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When 2-Year-Olds and 3-Year-Olds Think Like Scientists

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Abstract

In this article, which includes three video clips, the author argues that the small experiments, inventions, strategies, and pauses in young children's play seen in the clips reveal a legitimate form of scientific thinking. He notes that science and play both represent a frame of mind, an attitude toward the events one observes.

Introduction

We do not necessarily call all fun-filled behavior "play." Playfulness comes when children care less about reaching a particular goal and more about the energy or irony of the process. Play has an element of pretense, sometimes a sense of "the joke." Nor do we apply the adjective "scientific" to all of children's cause-and-effect thinking. Scientific thinking involves both a prediction and a method of testing the prediction; it comes about when a child both predicts and plays with an outcome.

Testing First

Science uses a variety of methods of investigation. Testing is one such method. Imagine a 3-year-old boy in the act of "testing first." The child pulls on the bottom strand of a clothesline that stretches in a circuit between two pairs of pulleys on opposite walls of the room. A basket that is attached to the top strand moves away from the child as he pulls the bottom strand toward him. Surprised that pulling the line attached to the basket makes it go away, the child pauses. The teacher, in full view of the child, then attaches the basket to the bottom strand. This time, the child does not make a complete pull on the rope. Rather he holds the rope lightly and moves it back and forth slowly to see which way the basket moves. Only after this confirmation—that pulling causes the basket to approach—does the boy make a full commitment to pulling the line toward himself.

Where is the science in this behavior? Had the boy simply pulled the bottom rope again, I would not view this behavior as an indication of scientific thinking. I might call it a prediction or an expectation but not a method of testing a prediction. Causing an action is not the same as testing an expectation that an action will occur when a cause is fully implemented. In other words, there is a difference between an instrumental action (I will do *X* to make *Y* happen) versus a testing action (I will do *Z* to see if *Y* will happen if I were to do *X*). (In this case, "I will pull lightly to see if the basket will come toward me if I were to pull more firmly.")

Sensing the Problem

Perhaps the first phase of early scientific thinking occurs when a child treats a situation as a problem. The problem, as framed by the child, determines the strategy that the child uses to solve the problem. For example, a child sees her mother in a new hat. The child thinks, "Whooaaa, who is that? Looks a little like my mommy but also looks like a stranger." The child grabs the hat to remove it from her mother's head. We can assume that the child understands that the discomfort of being with someone who seems like a stranger could decrease if she reestablishes the more familiar full face of the mother.

The child's being upset, in itself, is not sufficient grounds for us to say that she has sensed a problem. Problems are defined by the strategies used to solve them. For us to know that a young child has sensed a problem, we need to see that she is implementing a strategy. And all strategies are based on assumptions that give plausibility or sensibleness to the particular strategy used. The idea to lift the hat derives from the child's assumptions that the hat was not part of the face and that the face without the hat might be more familiar. (Imagine the child's surprise if a heap of purple hair fell forth from the rising hat!)

Inventing a Strategy

How do we know that the action is a strategy the child has come up with to solve a problem or simply another instrumental act to create an effect? The child who removes the hat may have wanted to put it in her mouth. And to call "the lack of hat in mouth" as a problem to solve begins to sound like a tautology. We look to the context to decide:

1. Mother comes on scene with hat.
2. Child begins to fret.
3. Child removes mother's hat.
4. Child smiles as mother's full face is revealed.
5. Child puts hat in mouth.

Within this context, it appears that the child constructs the problem as "The hat makes my mother look strange," which itself derives from the following assumptions:

1. The hat is not part of that face.
2. I can remove that part of the visage.
3. I will then see the more familiar face of my mother.

In this example, then, the child has identified a problem rather well, which is an important component of devising a method of solving the problem. We can call this method testing an effect by eliminating a cause (the way the hat causes the face to appear strange). This early form of scientific thinking eventually leads to the classic "isolation of variables" to discover which variables lead to which effects.

Finding a Class of Causes

Young children commonly exhibit a scientific method that deals with variation. You have seen it. A child discovers how to create an effect but then sets about to experiment with the range of actions that create this same effect: a single class of causes. Piaget (1952) writes of his child dropping a wad of paper into a basket. She derives great joy from seeing the paper fall within the rim of the basket instead of on the floor. Shortly after mastery of this basic cause and effect, she begins to play with the position of the release, releasing the paper a little to the right on one attempt, then a little to the left on another. She soon discovers the range of positions that allow the paper to fall within the basket.

So what else might we say she can discover through this period of experimentation? She may learn that the range of positions for successful drops is slightly smaller than the diameter of the basket rim. She may learn something about the degree of causality, a form of knowledge that is more than simply knowing what causes an effect. The cause of the successful drop in the basket is neither from a position *all* the way she can reach to the right nor *none* of the way to the right. Nor does success happen only from a drop dead center over the basket. The cause of success has a range, a degree of variation correlated to success (paper falling within the rim of the basket), that is, a class of causes. And at a certain age, children find this range intriguing. They are compelled to play with this range to determine its bounding limits. That's science.

Wondering about the Nonrandom

When children are new to the world of what-causes-what, they may not be amazed by nonrandom effects. Indeed, the recognition of the nonrandom presupposes a sense of the random. Why would repeatedly rolling billiard balls down a ramp cause the balls to roll across a table, rebound twice, and stop in essentially the same spot on the open table? In this clip, we listen to 3-year-old Ben question this pattern. Were he a year younger, he might accept the clustering of the balls as a non-event. At his age, however, he realizes that something happened that needs to be explained. Do the balls "decide" to join each other? No, balls are not alive. Do the balls have some sort of magnetic attraction to each other? Well, none that he can create by moving them closer together. Ben's search for the constraints that determine this clustering comes from a knowledge that the round objects can, and usually do, roll every which way—but for some *reason,* these roll in only one way. He is not amazed that the balls roll straight in the groove formed by the two cue sticks, but he is amazed about the clustering because he does not yet appreciate the action and reaction of the angle of incidence and coincidence when the balls hit the cushion. As a good scientist, he realizes that some constraint, less obvious than the parallel cue sticks, *must* be operative in this situation, and he wants to know what it is.

Video 1. Ben wonders about the clustering of billiard balls that he has rolled down a ramp.

Improving the Readability of an Event

Scientists understand that to observe an event so that it can be measured, one often must augment the clarity of that event. In science labs, this augmentation is done with histological stains, microscopes, oscilloscopes, and gauges to make the relevant attributes of an event more visible, more readable. For example, how does one measure a force if there is no movement, such as in the case of a weight lifter straining to lift 600 pounds? Perhaps we put a pressure gauge on the bar he holds and watch the needle move even if the barbell does not. Inventing methods to augment the readability of hard-to-see events supports the advance of science.

In this next video, you will observe a boy using a strategy that, functionally speaking, allows him to see a force that otherwise goes unnoticed. In this clip, two boys (3 years old) place different objects in a wind tower. The boy with the darker hair at first moves the feather in his hand into the wind flow and immediately releases the feather. He must have some sense that not only does the wind move the feather upward but it also pulls the feather from his hand. But he cannot see the pulling, only the rapid rise of the feather. Several times, he holds the feather firmly in the wind flow without releasing it. The feather bends upward but does not rise into the air column. The bending allows the boy to see the pulling force of the wind. Before he could only see the lifting force of the wind. He has invented a strategy that allowed him to see a force that was otherwise not “readable.”

Video 2. Two boys try different strategies when placing objects in a wind tower.

Understanding Reciprocal Relations

In this last example, we see a 4-year-old boy standing on a board that pivots on a pipe underneath. When he stands with his weight on the right side, the board tilts all the way down to touch the ground on the right.

Video 3. *A 4-year-old boy explores how to balance on a board.*

When he shifts his weight to the left side, the board tilts all the way down to the left. We catch the action as he seeks the in-between, that is, balance. To find the in-between position, he must implement two reciprocal forces simultaneously—a little push down on the right at the same time as a little push down on the left. Earlier, he was applying only one force at a time. But these are not simply two forces, like twisting at the waist at the same time you swing a baseball bat with your arms so that you will double the distance of your hit. These forces on the pivoting board are opposing forces. The child must recognize a paradox: Together the forces do not undo each other. They yield something positive—the balance of the board. His actions indicate that he has moved beyond thinking that causes are always causes only and effects are always effects only. Indeed, effects can be causes if two effects are part of the same system.

Scientists know to think about causes in a system of other causes. They recognize that a primary cause can have a reciprocal cause that attenuates the primary effect. Indeed, most systems of any complexity will have two or more causes in operation. Children even at the age of 4 begin to think about systems of interrelated causes, how one cause compensates, attenuates, negates, or balances the effects of another cause.

Summary

I hope you now see how these small experiments, inventions, strategies, and pauses in young children's play reveal a legitimate form of scientific thinking. Science and play both represent a frame of mind, an attitude toward the events one observes. From the simple "Can I make this happen again?" to the more complicated "Does this cause negate the effects of that cause?", the child thinks like a scientist, trying to find the pattern, the structure, the cause, or the degree of the events that happen during ordinary moments of play. I will not say these mind-sets are inborn, but I will say that children do not need direct instruction on how to play. But they need the partnership of another mind, older and equally curious, with which to wonder out loud.

Reference

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