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Discussion

Motor competence as integral to attribution of goal

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1. Introduction

In a recent article, Gergely et al. (1995) presented some interesting data encumbered, however, by an interpretation we think the data do not support. There is, nevertheless, an interpretation they do support—one which, in our view, gives the data their interest. In order to contrast the authors' interpretation with ours, we begin by presenting a simplified account of their experiment.

The account is simplified not only for brevity, but also because we suspect that much of their procedure is window dressing and has no substantive bearing on the outcome; interested readers can of course find the complete experiment in the original article.

Two groups of infants are shown computer animations in a traditional habituation/dishabituation paradigm. The experimental group is shown two circles of different size separated by a barrier. The smaller circle on the right (Fig. 1) jumps over the barrier, and makes contact with the larger circle on the left.

The scene shown the control group is exactly the same, except for the important fact that, as shown in Fig. 1, there is no barrier between the two circles.

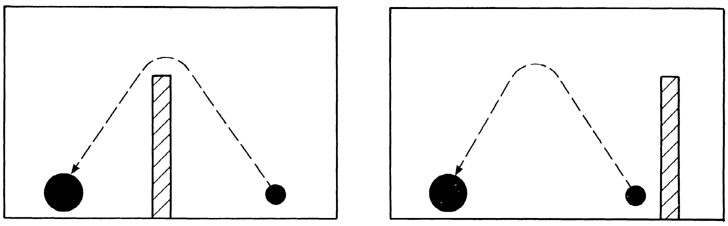

Fig. 1. The small circle jumps over the barrier and contacts the large circle (left panel); the small circle jumps over a non-existent barrier and contacts the large circle (right panel).

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Nevertheless, the smaller circle carries out exactly the same action—jumps over a non-existent barrier, and makes contact with the larger circle on the left.

Both groups are habituated on the scenes described and then tested on two conditions. The barrier is first removed (Fig. 2), and then, in what we will call the direct condition, the small circle heads directly to the larger one. In the indirect condition, the small circle again jumps over a nonexistent barrier when heading to the larger one. There are several outcomes but the main one on which the authors build their argument is this: the experimental group looks longer at the indirect test condition than the direct one, whereas the control group looks equally long at both conditions.

What does this difference indicate? We will tell you what we think in a later section; first, consider the interpretation the authors build on this outcome. Here are the main steps in their argument:

1. Infants take ''the intentional stance'' with respect to some objects (see Dennett, 1987, for details).
2. They do so provided they think the object is ''rational''.
3. They think an object is ''rational'' if, in a choice between paths, it takes the ''shortest path'' (ceteris paribus); though, of course, ''rational'' can be given a broader meaning. In this article it boils down to the shortest path (their treatment of rationality, relying exclusively on Dennett, 1987, makes no mention of the many other, often competing, accounts of rationality that philosophy offers).
4. To take the intentional stance entails attributing ''want'', ''belief'' and intentionality, all the major epistemic mental states, to the object in question.

Now consider the datum on which they base this interpretation: infants in the experimental group look less at the direct condition than at the indirect, while those in the control condition do not. Why? Because, the authors say, the infants in the experimental group take the ''intentional stance'' relative to the small circle, whereas those in the control do not. They do so because in the experimental condition the small circle has taken the ''shortest path'' and is therefore rational; whereas, in the control condition, the small circle has jumped over a non-existent barrier and is therefore not rational.

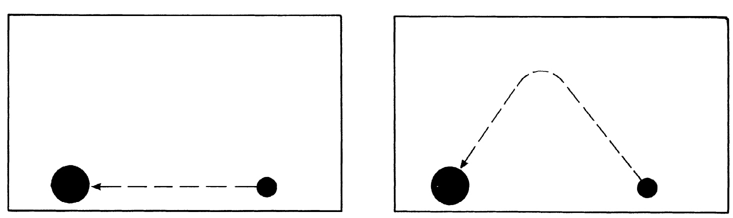

Fig. 2. The barrier is removed. The small circle moves directly to the large circle (left panel); the small circle moves indirectly to the large circle (right panel).

In the test condition, the infants in the experimental group are not surprised when the small circle takes the direct path (even though this differs from the path it took before); rational agents always take the shortest path. Instead, they are surprised when the small circle takes the indirect path (even though this is the same as the path it took before); rational agents should not take non-shortest paths.

These considerations do not apply to infants in the control condition for the small circle did not take the shortest path: it therefore is not rational, and therefore not the kind of object for which one takes the intentional stance. The infants, having assigned no mental states to the object—neither ''want'', ''belief'' nor intentionality—have no expectations as to how it will act, hence, look equally long at both the direct and indirect conditions.

2. What we think the results mean

Rationality is not, in our view, a factor that plays any role in an infant's attribution of intentionality. As a higher-order factor, rationality figures in adult conceptions of mind but not in those of infants (see Premack, 1988, for a critique of Dennett's intentional stance that adumbrates this point). Goal or goal-directedness, not rationality, is in our view the primary factor on which the infant's attribution of intentionality depends. And the authors' data accrue interest because of the contribution they make to the question of whether infants attribute goal-directedness to the objects in question.

To deal with goal, we must do two things: identify the conditions that cause an infant to make this attribution, and devise tests that will diagnose whether or not an infant has made the attribution.

What conditions cause an infant to attribute goal or goal-directedness to the action of an object? We recommend the assumptions contained in our recent model (Premack and Premack, 1994, 1995a,b; Premack and Premack, in press) as providing the best available answer to this question.

According to the model, infants use four properties in attributing goals or goal-directedness. We will discuss three of them here: trajectory, target, and greater than default values.

1. Trajectory is the direction in which an object moves. Because a self-propelled object can move in many directions, its consistent movement in only one direction is significant. There is an interesting parallel between the trajectory of a moving object and that of both gazing and pointing. Infants by 11 months of age follow the mother's gaze; rather than look at her they look where she is looking (Butterworth, 1990; Baron-Cohen, 1995). They react in essentially the same manner to pointing; rather than look at the end of the finger (as many species do) they look where the finger points. We argue that infants react in the same manner to the trajectories of gazing, pointing, or object movement; that is, they anticipate the target, whether the target is being regarded, pointed to, or moved toward.

2. The target at which a trajectory is aimed can be either an object or a location. If an object, it can be either physical or intentional. The location could be the top of a hill that the intentional object seeks to climb, or a break in an enclosure from which an intentional object seeks to escape. The model argues that these three targets—to contact/avoid another intentional object, to overcome gravity, to escape confinement—are salient for the infant.
3. The model further states that infants have default values for ''normal action''. If the frequency/intensity of the object's motion exceeds these values, the infant interprets the action as goal-directed.

What tests shall we use to determine whether or not an infant has attributed a goal? Consider an admirably simple one—so simple, so much the ''shortest possible path'' to deciding whether or not an infant has made the attribution of goal, that we expect every rational experimenter to use it in making this decision.

The following example will clarify the test, which consists of two steps. First, we show infants a self-propelled object, a black ball, that consistently directs its trajectory at a red ball—thus, fulfilling the conditions that the model asserts will lead the infant to attribute goal-seeking to the black ball. Second, we change the location of the red ball. On some trials the black ball accommodates this change, adjusting its trajectory so that it again heads toward the red ball; whereas on other trials it does not. Despite the change in location of the red ball, the black ball maintains its previous trajectory.

If the infants are surprised by the ''failure'' of the black ball to accommodate the change in location of the red ball, and therefore look longer on these trials than on those in which the black ball does adjust to the change in location of the red ball, the test outcome is positive. The infants have attributed a goal to the black ball—that of contacting the red ball.

On the other hand, if there is no difference in the duration for which infants look at the two kinds of trials, the test outcome is negative; the infants have not attributed a goal to the black ball, or at least we have no evidence that they have.

The test illustrates a fundamental entailment of what is meant by ''having a goal''. Why does a goal-directed object accommodate changes in the location of its target? For two reasons. First, because such an object is presently engaged in an action which is not a high-order commitment; the action is merely an instrument, a means for attaining a goal. Second, a goal-directed object has an intrinsic motor *competence*, assuring the object its flexibility, the capacity for change, the capability of appropriate change; for example, if the target moves to the right, the object will not move to the left. Infants may be sensitive not only to the appropriateness of the motor adjustments of intentional objects but also to their form. Biological objects move in characteristic ways—for example, they seldom move backwards or sideways—and infants may distinguish ''natural'' from unnatural motion.

But do infants really ''know'' that goal-directed objects have a motor competence of the kind indicated? Of course, infants do not know that objects have a motor competence of any kind! Nevertheless, the action which infants can be shown to expect of objects to which they attribute intentionality complies with the assumption of such a competence. If infants did not ''assume'' that goal-directed objects were capable of ''flexible appropriate adjustment'', they could not expect a goal-directed object to accommodate changes in the location of its target. And infants of 11 months do react in this manner (unpublished data).

Another test of virtually equal simplicity is suggested—a test which also consists of two steps. First, we place a barrier between the black ball and its target the red ball—a hill, a tunnel, a chasm, anything an infant can recognize as a ''barrier''—and show the black ball consistently surmounting the barrier in the course of contacting the red ball.

Second, we remove the barrier. On some trials the black ball immediately accommodates the change, moving directly to the red ball rather than carrying out actions imposed upon it by the barrier; whereas on other trials it does not, and despite the removal of the barrier continues to carry out actions previously imposed upon it by the barrier.

If infants are surprised by the ''failure'' of the black ball to adjust to the removal of the barrier, and therefore look longer on these trials than on those in which the black ball does make the adjustment, the test outcome is positive. The infants have attributed a goal to the black ball: that of contacting the red one. On the other hand, if there is no difference in the duration for which they look at the two kinds of trials, the test outcome is negative and infants have not attributed a goal to the black ball, or at least there is no evidence that they have.

Alert readers will note a striking similarity between this test and the one the authors conducted—as well as a striking dissimilarity between our interpretation and that of the authors. On our view, a positive outcome demonstrates that the infant has attributed a goal to the object in question; on the authors' view, that the infant has attributed rationality, intentionality, want and belief. Indeed, the authors recommend their test as historic: the first time these basic mental states have been properly demonstrated in infants.

Readers, especially those of a previous generation, may be amused by the fact that infants, in passing both the above tests, show evidence of having better-informed expectations about the behaviour of goal-directed objects than did the majority of learning theorists in the 1940s and 1950s. An infant having seen, say, a rat obtain a target by swimming down a maze, will not be surprised (water having been drained from the maze) to see the rat run down the maze. Though in perfect accord with an infant's expectations, this accomplishment posed a serious problem for behaviourism: how could the rat, having associated the effector events of swimming with the maze, generalize to the quite different effector events of running? The infant's expectancies (having evolved in the real world) accord better with the actual behaviour of the rat than did theories of behaviourism.

By accepting Dennett, who erringly treats propositional attitude theory as a psychological model, the authors claim to have demonstrated the attribution of essentially all mental states—want, belief, and intentionality. From the point of view of our position, they have shown nothing more than the attribution of goal. While propositional attitude is a model of some elegance—considerably more elegant than any yet provided by psychology—it remains a dubious representation of actual psychological process. Its worst feature lies in its treatment of belief as an ineluctable cause of motor change

When a goal-directed object turns left in tracking a left-turning target, it does so, according to Dennett (in agreement with propositional attitude theory), because ''it believes that by turning left it can contact the target''—a completely gratuitous invocation of belief as a cause of motor adjustment! The position is not supported by evidence, but is dictated by the strictures of the classical model. Most cases of motor adjustment follow automatically from the perception of changed conditions, mapping directly onto a representation of such changes. Motor adjustment is not caused by belief.

Dennett therefore errs twice: in advocating an empirically unacceptable model of motor behaviour, and by attributing this mistaken model to the infant. The authors, in adopting the position, perpetuate Dennett's errors. Evidence for belief cannot be based on action as simple as that of motor adjustment.[1]

Now, how shall we apply our interpretation to the negative results of the authors' control group? On our view, the infants in the control group did not attribute a goal to the small ball. Why not? Since the small ball consistently took the same path to the target, why did this not lead the infants to attribute a goal to the object?

That, you should excuse the expression, is an empirical question—and is so for the best of all possible reasons. There is no theory that permits predicting which trajectories will cause an infant to attribute a goal and which will not. For example, consider the possibilities illustrated in Fig. 3.

In panel A (left panel), though a ball jumps over a hill in reaching its target, it jumps higher than needed: not the ''shortest path''. In panel B (right panel), the

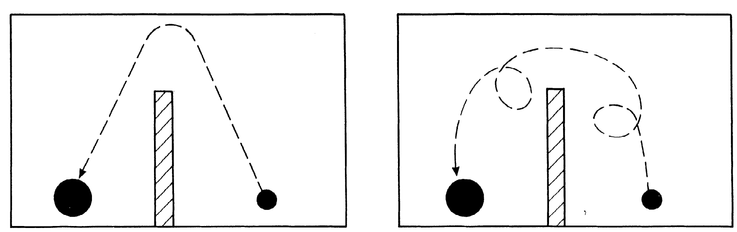

Fig. 3. The small ball jumps over the barrier, but at a height greater than necessary, and contacts the large ball (left panel); the small ball makes two flips in jumping over the barrier, and then contacts the large ball (right panel).

[1] All intentional action is caused by belief according to Dennett's model. However, when we link belief with a specific neural state, and then, whenever we observe an intentional action, hunt for the neural state, we will generally come up empty-handed. A recent study by Sirigu et al. (1996), though only an approximation of the test we want comes engagingly close. These researchers find that while patients who suffer from lesions in the parietal cortex cannot ''image'' certain movements, they can nevertheless execute the movements without difficulty. If we substitute ''belief'' for ''image'' we have exactly what we are looking for: intentional action without belief.

height of the jump is minimal but the ball makes several ''playful'' flips in the course of clearing the hill. Now we invite the reader to imagine panels C, D and E, in which the balls are replaced with ''little men'': creatures with appendages, in order to enlarge the motor possibilities. In panel C, the creature executes a canonical approach, but in D it does not—it walks backwards, while in E, though proceeding face first, it cleans its glasses as it walks and does not look where it is going.

Which of these paths will cause an infant to attribute goal? Will the answer vary with the age of the infant: younger infants being sticklers for propriety, attributing goal only when the path is absolutely canonical; older infants being more liberal, accepting paths younger infants would reject?

The question of whether infants will accept as goal-directed objects that walk backwards, somersault, or clean their glasses while walking, points to a further problem in the authors' formulation. Their treatment of rationality as a precondition for intentionality has consequences which are both bizarre and unacceptable.

The treatment of rationality as a precondition for intentionality has the untenable consequence of completely eliminating the category ''irrational'' or ''non-rational''. That is, if an object must be rational in order to be intentional, there can be no non-rational intentional objects. (On the other hand, the authors might wish to be applauded for an act of genius in eliminating irrationality by a legislative stroke.) Neither is it acceptable, even for introductory purposes, to reduce rationality to: ''taking the shortest path''. Rationality is the business of the adult and needs to be given a treatment in keeping with adult mentality.

Hume's classic treatment (Hume, 1739) is a favourite starting point. Briefly, an individual who is both informed and able to soundly calculate probabilities will, if rational, use this capacity to realize his preferences; he is irrational otherwise. Many dissent from this view, needless to say, a favourite riposte being that preferences themselves can be irrational, so that even if one did justice, or especially if one did justice to one's preferences, one would be irrational (see Gibbard, 1994 for an incisive recent discussion; Hare, 1979 and Ramsey, 1931 for classic earlier ones).

Taking the shortest path in the pursuit of a target, like not turning left when a target turns right, is evidence, not for rationality, but for motor competence. It is the kind of competence that adults ascribe to, and even young infants expect of, intentional objects.

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