonomy. The delay before movement may signal that a spontaneous change within the agent is necessary for it to move toward its goal. For example, an amoeba needs time for the chemicals emitted by a paramecium to reach it before the amoeba moves toward it, and a person needs a moment at least to identify a cup of coffee before reaching for it. The change in direction highlights that the agent is not already moving in a particular direction, but perhaps that the goal (or the idea of the goal) itself affected some change in the agent. For example, if a person steps on her cat's tail on the way to the refrigerator, we might say that stepping on the tail was accidental rather than goal-directed. If, however, the cat then ran away from the person's path to the refrigerator and the person immediately changed her direction and again stepped on her cat's tail, we would then doubt the tail-stepping to be accidental.

Whether *delay before movement* and *change in direction*, either independently or in combination, or other factors actually determine impressions of goal-directedness is unclear. Some authors, for example, emphasize the importance of *change in direction* (Poulin-Dubois & Héroux, 1994; Premack & Premack, 1997) and *delay before movement* (Poulin-Dubois & Héroux, 1994). Others claim that an agent must additionally terminate its action upon reaching its goal (*satisfaction*) (Premack & Premack, 1997) and that it must move directly toward the goal (*direct trajectory*) (Gergely, Nadasdy, Csibra, & Biro, 1995; Premack & Premack, 1997).

In light of these features, it is worth reconsidering one study suggesting that goal-directed movement does *not* elicit any more life and sentience judgments from children and adults than aimless autonomous movement. Richards and Siegler (1986) presented a computer image of a rectangle to 5- to 6-year-olds. The children were told that they were to imagine that they had gone to another planet in search of living things and “sometimes you'll put [a toy truck] in front of the object to see if the object goes to it”. In one condition, the rectangle moved without any apparent external impetus (autonomous motion). In another condition, the rectangle moved to the depicted toy truck (goal-directed motion). No age group, either alone or in combination with other factors (such as whether the rectangle had legs or wheels, and whether the terrain was flat, uphill, or downhill), associated this goal-directed activity with life. The authors concluded that either the toy truck did not represent a goal to the children or that goal-directed movement was not important for inferring that the agent was alive.

Referring back to the proposed signals of goal-directedness, there are at least three reasons to agree with Richards and Siegler's suggestion that the children had no cause to interpret the toy truck as a goal for the alien life forms. First, there was no delay before the rectangle moved to the toy truck. A plausible interpretation, then, might be that the rectangle was pulled by a magnet. Second, the rectangles were not shown changing direction toward the toy truck; therefore, it was impossible to determine whether the rectangle's movement to the toy truck was accidental or goal-directed. Third, the scenario did not specify what would satisfy the rectangle, that is, indicate the conditions under which the rectangles do or do not pursue goals. Therefore, the toy truck may have seemed an unlikely goal for the rectangles.

In sum, neither attributions of sentience nor life have been shown to rest on seeing an

object move autonomously or toward goals, but these failures seem to stem from different causes. Displays of autonomous motion have played little role in biological and psychological judgments seemingly because autonomous motion itself is ambiguous (Gelman et al., 1995; Poulin-Dubois & Héroux, 1994). The display of goal-directed motion, however, seems to have had little effect because the particular presentation of goal-directed movement did not vary important features of goal-directedness (e.g. delay before movement, change in direction, and indication of satisfaction).

1.3. Understanding goal-directedness as a biological versus psychological capacity

Preschoolers' previous failures to base their judgments on movement type do not appear to have resulted from their age: even adults failed to attribute biological and psychological properties to the stimuli heretofore described, possibly because the displays themselves were ambiguous rather than because adults cannot identify animates on the basis of movement. Thus, if we eliminate the ambiguity of these stimuli and we find that adults *do* differentiate autonomous and goal-directed motion, then we have reason to believe that preschoolers may do so as well. Such findings would then raise the question: when goal-directedness signals animacy, does it primarily elicit biological or psychological judgments? That is, does a thing's goal-directed movement imply that it has psychological capacities (such as the ability to sense or desire the goal), just biological capacities (such as the ability to eat the goal), both, or neither? Which meaning people take from goal-directed movement at various ages is important because it helps to resolve issues about the nature of conceptual change in the biological domain.

First, goal-directed movement may imply neither biological nor psychological capacities. A non-mentalistic, non-biological interpretation of goal-directed movement has been attributed to infants participating in several studies (Csibra & Gergely, 1998; Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Gergely & Csibra, 1997; Gergely et al., 1995). Young children, too, may attribute goals to agents without spontaneously identifying the mental or physiological causes of such actions or the psychological or biological significance of such goals. Under this proposal, a young child faced with goal-directed movement is concerned chiefly with the determination of goal-directedness *per se* and is otherwise agnostic about the agents' biological and psychological properties, including even its ability to move autonomously.

Second, young children may initially predicate "life" and other biological capacities on the capacity to act intentionally (which is psychologically-caused goal-directed action), thereby leading them to wrongly exclude plants and other insentient life forms (such as germs) from their *living things* concept and biological reasoning (Carey, 1985; Solomon & Cassimatis, 1999). Thus, until children change their minds about the life-intention connection, they cannot understand why organisms they know to be insentient (e.g. plants) are "alive" (Carey, 2000). In this view, knowing that something acts toward goals elicits preschoolers' judgment of life only if they also judge the action intentional. If this characterization of preschoolers' beliefs is correct, then showing them a novel entity self-moving toward a goal should affect their biological and psychological judgments equally *and* preschoolers' judgment that something is alive should be no more likely than their judgment that it is psychological.

Lastly, children may predicate “life”, not on the capacity for intentional action, but on the capacity for goal-directed action, whether presumed intentional or not. If children equate life with the capacity to act toward goals, then no change in the concept “life” is necessary to understand why plants and other insentient organisms are alive: they need only learn that plants and other insentient organisms act toward goals, just as animals must do to be alive. According to this characterization, knowing that a thing acts toward goals is sufficient to know that it is alive, whether or not the action is believed to be intentional. A stronger (though logically unnecessary) version of this view is that preschoolers understand that goal-directed actions may be living actions yet non-intentional (Keil, 1992). If this strong view is correct, then evidence of goal-directedness should increase the likelihood of biological judgments more than psychological ones, as opposed to increasing them equally (according to the weaker version).

Interestingly, biological versus psychological interpretations of goal-directed action seem to change between the ages of 5 and 10 years. Opfer and Gelman (2001), for example, investigated the sorts of information 5-year-olds through adults use to predict and explain teleological action (i.e. self-beneficial, goal-directed movement). Participants were asked whether animals, plants, machines, and simple artifacts would direct their movement toward a needed goal (e.g. an animal toward a mouse, a plant toward sunlight, or a machine toward electricity) versus toward an object the entity did not need (e.g. an animal toward a box or a plant and machine toward a picture on the wall). Five-year-olds seemed to believe that only animals are teleological agents. They were likely to predict that animals would move toward needed goals, were more likely to predict that animals would move toward these goals than toward objects they did not need, and were more likely to predict that animals would act toward goals than that plants and artifacts would. When explaining their predictions, preschoolers referred to psychological states more often than any other factor, including biological needs or mechanical forces, and they attributed psychological capacities only to animals at above-chance levels. From this evidence, Opfer and Gelman (2001) concluded that preschoolers take goal-directed action to be a distinctive capacity of psychological living things.

Adults and fifth graders, like preschoolers, restricted their predictions of teleological action to living things, but they did not seem to think that psychological capacities were also necessary. For example, both adults and fifth graders predicted that insentient plants would act in a number of goal-directed ways, such as growing toward sunlight rather than pictures, growing toward water rather than oil, and enclosing a fly rather than a pebble. When asked to explain why plants and animals would move toward goals, fifth graders and adults (unlike preschoolers) were likely to refer to how these goals benefited the actors' *lives*, and they were unlikely to attribute psychological capacities to plants (Opfer & Gelman, 2001). Adults and older children seemed to understand that goals can be pursued but not desired and that the things that pursue goals are living things (whether mindless or not).

1.4. The present experiment

Across several studies, children's and adults' judgments about the life and sentience of familiar entities have been only weakly linked to autonomous movement (Bullock, 1985;

Dolgin & Behrend, 1984; Richards & Siegler, 1984). Their expectations of goal-directed movement, however, have closely followed their judgments of what can be alive (Opfer & Gelman, 2001) – animals according to 5-year-olds, plants and animals according to 10-year-olds and adults (Carey, 1985; Hatano et al., 1993; Richards & Siegler, 1984). These findings suggest that children and adults, though their judgments of what is alive differ dramatically, may both base their life judgments on the same dynamic feature – goal-directed movement. Judgments of sentience, in contrast, do not appear to be predicated on goal-directedness among older children and adults.

The purpose of the present experiment is to test these hypotheses and address the following questions. (1) Can animates be distinguished from inanimates simply based on goal-directedness? (2) When in development do children first use goal-directedness to identify living and sentient kinds? (3) Does the meaning of goal-directedness change with the development of biological and psychological knowledge?

To answer these questions, this experiment sought to identify the effect of a goal on children's and adults' interpretation of autonomously moving agents. Two sorts of interpretations were of interest here: whether the agent was thought to possess various biological and psychological capacities, and what the agent was identified to be. To rule out prior biases about the agents' identity, the agents (blob-like microorganisms) were chosen based on a pilot study with adults, which established that the blobs were in fact unfamiliar and not recognizable as microorganisms.

To explore the role that developing biological and psychological knowledge might have on the interpretation of these goal-directed agents, four age groups of children (4-, 5-, 7-, and 10-year-olds) were chosen that typically differ greatly in their biological and psychological knowledge. Four-year-olds were selected because they often fail to attribute life consistently to novel and familiar entities (Carey, 1985; Laurendeau & Pinard, 1962; Looft & Bartz, 1969; Piaget, 1929; but see Richards & Siegler, 1984), because they have been said to rely heavily on whether novel agents move independently (Laurendeau & Pinard, 1962; Piaget, 1929), and because they reportedly fail to differentiate the biological and psychological domains (Carey, 1985). If 4-year-olds – like adults – attribute biological but not psychological capacities to goal-directed but not autonomous agents, then we would have evidence consistent with the notion that goal-directed action is a perceptual primitive in the biological domain.

Five-year-olds were chosen because they attribute life consistently (if incorrectly) to animals but not plants and artifacts (Dolgin & Behrend, 1984; Richards & Siegler, 1984), expect that animals will act teleologically (Opfer & Gelman, 2001), and reportedly use neither autonomous nor goal-directed movement to attribute biological capacities to non-animals (Dolgin & Behrend, 1984; Poulin-Dubois & Héroux, 1994; Richards & Siegler, 1984). These studies suggest that 5-year-olds reason about animals in a uniquely biological manner and that they are not willing to reason about other living things (such as plants and germs) similarly (Carey, 1985).

The 7- and 10-year-olds were selected because their knowledge of the biological and psychological domains has been characterized as adult-like in most of the respects relevant here (Carey, 1995). Neither of these age groups has been shown to reliably attribute biological properties to autonomously moving things (Poulin-Dubois & Héroux, 1994),

and at least 10-year-olds expect that both insentient plants and sentient animals will act teleologically (Opfer & Gelman, 2001).

Adults were included because they presumably know of many more insentient living things than do children. Accordingly, even if goal-directedness is an equally strong cue across all ages that something is a living thing, the effect of the cue on adults' psychological attributions should still be less than that on children's attributions. In this way, developing knowledge about the scope of living things could yield different sorts of interpretations about goal-directed agents: for children, goal-directedness would serve as an equally strong biological and psychological cue, whereas for adults, goal-directedness would serve as a stronger biological than psychological cue. Similarly, as children learn about what is necessary to be a living thing (e.g. dying, reproducing, needing water and nutrients), goal-directedness should have a successively greater impact on biological attributions generally.

2. Method

2.1. Participants

Participants included 4-year-olds (Goal condition: $N = 16$, ages 4.01–4.87, mean age = 4.51; No Goal condition: $N = 16$, ages 4.01–4.99, mean age = 4.48), 5-year-olds (Goal: $N = 16$, ages 5.09–5.93, mean age = 5.41; No Goal: $N = 16$, ages 5.03–5.98, mean age = 5.46), 7-year-olds (Goal: $N = 16$, ages 7.33–8.44, mean age = 7.84; No Goal: $N = 16$, ages 7.51–8.37, mean age = 7.91), 10-year-olds (Goal: $N = 16$, ages 10.66–11.22, mean age = 10.92; No Goal: $N = 16$, ages 10.41–11.21, mean age = 10.71), and adults (Goal: $N = 16$, ages 18.69–21.44, mean age = 19.62; No Goal: $N = 16$, ages 18.18–21.45, mean age = 19.56). Four- and 5-year-olds were recruited from a university-affiliated preschool, and 7- and 10-year-olds were recruited from a suburban public elementary school. Adults volunteered to fulfill their introductory psychology class research participation requirement.

2.2. Materials

The materials comprised eight QuickTime™ videos of moving blobs; half of these videos depicted a blob moving itself toward a goal (an irregularly-shaped dark dot), and the other half were identical except that the goal was removed. All the agents themselves were irregularly-shaped, such that the agent could be viewed as having an orientation. The paths of the agents' and goals' movement are depicted in Fig. 1.

Each of the videos depicted at least one of the properties thought to indicate goal-directed movement: goal-directed change in the agent's orientation (e.g. pointed left toward the goal and then right toward the goal), goal-directed change in the direction of the agent's movement (e.g. moving toward the goal to the left and then toward the goal to the right), delay before the agent's movement (i.e. moving only when the goal is present), and change in movement upon reaching the goal (e.g. ceasing movement upon reaching the goal or changing direction toward a new goal). One change in orientation was depicted in Videos A, B, and D, and three in Video C. One change in direction was depicted in

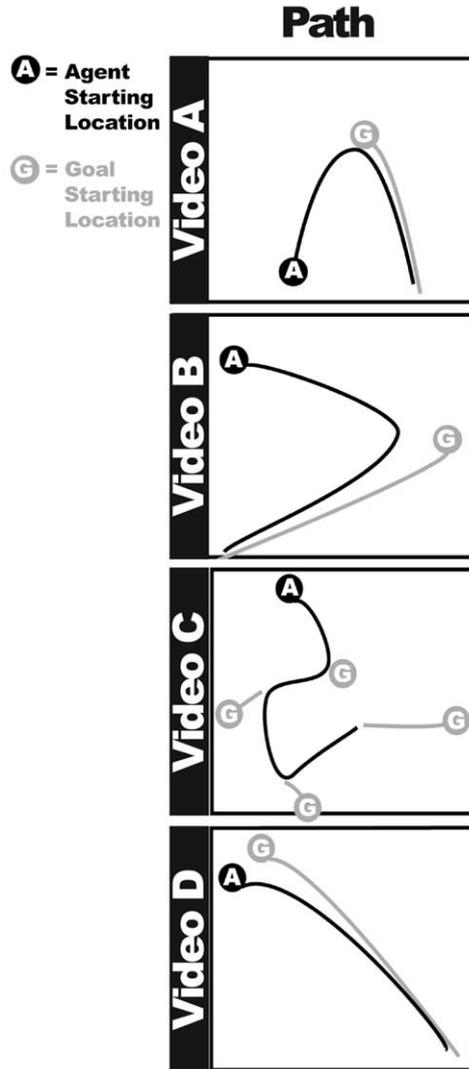


Fig. 1. Video presentations of agent and goal paths: Goal condition.

Videos A and B, and three in Video C. A delay before movement was depicted in Videos C and D. Lastly, changes in movement upon reaching the goal were depicted in Videos A, B, C, and D.

These videos were selected from a larger group of videos shown to adults in a pilot study, which sought to ensure that the agents were not identifiable as microorganisms. In this pilot study, 24 adults were each shown ten stills from a pool of ten videos of microorganisms moving toward no goal. For each still, adults were asked to identify the micro-

organism (1 = living kind, 0 = non-living kind), how confident they were with their identification (9 = most confident, 1 = least confident), how familiar they were with those entities (9 = most familiar, 1 = least familiar), whether the entity could move by itself or whether it required an outside force (0 = externally-caused movement, 1 = autonomous movement), and whether it could move toward something it needs consistently or only accidentally (0 = accidental movement, 1 = goal-directed movement). Videos A, B, C, and D were the four videos that were most unlikely to be identified as living kinds ($M = 0.16$, range: 0.04–0.26) and were the only videos unlikely to be judged self-moving ($M = 0.24$, range: 0.17–0.38) and goal-directed ($M = 0.19$, range: 0.08–0.25) ($P_s < 0.10$). Although adults incorrectly identified the microorganisms as non-living things, they reported moderate familiarity with the items ($M = 4.50$) though very low confidence in their judgments ($M = 2.80$). In short, adults were not sure what the blobs were, but were more likely to guess that they were clouds, islands, and comets than to guess that they were organisms that could move autonomously or toward goals.

2.3. Procedure

Participants were randomly assigned to one of two conditions. In the Goal condition, participants were shown four videos of a blob moving toward a goal (Videos A, B, C, and D); in the No Goal condition, they were shown the identical videos, except the goal was removed. Participants were shown only one type of movement (goal-directed or not goal-directed) in order to control for the possibility of contrast effects between the two conditions; however, this design could work against the hypotheses if participants avoid repetitive answers. The order of videos in each condition was counterbalanced across subjects using a Latin square. After the presentation of each video, participants completed an attribution task followed by an identification task.

The attribution task presented participants with a battery of questions about the biological and psychological capacities of the agents in the video. The order of biological and psychological batteries was counterbalanced across subjects, and the order of questions within each battery was random. The biological battery comprised the following questions: “Can it die?”, “Can it grow?”, “Can it make more little ones just like it?”, “Does it need something?”, “Does it need food?”, “Does it need water?”, and “Is it alive?”. The psychological battery comprised these questions: “Can it want something?”, “Can it feel pain?”, “Can it think?”, “Can it see?”, “Can it be happy?”, “Can it make choices?”, and “Can it make plans?”.

After the attribution task, participants completed an identification task, in which the agent in the video was indicated, and participants were asked, “What is it?” In the Goal condition, participants were also asked “Did this thing [the agent] move so that it could get closer to this thing [the goal]?” in order to check whether all age groups were equally likely to judge the entity to be goal-directed. Finally, in both conditions, participants were asked “Did this thing [the agent] move by itself or did something else move it?” to test whether judgments of self-movement interacted with the actual type of movements displayed in the videos.

3. Results

3.1. *Attributions of goal-directed and autonomous movement*

Each participant in the Goal condition received one score (0–1) indicating the proportion of attributions of goal-directed movement to the four goal-directed agents. A single-factor (age: 4-year-olds, 5-year-olds, 7-year-olds, 10-year-olds, and adults) ANOVA was performed on these scores, and post-hoc comparisons used a Newman–Keuls test (unless otherwise indicated, all post-hoc comparisons used a Newman–Keuls test). There was no main effect of age, and no age group differed from any other (4s, $M = 0.89$; 5s, $M = 0.94$; 7s, $M = 0.94$; 10s, $M = 0.80$; adults, $M = 0.91$). Two-tailed, one-group t -tests indicated that every age group attributed goal-directed action at above-chance levels ($P_s < 0.0001$).

In both conditions, participants received one score (0–4) indicating the number of agents they judged to move autonomously. A 2 (condition: Goal, No Goal) \times 5 (age: 4-year-olds, 5-year-olds, 7-year-olds, 10-year-olds, and adults) ANOVA was performed on these scores. There was a main effect of age ($F(4, 150) = 5.42, P < 0.001$), indicating that 4-year-olds were less likely to attribute self-movement than 10-year-olds and adults ($P_s < 0.05$) and that 5-year-olds were less likely to attribute movement than adults ($P < 0.05$). There was also a main effect of condition ($F(1, 150) = 13.16, P < 0.001$), indicating that agents in the Goal condition ($M = 2.60$) were more likely to be judged self-moving than agents in the No Goal condition ($M = 1.89$). Age and condition did not interact.

3.2. *Attributions of biological and psychological capacities*

In both conditions, each participant received two scores (each ranging from 0 to 7), one indicating the mean number of biological capacities attributed to the novel agents and another the mean number of psychological capacities. Thus, if participants guessed randomly, we would expect 3.5 biological and 3.5 psychological attributions.

A 2 (condition: Goal, No Goal) \times 2 (attribution: biological, psychological) \times 5 (age: 4-year-olds, 5-year-olds, 7-year-olds, 10-year-olds, and adults) \times 4 (item: Video A, B, C, and D) repeated-measures ANOVA was performed on the mean scores (see Fig. 2). As indicated in the table of effects (Table 1), goal-directed agents elicited significantly more attributions of biological and psychological capacities than aimless autonomous agents. The presence of the goal affected the attributions of 5-year-olds through adults, but had no effect on 4-year-olds ($P = 0.56$). Biological capacities were also attributed more often than psychological ones, and the difference between attributions of biological and psychological capacities was progressively larger at older ages. Although the difference in these attributions increased with age, even 4-year-olds were more likely to attribute biological capacities than psychological ones. Lastly, the presence of a goal affected adults' biological attributions significantly more than their psychological attributions, but this distinctively biological effect of goal-directedness was attenuated in younger age groups (adults, $F = 9.01$; 10-year-olds, $F = 1.30$; 7-year-olds, $F = 0.13$; 5-year-olds, $F = 0.00$; 4-year-olds, $F = 0.20$).

To indicate which biological and psychological capacities goal-directedness affected, a

Table 1
Table of effects: condition, attribution type, and item

| Effect | F test | Post-hoc |
|------------------------------------|----------------------------|--|
| Condition | $F(1, 150) = 28.57^{***}$ | Goal ($M = 3.68$) > No Goal ($M = 2.28$) |
| Attribution type | $F(1, 150) = 210.95^{***}$ | Biological ($M = 3.64$) > Psychological ($M = 2.31$) |
| Item | $F(3, 450) = 3.61^*$ | Item C ($M = 3.2$) > Item B ($M = 2.7$) |
| Age × condition × attribution type | $F(4, 150) = 3.71^{**}$ | |
| <i>Four-year-olds:</i> | | |
| Attribution type | $F(1, 30) = 4.71^*$ | Biological ($M = 2.96$) > Psychological ($M = 2.56$) |
| <i>Five-year-olds:</i> | | |
| Condition | $F(1, 30) = 5.14^*$ | Goal ($M = 3.61$) > No Goal ($M = 2.48$) |
| Attribution type | $F(1, 30) = 13.75^{**}$ | Biological ($M = 3.17$) > Psychological ($M = 2.48$) |
| <i>Seven-year-olds:</i> | | |
| Condition | $F(1, 30) = 8.66^{**}$ | Goal ($M = 3.74$) > No Goal ($M = 2.17$) |
| Attribution type | $F(1, 30) = 17.93^{***}$ | Biological ($M = 3.38$) > Psychological ($M = 2.54$) |
| <i>Ten-year-olds:</i> | | |
| Condition | $F(1, 30) = 8.45^{**}$ | Goal ($M = 4.13$) > No Goal ($M = 2.79$) |
| Attribution type | $F(1, 30) = 103.36^{***}$ | Biological ($M = 3.38$) > Psychological ($M = 2.54$) |
| Item × condition | $F(3, 60) = 3.7^*$ | Goal ($A = B = C = D$), No Goal ($C, D > A, B$) |
| <i>Adults:</i> | | |
| Condition | $F(1, 30) = 38.62^{****}$ | Goal ($M = 3.90$) > No Goal ($M = 1.84$) |
| Attribution type | $F(1, 30) = 121.50^{****}$ | Biological ($M = 4.45$) > Psychological ($M = 1.29$) |
| | | Biological (Goal, $M = 5.91$; No Goal, $M = 2.98$), Psychological (Goal, $M = 1.89$; No Goal, $M = 0.69$) |
| Condition × attribution type | $F(3, 60) = 9.01^*$ | |
| Item × condition | $F(1, 30) = 3.96^*$ | Goal ($A = B = C = D$), No Goal ($A, C > B, D$) |

* P-value = .05, ** p-value = .01 *** p-value = .001 **** p-value = .0001.

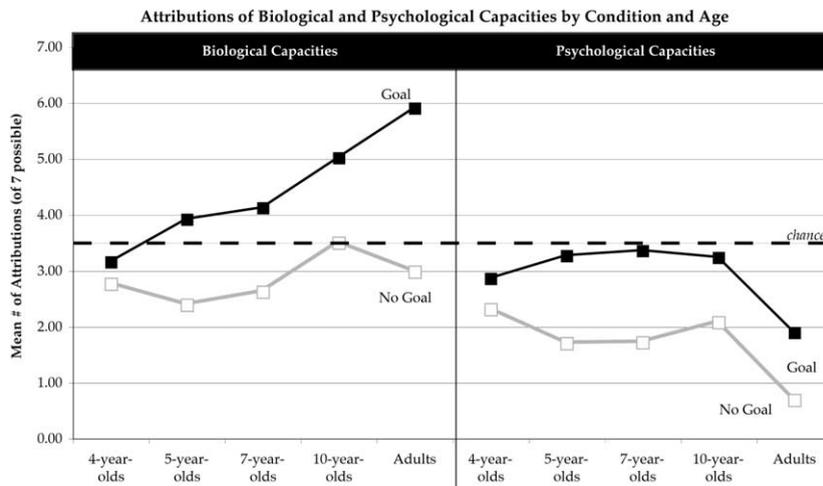


Fig. 2. Attributions of biological and psychological capacities by age and condition.

2 (condition: Goal, No Goal) \times 14 (attribution: die, grow, reproduce, need, need food, need water, alive, want, pain, think, see, be happy, choose, and plan) repeated-measures ANOVA was conducted on the scores (0–4) for each capacity separately. These comparisons are illustrated in Figs. 3–7. As indicated, 4-year-olds failed to distinguish goal-directed from autonomous agents in all of their attributions. In contrast, condition and attribution interacted for every other age group (P s $<$ 0.05). Post-hoc comparisons using the pooled variance term indicated that the presence of the goal affected the following at the 0.05 level: 5-year-olds' attributions of life and being able to grow, to need food, to see, and to choose; 7-year-olds' attributions of life and being able to grow, to need food, to want, to think, and to plan; 10-year-olds' attributions of life and being able to die, to need something, to need water, to want, to think, and to see; and adults' attributions of life and being able to die, to grow, to need something, to reproduce, to need food and to need water, to want, to choose, and to see.

Although the presence of the goal affected the attributions of both biological and psychological capacities, generally only biological capacities were attributed to the goal-directed agents at above-chance levels ($P < 0.05$). As illustrated in Figs. 5–9, 5-year-olds were likely to attribute *life*; to which 7-year-olds added *growth*; to which fifth graders added *dying*, *needing something*, and *reproducing*; to which adults finally added *needing food* and *needing water*. Fifth graders' attributions represented a singular exception to this trend: they were likely to say that even the aimless blobs “could make more

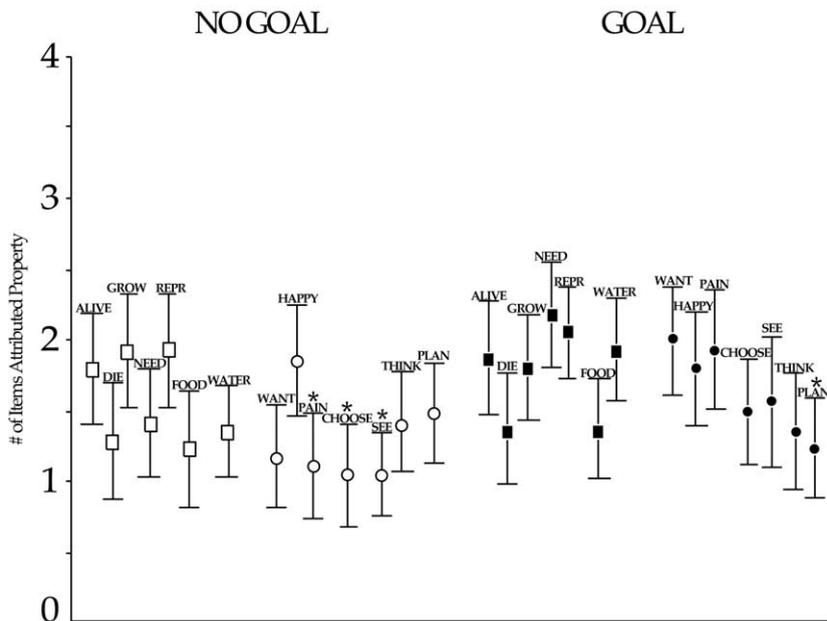


Fig. 3. Four-year-olds' attributions of individual biological and psychological capacities by condition. Asterisks indicate attributions that differ from chance ($P < 0.05$).

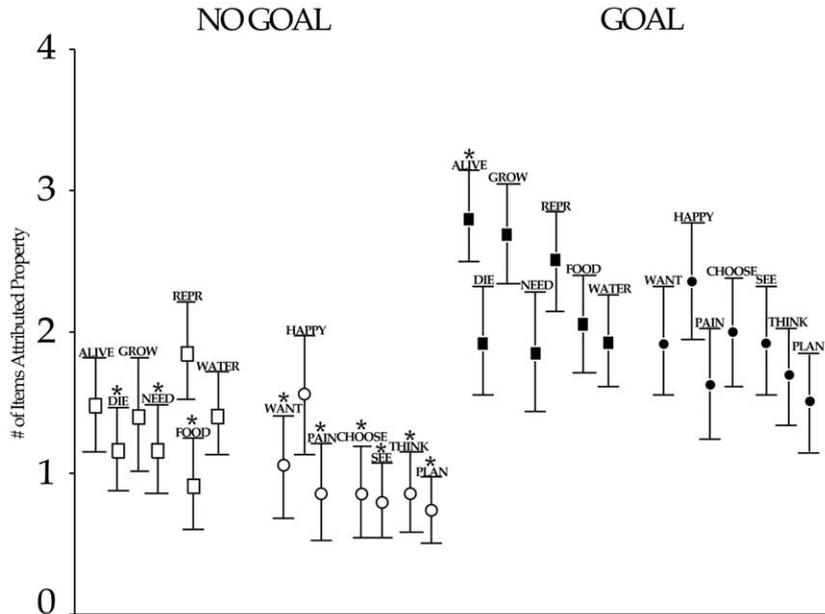


Fig. 4. Five-year-olds’ attributions of biological and psychological capacities by condition. Asterisks indicate attributions that differ from chance ($P < 0.05$).

little ones just like it”, and they were alone in attributing wanting to the goal-directed blobs.

3.3. Correlations between attributions of self-movement and biological and psychological capacities

To test whether judgments and perceptions of autonomous movement might independently elicit biological and psychological attributions, each participant’s self-movement attributions (0–4) were regressed against his or her attributions of biological (0–7) and psychological (0–7) capacities. In the No Goal condition, participants’ judgments of autonomous movement were unrelated to their attributions of biological ($r(79) = 0.18$, n.s.) and psychological capacities ($r(79) = 0.08$, n.s.). That is, when agents moved by themselves but toward no goal, participants who said that those agents did in fact move by themselves were no more likely to attribute biological and psychological capacities to the agents than participants who did not judge the agents to move by themselves. Indeed, for every age group that saw aimless self-movements, judgments of self-movement were unrelated to biological and psychological attributions (R^2 s = 0.004–0.20, n.s.). In the Goal condition, however, participants’ judgments of autonomous movement were strongly correlated with their attributions of biological capacities ($r(79) = 0.51$, $P < 0.001$), though not psychological capacities ($r(79) = 0.00$, n.s.), suggesting that the capacity for self-movement, while thought to be correlated with other biological capacities, is not thought to be sufficient to imply such capacities. Indeed, if we restrict our analysis of

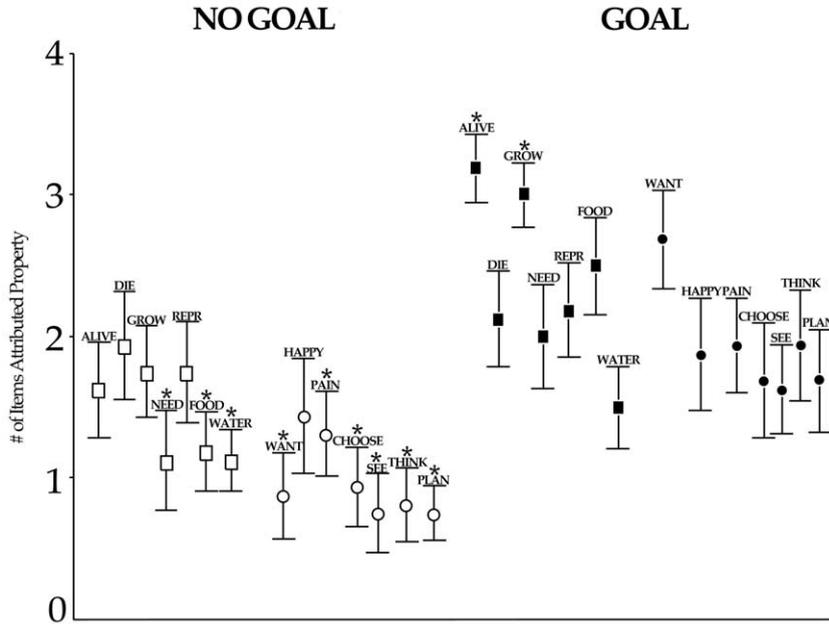


Fig. 5. Seven-year-olds' attributions of biological and psychological capacities by condition. Asterisks indicate attributions that differ from chance ($P < 0.05$).

variance only to those participants who judged all of the agents to move by themselves, we still find that goal-directed agents are attributed about twice as many biological capacities ($M = 5.09$) as are the non-goal-directed agents ($M = 2.28$) ($F(1, 34) = 18.28$, $P < 0.001$), and about twice as many psychological capacities (Goal, $M = 2.71$; No Goal, $M = 1.15$) ($F(1, 34) = 4.72$, $P < 0.05$) as well.

3.4. Agent identifications

To examine what the agents were thought to be, participants' identifications of the four agents were coded as either organismal (1) or inanimate (0). Organismal identifications named any life form, including animal labels (e.g. "an animal", "a jellyfish"), fanciful organisms (e.g. "space creature", "fish monster"), organ labels (e.g. "a stomach", "a heart"), collections of living things (e.g. "ten men", "herd of animals"), and descriptions of living things (e.g. "something that lives and can die", "something like a dog"). Inanimate identifications named any non-living kind or artifact, including celestial bodies (e.g. "shooting star", "rocksteroid"), terrestrial substances (e.g. "rock", "volcano guts"), formerly living things (e.g. "ghost"), and artifacts (e.g. "magnet", "spaceship"). Responses that were uncodable, such as a persistent "I don't know", were eliminated, and the ratio of organism identifications to the total number of codable identifications was calculated. Interrater reliability on a randomly selected subset of responses (128/640) was 97%.

Each participant received a weighted score between 0 and 1, indicating the proportion of

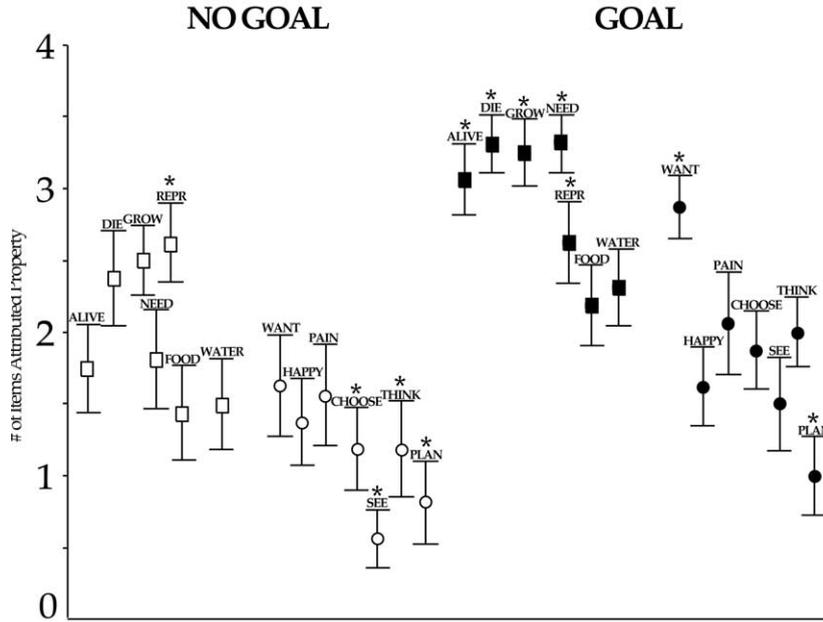


Fig. 6. Ten-year-olds' attributions of biological and psychological capacities by condition. Asterisks indicate attributions that differ from chance ($P < 0.05$).

agents identified as a living kind. A 2 (condition: Goal, No Goal) \times 5 (age: 4-year-olds, 5-year-olds, 7-year-olds, 10-year-olds, and adults) ANOVA was conducted on these scores. There was a main effect of condition ($F(1, 149) = 28.35, P < 0.0001$), indicating that participants were more likely to identify the goal-directed agent ($M = 0.52$) than the autonomous agent ($M = 0.28$) as an organism. Further, there was a main effect of age ($F(4, 149) = 8.02, P < 0.0001$), and post-hoc tests indicated that adults ($M = 0.63$) provided more organismal identifications than any other age group (4-year-olds, $M = 0.28$; 5-year-olds, $M = 0.31$; 7-year-olds, $M = 0.31$; 10-year-olds, $M = 0.45$; $P_s < 0.05$), which did not differ. Condition and age did not interact ($P = 0.36$). See Fig. 8 for results.

Although 5-year-olds through adults were more likely to say that the goal-directed blob was a life form than to say the autonomous blob was, their pattern of attributions suggest that they did not consider the goal-directed blob to be the same kind of organism. As we have seen, goal-directedness affected the children's biological and psychological attributions about equally, whereas it primarily affected adults' biological attributions. Possibly children thought the goal-directed agent to be an animal (e.g. a bug or jellyfish), whereas adults thought the goal-directed agent to be another sort of (non-psychological) organism (e.g. a plant or germ or fungus).

To explore this possibility, participants' organismal identifications of goal-directed blobs were re-coded to separate animal-organismal identifications and non-animal-organismal identifications. Thus, every participant received two scores, one indicating the

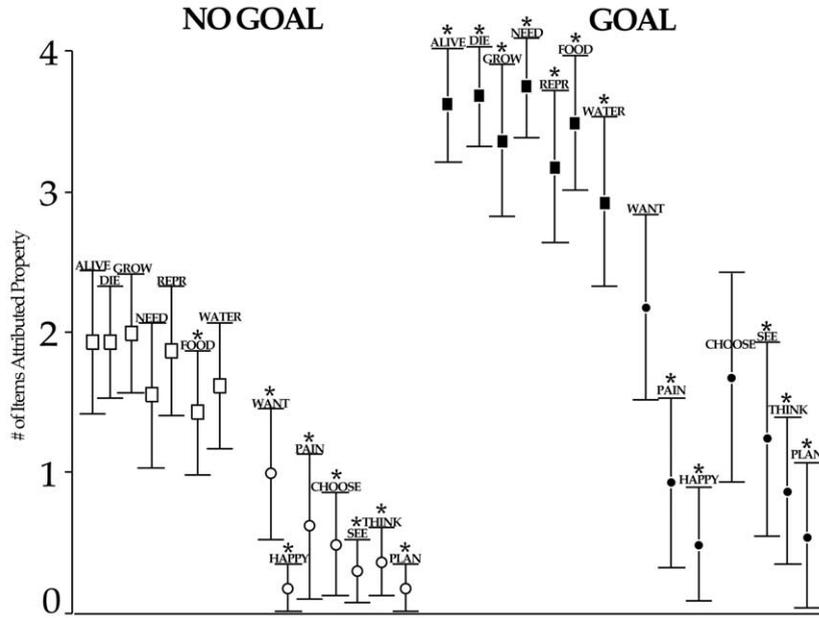


Fig. 7. Adults' attributions of biological and psychological capacities by condition. Asterisks indicate attributions that differ from chance ($P < 0.05$).

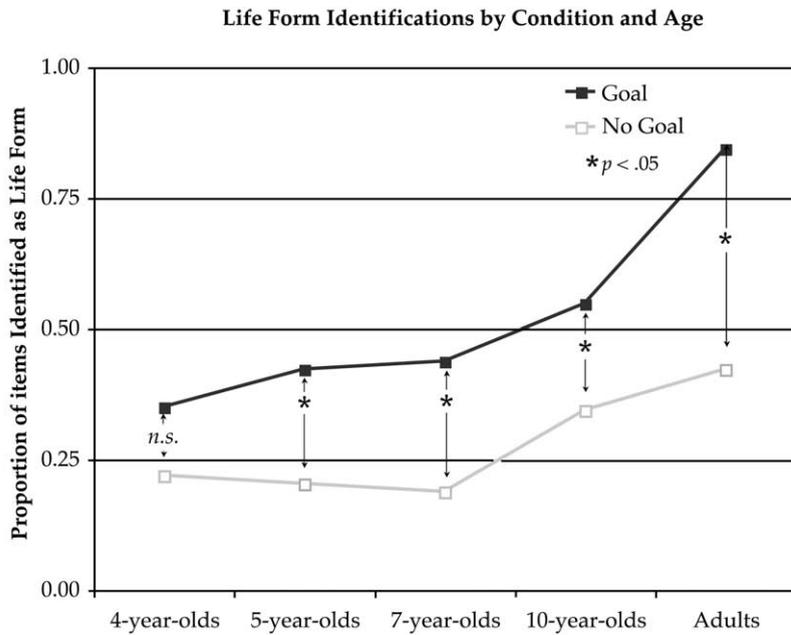


Fig. 8. Life form identifications by condition and age.

proportion of identifications that named an animal (0–1) and another indicating the proportion that named another sort of living thing (0–1). To allow for the possibility that participants (presumably children) wanted to express that the thing was a non-animal organism, but simply lacked names for such entities, “animal” identifications were defined in the most strict sense, including only those life forms that are scientifically recognized to belong to the animal kingdom (e.g. “baby”, “frog”, “insect”), whereas “other life form” identifications included any other life form, including descriptions (e.g. “growing moving thing”, “something chasing food”), fanciful organisms (e.g. “jelly monster”, “aliens”, “space creature”), organs (“heart”, “stomach”), and plants and unicellular bodies (e.g. “flower”, “germ”, “blood cell”, “bacteria”). This coding scheme thus allows children, who were hypothesized to identify the blobs as animals, the greatest possible chance to behave otherwise. Interrater reliability on a randomly selected subset of responses (128/640) was 93%.

A 2 (life form: animal, other) × 5 (age: 4-year-olds, 5-year-olds, 7-year-olds, 10-year-olds, and adults) ANOVA was conducted on these scores. There was a main effect of life form ($F(1, 74) = 8.89, P < 0.01$), indicating that the goal-directed agent was most often identified as an animal ($M = 0.33$; other, $M = 0.19$). Further, there was a main effect of age ($F(4, 74) = 6.17, P < 0.001$); post-hoc tests indicated that adults were more likely than any other age group to identify the goal-directed agent as some life form, and these other age groups did not differ. Lastly, age and life form interacted ($F(4, 74) = 9.97, P < 0.0001$), indicating that age affected other life form identifications ($P < 0.001$) but failed to affect animal identifications ($P = 0.23$). See Fig. 9 for results.

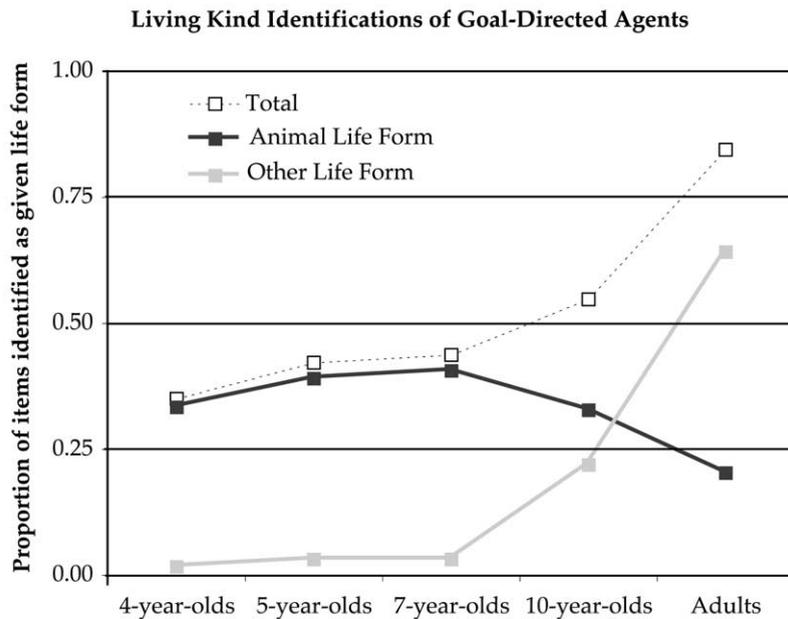


Fig. 9. Living kind identifications of goal-directed agents.

4. Discussion

Movement provides important information about the identity of familiar animate entities. Numerous studies have demonstrated that adults can identify people – including their sex and emotion – and other animals just by seeing how they move their joints (Brownlow, Dixon, Egbert, & Radcliffe, 1997; Dittrich, Troscianko, Lea, & Morgan, 1996; Johansson, 1973; Mather & Murdoch, 1994; Montepare & Zebrowitz, 1993). Indeed, switching these jointed movements for movements that violate the structure of the human form causes even infants (and cats and pigeons) to take notice (Bertenthal, Proffitt, Spetner, & Thomas, 1985; Blake, 1993; Dittrich, Lea, Barrett, & Gurr, 1998; Fox & McDaniel, 1982; Ruff, 1985). That movement can convey critical information about an organism's identity cannot be disputed. However, what can be disputed is whether these movements (or other sorts) are sufficient to identify living organisms more generally. After all, non-jointed organisms – worms, barnacles, plants, bacteria, fungi – are known to be alive, so people must have discovered this fact without relying on the so-called “biological motion” that is actually unique to organisms with legs. Moreover, the discovery of what is alive is not just an historical problem, but an ongoing problem that faces young children and adults of every generation whenever they encounter an unfamiliar entity.

The present results demonstrate that unfamiliar entities – blobs otherwise guessed to be clouds, islands, and comets – are identified as living organisms when they are shown to be capable of goal-directed movement. The goal-directedness appeared to be the decisive factor in these displays: identical blobs that moved identically but toward no goal failed to convince children and adults that they were living things. This biological interpretation of goal-directed movement was in place as early as 5 years of age, when goal-directed movement was first associated with life. From the age of 5 years to adulthood, the initial judgment of life was successively elaborated with progressively more biological judgments and progressively fewer psychological ones, suggesting that goal-directed movement is more closely connected to the biological than psychological domain.

Although aimless autonomous agents were not convincing as living things, it was important that the goal-directed agents were judged to have moved autonomously. If goal-directed agents were thought to have been moved by an outside force (like an object pulled or pushed toward a goal), participants were less likely to attribute biological characteristics to the agent. Interestingly, though the movement was in fact identical, goal-directed agents were more often judged to have moved autonomously than were agents that did not move toward goals. However, even when aimless agents were thought to have moved autonomously, they were not thought to have biological or psychological properties.

These results support and delimit several claims about the role of movement in the identification of animates (e.g. Gelman et al., 1995; Richards & Siegler, 1986; Scholl & Tremoulet, 2000; Stewart, 1982). First, the results support the claim that some non-Newtonian movements – specifically, aimless autonomous movements – do not elicit animacy judgments, much as Gelman et al. found when attempting to test the proposal by Stewart (1982) along the same lines. In the present study, too, aimless autonomous movements were ambiguous as animacy cues, even when participants were certain that the movements were autonomous. As Csibra, Gergely and others (Csibra et al., 1999) have

argued, the sort of mandatory interpretation of self-propulsion envisioned by some investigators (e.g. Baron-Cohen, 1994; Premack, 1990) would not be “a truly functional evolutionary adaptation as it would flood our perceptual system with false positives” (p. 263).

General skepticism about the ability to distinguish animates from inanimates on the basis of motion, however, does not appear warranted. Some kinds of movement – specifically, goal-directed movements – reliably elicited animacy judgments, particularly life judgments. This result is consistent with the proposal that animacy is directly perceived (Scholl & Tremoulet, 2000), and it suggests that the critical cause of that perception is goal-directed movement. Possibly, a mandatory biological interpretation of goal-directed movement is more adaptive than a mandatory interpretation of autonomous movement more broadly because goal-directed movement is a more conservative diagnostic of living kinds (Binswanger, 1992; Mayr, 1982). Additionally, goal-directed movement might be critical for identifying predators, whose biological goals are especially important to discern: if you find yourself the goal of an unfamiliar animal’s contingent movement, it may be safer to assume that its life depends on eating you than to assume that it really wants to play with you.

Prior causal knowledge, such as that envisioned in the teleological core of preschoolers’ theory of biology (Keil, 1992; Opfer & Gelman, 2001) or psychology (Carey, 1985, 2000), may also moderate the impact of goal-directed movement on animacy judgments. Consistent with this view, goal-directed movement did not signal life or any other biological or psychological capacity to 4-year-olds, who are known to possess less biological knowledge than 5-year-olds (Laurendeau & Pinard, 1962), who did attribute life to the goal-directed agents. Although 4-year-olds were as likely as any age group to say that the goal-directed agents “moved so that [they] could get closer to [the goal]”,¹ they failed to interpret the movement as a signal that the agents possessed any of the characteristics of living and sentient kinds that were tested. Some investigators have proposed that goal-directedness is interpreted psychologically by the age of 4 (Baron-Cohen, 1994; Premack & Premack, 1996) or that intentional behavior *qua* intentional is directly perceived (Dittrich & Lea, 1994). The current results do not support these proposals. Rather, they support proposals (e.g. Csibra et al., 1999; Gergely et al., 1995) that young children initially interpret goal-directed movement as goal-directed and can do so without agreeing on any of the psychological or biological properties that the agent might possess.

Insufficient causal knowledge may have impacted 4-year-olds’ animacy judgments in at least three ways. First, 4-year-olds may represent the distinction between goal-directed and aimless autonomous movement, yet the distinction may not yet play a role in their biological reasoning until they first appreciate how life is caused by goal-directed actions. Csibra and Gergely (1998) have articulated a related argument concerning the elaboration of teleological interpretations into causal mentalistic ones. The current results are consis-

¹ The fact that 4-year-olds (or any age group) affirmed the question, “Did this move so that it could get closer to this thing?” may not definitively confirm the *impression* of goal-directedness. The phrasing of the question may not denote goal-directedness to the participants, especially if they do not differentiate the purpose construction “so that it could” from the purpose-neutral conjunction “and”. Future work may identify the language that best denotes the impression of goal-directedness, as well as the development of this knowledge, but as it stands, I cannot say that the subjects’ *impression* of goal-directedness moderated the effect of the goal, only that the presence of the goal elicited biological attributions.

tent with their conclusions and suggest that they may apply to the biological domain as well. Second, goal-directed movement may play an important role in 4-year-olds' reasoning about living and sentient kinds, but the 4-year-olds did not spontaneously attempt to find reasons for the agents' movement as often as did older children: although 4-year-olds often understand the causes of goal-directed events, explanatory questions are sometimes needed to elicit evidence of this knowledge (Trabasso, Stein, Rodkin, & Munger, 1992). Lastly, 4-year-olds may not differentiate *life* from such non-biological concepts as *real* (Carey, 1985), thought that both the goal-directed and autonomous agents were equally real, and thus failed to distinguish them with respect to life status and causally derivative properties (such as growth and sentience). Each of these three alternatives posits that causal knowledge plays an important role in children's interpretation of goal-directed movement, yet none need assume that the interpretation is mandatory.

Prior knowledge also seems to affect the meaning that older children and adults take from goal-directed movement. Five-year-olds through adults, for example, seem to share the belief that teleological agents are living things. Five-year-olds, for example, predict that only animals will act teleologically (Opfer & Gelman, 2001) and believe that only animals are living things (Carey, 1985; Hatano et al., 1993; Richards & Siegler, 1984); 10-year-olds and adults, in contrast, predict that both plants and animals will act teleologically (Opfer & Gelman, 2001) and typically believe that both plants and animals are living things (Carey, 1985; Hatano et al., 1993; Richards & Siegler, 1984). Recent work suggests that teaching 5-year-olds that both plants and animals act teleologically also convinces them that plants are living things, whereas teaching them that plants and animals share other biological properties (e.g. growth) fails to convince them that plants are living things (Opfer & Siegler, 2001). Children's judgments that novel goal-directed agents are alive are consistent with these findings, suggesting that 5-year-olds through adults use goal-directed movement as a common measure for deciding whether an entity is alive. These results are not consistent with the claim by Carey (1985, 2000) that 5-year-olds' and adults' *living things* concept is incommensurable (literally, "without a common measure").

Differences in prior knowledge – specifically, in the range of organisms known to be living things – may have led to differences in the attribution of psychological properties. Adults' knowledge about such insentient living things as germs and plants (Richards & Siegler, 1984; Solomon & Cassimatis, 1999), for example, should lead them to consider the possibility that an unfamiliar life form has many biological but no psychological properties. Consistent with this hypothesis, many adults identified the goal-directed agent (but not aimless agent) to be a microorganism, and the presence of the goal affected their biological attributions more than their psychological ones. In contrast, younger children may not believe that totally insentient organisms can exist (as Carey, 1985, implied), or at least they do not consider them as a first hypothesis. Either of these possibilities could explain the present results too: when children said that a goal-directed agent was alive, they generally identified it to be a (sentient) animal of some type, and the presence of the goal affected their biological and psychological attributions equally, with the difference between these attributions increasing over time (see Coley, 1995, for a similar observation). Against the former possibility, however, many children do seem to believe that insentient organisms exist. Of the 32 participants in each age group, 12 5-year-

olds, 13 7-year-olds, 16 10-year-olds, and 18 adults at least once attributed biological but no psychological properties to an agent. (No participant, however, attributed psychological but no biological properties to any agent.) These results extend previous findings that young children believe that some animals (such as houseflies) have little to nothing in the way of a mental life (Gutheil, Vera, & Keil, 1998).

Given the range of living, goal-directed agents known by 10-year-olds (e.g. plants; Opfer & Gelman, 2001; Richards & Siegler, 1984), it is surprising that they continued to take the presence of the goal as an equally strong biological and psychological cue. One possibility is that 10-year-olds believe that only plants and animals are alive and simply do not know that other life forms exist. Thus, when they saw a motion that indicated life to them, their task was to decide whether the unfamiliar life form was a plant or an animal. Given that the blob was neither rooted nor leafy nor green, they could have deduced that all the life form alternatives had been exhausted, and thus it was likely that the life form was an animal (i.e. a psychological organism). At the very least, the present data suggest that this is not the whole story. First, nine of 32 10-year-olds identified the agent as a non-plant, non-animal, microscopic living thing (e.g. “blood cell”, “bacteria”, “germ”). Thus, at least some 10-year-olds know that plants and animals are not the only life forms. If we additionally count the number of 10-year-olds who guessed the agent to be part of an organism (e.g. “brain”, “stomach”, “roots”), half named non-animal, non-plant life forms. Clearly, for many 10-year-olds, *living things* is broader than *plant or animal*. Therefore, the fact that the blob did not look like a plant cannot wholly account for their performance.

Another possibility is that goal-directed action affects biological and psychological inferences equally for all ages unless overridden by extra knowledge about the agents themselves (e.g. that plants and microorganisms are insentient). This possibility maintains a prerequisite connection between biology and goal-directedness, credits children with knowing that insentient life forms can exist, and can account for 10-year-olds’ performance. Additionally, it yields two specific predictions. First, 5- through 10-year-olds could behave as adults did just in case they learn that microscopic life forms and plants are insentient. Second, if adults cannot positively identify a goal-directed agent as a plant or microscopic life form (e.g. triangles in Heider & Simmel, 1944), even their attributions may resemble those of 5- through 10-year-olds: that is, blocking all information about the agent itself, goal-directed action may serve as an equally strong biological and psychological cue.

In sum, the results support the proposal that 5-year-olds through 10-year-olds and adults share at least one standard in deciding what is “alive”, that is, to be “alive” is to be an agent capable of goal-directed action (animals for 5-year-olds, animals and other organisms for 10-year-olds and adults). Accordingly, children and adults can identify living things from goal-directed motion alone. However, children and adults may differ in the sorts of psychological capacities they think to correlate with moving toward goals: for children, goal-directedness affected attributions of biological and psychological capacities fairly similarly, whereas for adults, it affected attributions of biological capacities much more than psychological ones. These age differences in biology and psychology judgments suggest that goal-directed action could be an early standard for identifying *living things*, but that other information may play a role in psychology judgments.

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