Young Children's Understanding of Random Phenomena

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KUZMAK, SYLVIA D., and GELMAN, ROCHEL. *Young Children's Understanding of Random Phenomena.* CHILD DEVELOPMENT, 1986, 57, 559–566. 2 experiments on the development of the understanding of random phenomena are reported. Of interest was whether children understand the characteristic uncertainty in the physical nature of random phenomena as well as the unpredictability of outcomes. Children were asked, for both a random and a determined phenomenon, whether they knew what its next outcome would be and why. In Experiment 1, 4-, 5-, and 7-year-olds correctly differentiated their responses to the question of outcome predictability; the 2 older groups also mentioned appropriate characteristics of the random mechanism in explaining why they did not know what its outcome would be. Although 3-year-olds did not differentiate the random and determined phenomena, neither did they treat both phenomena as predictable. This latter result is inconsistent with Piaget and Inhelder's characterization of an early stage of development. Experiment 2 was designed to control for the possibility that children in Experiment 1 learned how to respond on the basis of pretest experience with the 2 different phenomena. 5- and 7-year-olds performed at a comparable level to the same-aged children in Experiment 1. Results suggest an earlier understanding of random phenomena than previously has been reported and support results in the literature indicating an early understanding of causality.

Understanding probability and randomness can be central to effective reasoning concerning everyday phenomena (Nisbett & Ross, 1980). The research reported here assesses children's early competence in this area. The particular concern is with children's understanding of "random phenomena." By a "random phenomenon," we mean a physical phenomenon that is conventionally viewed as having a number of equally probable outcomes (e.g., the roll of a die or the toss of a coin).

Two basic characteristics of random phenomena are that (1) details of the mechanism by which outcomes are produced are uncertain (e.g., the orientation of a tossed coin when caught in the air is uncertain), from which it follows that (2) the individual outcomes of the phenomenon are unpredictable. Piaget and Inhelder (1951/1975) addressed the question of young children's understanding of these characteristics of random phenomena. They identified the understanding of the "nondeducible" nature of random phenomena and the "logical unpredictability" of their outcomes as the first fundamental step in the development of the idea of chance. According to Piaget and Inhelder, this understanding appeared about the age of 7 years, with the emergence of concrete operational thought. Operational thought permitted the first understanding of causal necessity and logical deduction, which enabled the understanding of random phenomena in contrast.

Piaget and Inhelder drew their conclusions from children's responses to several different physical phenomena, including: a spinner with eight colored sections, a box containing two colors of marbles that could be tilted back and forth on a pivot, and a bag

For their comments on early drafts of this work, we thank C. R. Gallistel, Lila Gleitman, and Elizabeth Spelke. We also thank several anonymous reviewers for their helpful comments. The work reported here was part of the first author's thesis research. Partial support for this work came from NSF grant no. BNS-8140573 to the second author. The first author worked on the manuscript while a postdoctoral fellow at the Learning Research and Development Center, University of Pittsburgh, and funded by the Personnel and Training Research Programs, Psychological Sciences Division, Office of Naval Research, under contract no. N00014-82-K-0613, Contract Authority Identification no. NR 154-497. The second author helped with the manuscript while she was a fellow at the Center for Advanced Study in the Behavioral Sciences and supported by funds from the Alfred P. Sloan and Spencer Foundations as well as NIHHCD Senior Fellowship no. F33HD06623. Address correspondence to the first author at: AT &T Bell Laboratories, 1 Whippany Road, Whippany, NJ 07981.

[*Child Development*, 1986, 57, 559–566. 0009-3920/86/5703-0015$01.00]

from which counters of different colors could be drawn. Children younger than about 7 years tended to say they knew where the spinner would stop and/or to make predictions of specific colors. They tended to predict orderly changes in marbles' positions in the tilting box, instead of progressive mixture. They tended not to base their predictions of colors drawn from the bag on the relative proportions of colors in the bag. Children's reasons for their predictions could often be interpreted as indicating a belief in a "hidden" and "arbitrary" order underlying outcomes (e.g., for the spinner, "Because it goes very quickly to the same color"). In a study using the tilting box and mixing counter tasks, Green (1978) has replicated some of these results.

Although Piaget and Inhelder took such results to mean that young children do not understand the physical nature of random phenomena and the unpredictability of their outcomes, there are alternative explanations. The studies may have failed to reveal competence because: information indicating randomness was not salient (e.g., in the bag of counters, the mixture occurs hidden inside the bag), the child could focus on determined aspects of the mechanism (e.g., for the spinner, the force of the spin *is* related to the distance traveled, and for the tilting box, there *is* a tendency for marbles to return near their original positions), or the intent of the questions posed to children was not clear (e.g., for the spinner, the question, "Can we know where it will stop?" could be interpreted as a request to hazard a guess). In the experiments presented here, we attempted to remove these factors as possible influences on performance.

Fischbein, Pampu, and Minzat (1975) presented evidence that 5–7-year-olds in fact have an early "intuition" of randomness, that is, a sensitivity to uncertainty, but without a deep understanding of the physical nature of random phenomena. Children were presented with an apparatus in which a marble could follow two equally likely paths and were asked, ". . . where will it come out at the bottom? Will it always come out there, or can it come out in other places?" Children responded that the marble could come out either way, thus demonstrating, according to Fischbein et al., that "they could distinguish clearly between certainty and uncertainty." However, they failed to give physical explanations for the uncertainty, showing "a reduced capacity for analysis and a relative indifference to detail." In fact, the results of Fischbein et al. are ambiguous because responses were not collected for a determined phenomenon. The wording of the question may have encouraged the children to give "either/or" responses, which they likewise would have given for a determined phenomenon. That the wording of a question can affect the tendency to give an either/or judgment is illustrated by the finding of Cohen and Hansel (1955) that only a minority of 12- and 14-year-olds gave an either/or judgment for the tossing of a coin. Thus an early understanding of the physical nature or unpredictability of random phenomena remains to be established.

Recent work on children's understanding of physical causality raises the possibility that young children may have an understanding of the physical nature of random phenomena. Preschool-aged children are sensitive to the role of mechanism in a determined cause-effect sequence (Bullock, Gelman, & Baillargeon, 1982; Koslowski, Spilton, & Snipper, 1981; Schultz, 1982). Children thus might be expected to have a corresponding understanding of physical mechanism for random phenomena.

Two studies are presented here in which we assessed children's understanding of random phenomena. Our approach differs from previous studies because children were questioned regarding both a random and a determined phenomenon, in particular, with regard to the predictability of their outcomes. In studies with determined cause-effect sequences, the presence of contrasting conditions has been effective in eliciting responses from young children (Bullock et al., 1982). If children are insensitive to the different physical mechanisms, then they should fail to give differentiating responses to the two phenomena. However, differential responding to the two phenomena would suggest some understanding of the physical nature and unpredictability of random phenomena. Children's ability to explain the unpredictability of the random phenomenon provides further evidence of understanding.

Experiment 1

Subjects.—Forty-eight preschool and elementary school children participated in the experiment, 12 from each of four age ranges: 3-3 to 3-9 (M = 3-7), 4-1 to 4-11 (M = 4-8), 5-0 to 6-1 (M = 5-6), and 7-0 to 7-8 (M = 7-5). The children were predominantly middle class and formed an interracial sample. Half of the children in each age group were male and half female.

Apparatus.—Children were presented with two physical phenomena, one chosen to be clearly random and the other to be clearly determined (Fig. 1). The random phenomenon or "marble cage game" consisted of a steel cage filled with blue, red, and yellow marbles, 10 of each color. When the handle of the cage was turned, marbles would mix inside the cage, and periodically a marble would fall out of the cage via a rotating cup. The determined phenomenon or "marble tube game" consisted of a clear plastic tube mounted vertically on a wooden stand, filled with blue, red, and yellow marbles (seven of each color, ordered haphazardly). At the base of the tube was a knob which, when turned back and forth, would release the marble at the bottom of the tube to fall into a plastic ramp below.

Additional materials used in playing a "guessing game" during the course of the experiment were: a set of white plastic chips; two long thin blocks of wood or "pegboards," each with 12 holes drilled in a line on its top surface; and a set of blue, red, and yellow pegs.

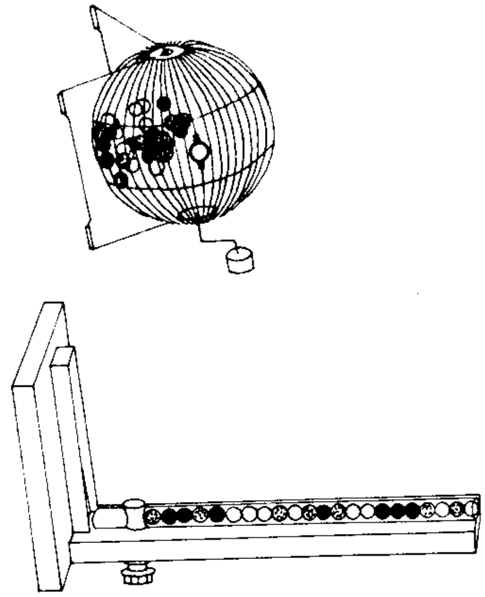

FIG. 1.—The marble cage and marble tube phenomena (random and determined, respectively) used in questioning children.

Procedure.—Children were individually tested in a four-phase experiment, which lasted approximately 25 min. During Phase 1, for each of the "games" in turn, the experimenter demonstrated how it worked and then let the child operate it several times. To orient the child to answering questions about the mechanisms, the child was asked how marbles came to get outside the mechanism. Children typically responded by mentioning the hole at the bottom of the tube for the tube and the rotating cup for the cage. Children were then given a few more turns at operating the game. Order of presentation of the games was counterbalanced within each age × sex group.

The first assessment of whether children understood the physical nature of the random phenomenon and the unpredictability of its outcomes occurred in Phase 2. For each phenomenon, the child was asked a "question about knowing": "Tell me, when you play with this game here, do you *know* which color is going to come out next? Yes or no?" To minimize children's tendency to interpret this as a request to guess a color, the experimenter placed heavy emphasis on the word "know" and included the yes-or-no tag. If, nevertheless, the child simply stated a color, the experimenter said, "No, *yes* or *no*. Do you *know* what color is going to come out? Yes or no?"[1]

Children were also asked to explain their responses. Children who said they knew which color would fall out of the apparatus were asked first what color it would be and then why that color would occur. Children who said they did not know which color would fall were asked why. If they simply repeated that they did not know, the experimenter pursued by asking, "But why don't you know?" Children's responses to these and later questions were tape-recorded for later transcription. The order in which the two games were presented was the same as for Phase 1.

In Phase 3 of the experiment, children had extended experience interacting with the two phenomena, which it was thought might increase their likelihood of showing understanding in their responses. Children played a "guessing game" with each phenomenon, consisting of 12 trials in which they predicted a color to fall next and then operated the mechanism to make a color fall. Correct pre-

[1] The question was restated in this manner for 15 out of 96 occasions on which children were questioned in Phase 2 (each child was questioned regarding tube and cage). Seven changed their response to "yes," 5 to "no," and 3 continued to give some other response.

dictions were rewarded with white plastic chips. In addition, children recorded the color of the marble that fell on each trial by placing a peg of that color in a wooden board. There were 12 holes in a row in the board, so that after 12 trials, children had placed a colored peg in each hole, and that guessing game was over. Thus, when children had finished the two guessing games, they had in front of them the two physical phenomena, the two piles of white chips collected, and two filled pegboards. The colors in each pegboard were arranged haphazardly, as would be expected. Most children collected 12 chips for the marble tube because its outcomes were predictable and, in contrast, collected far fewer chips (i.e., 2–6) for the marble cage.

In Phase 4, children's understanding was reassessed to determine the impact of the extended experience they had obtained. With the records of Phase 3 still before them, children were asked the set of questions from Phase 2.

Results.—Children's responses to the questions about knowing were coded as (1) *yes* if the child responded "yes," and when asked what color would occur, predicted a color; (2) *no* if the child responded "no"; and (3) *ambiguous* otherwise, including such responses as saying "yes" but failing to predict a color when asked (a contradiction) or failing to answer the yes-no question (even when repeated) and simply predicting a color. If children understood the physical nature of the random phenomenon and the unpredictability of its outcomes, then they should respond *no* for the marble cage and *yes* for the marble tube (*no/yes*). The number of children who correctly differentiated the phenomena in this way appears in Table 1. *No/yes* responses were not significantly related to either sex of child ($\chi^2[3, N = 27] = 3.67, p < .5$, for Phase 1; $\chi^2[3, N = 29] = 2.78, p < .5$, for Phase 2) or order of presentation of the phenomena ($\chi^2[3, N = 27] = 1.00, p < .9$, for Phase 1; $\chi^2[3, N = 29] = 2.11, p < .75$, for Phase 2), so these variables are not considered below. On the conservative assumption of a .25 probability of children responding *no/yes* by chance,[2] all but the 3-year-olds showed a significant tendency to respond in this manner (binomial

TABLE 1

NUMBER OF CHILDREN WITH DIFFERENT RESPONSE PAIRS TO THE QUESTION ABOUT KNOWING FOR THE MARBLE CAGE AND MARBLE TUBE (Experiment 1)

	CAGE RESPONSE					
	Phase 2			Phase 4		
TUBE RESPONSE	Yes	Ambiguous	No	Yes	Ambiguous	No
Age 3:						
Yes	1	3	1	0	3	2
Ambiguous	1	0	1	1	2	1
No	0	3	2	0	1	2
Age 4:						
Yes	3	1	6*	2	1	6*
Ambiguous	1	0	0	1	0	2
No	1	0	0	0	0	0
Age 5:						
Yes	0	1	8**	1	0	9**
Ambiguous	1	0	1	1	0	1
No	0	0	1	0	0	0
Age 7:						
Yes	0	0	12**	0	0	12**
Ambiguous	0	0	0	0	0	0
No	0	0	0	0	0	0

NOTE.—Responses of the 12 children of that age are tabulated in each age × phase subsection of the Table.

* $p < .05$, binomial test, $N = 12$, $\theta = .25$.

** $p < .005$, binomial test, $N = 12$, $\theta = .25$.

[2] The .25 probability is based on the assumption of a .5 probability for responding either yes or no. Given the possibility of ambiguous responses, however, those probabilities should be less than .5.

tests, $N = 12$, $\theta = .25$, within age × phase groups, $p < .05$). There was an effect of age on the number of children giving *no/yes* responses (Wilcoxon rank sum test, $N = 48$, $p < .0001$).

To see whether even the 3-year-olds treated the random phenomenon as "less predictable" than the determined phenomenon, a second analysis of responses was conducted. The number of 3-year-olds treating the random phenomenon as less predictable, that is, responding *no/yes, no/ambiguous,* or *ambiguous/yes* for the cage and tube games, respectively, was compared to the number treating the random phenomenon as more predictable (giving the reverse of the above responses). Although children tended to treat the marble cage as less predictable, the tendency was not significant (binomial test, $N = 9$, $\theta = .5$, $p < .5$, for Phase 2; binomial test, $N = 8$, $\theta = .5$, $p < .15$, for Phase 4). Among the 3- and 4-year-olds, the children who were not near ceiling in giving *no/yes* responses, children's responses from Phase 2 to Phase 4 did not change significantly (sign test on individuals' improvement in differentiating the phenomena, $p < .5$). Thus Phase 3 experience had no effect.

While the 3-year-olds gave no evidence of appreciating the unpredictability of the random phenomenon, neither did they give evidence of treating both phenomena as orderly and predictable, thus failing to confirm an early stage of development described by Piaget and Inhelder. *Yes/yes* responses would indicate a tendency to view both phenomena as predictable, corresponding to the tendency Piaget and Inhelder observed for children to say they knew what the outcome of a random phenomenon would be and to predict an outcome. As can be seen in Table 1, however, no more than three children (out of 12) at any age responded in this way. Further, children's explanations for *yes/yes* responses did not tend to express a belief in hidden order: for example, children said, "They have a little cup," or "Because it was first, here [near the front of the cage]," or "Cause you guessed." Indeed, the even distribution of 3-year-olds' yes-no-ambiguous responses would be consistent with the children simply failing to understand the question.

Additional evidence concerning children's understanding comes from their explanations of their yes-no responses. Three kinds of explanations were scored as "appropriate" for the random phenomenon. Each involved identifying a characteristic of the phenomenon that actually made its outcomes unpredictable. Categories were those that (1) mentioned that the marbles inside the cage were mixed up, (2) described some aspect of how the marbles moved in relation to the cup when the cage was turned, making the color to occur unpredictable (e.g., mentioning that many marbles move near the cup when the cage is turned), and (3) mentioned that one could not see how the marbles were going when the cage was turned. Examples of each, respectively, are: (1) "Because I don't know if the same color's coming up, because they're all mixed up in one cage"; (2) "Because it was so much colors that I didn't know . . . . Because whichever one gets in here [the cup], we don't know which. If it falls out like back into here [the cage], we don't know when it comes in here [the cup]. If we think it's going to come out, it may not . . . "; and (3) "But that one's a tricky one cause there's all different kinds of these and it goes around and around and around and you can't see it, but in this one [tube] you could see cause it's right at the bottom and you just turn it [child turns it] and take it out." Most of children's "appropriate" explanations were of the first type.

All other responses children gave were coded as "inappropriate." These responses either failed to describe a characteristic of the phenomenon that made its outcomes unpredictable or referred to a factor that was common to both phenomena, for example, "Because you have to see if it's gonna be red," or "Because there's all different colors, and you don't know which one's gonna come out, what color's gonna come out."

Explanations were coded by two independent raters. Interrater agreement was 95%. Those protocols for which conflicts could not be resolved by discussion were scored as inappropriate.

In Phase 2, 1, 6, 8, and 12 of 12 children at ages 3, 4, 5, and 7, respectively, correctly differentiated the marble cage and marble tube in their responses. The observed proportions of these children also giving an appropriate explanation for the marble cage are .00, .33, .75, and .75 for the 3-, 4-, 5-, and 7-year-olds, respectively. The comparable observed proportions for Phase 4 responses are .00, .33, .78, and .83. Again, the extended experience gained during Phase 3 did not have an effect ($\chi^2[3, N = 36] = .13$, $p < .99$). The youngest children, then, were unable to provide appropriate explanations. In contrast, a substantial number of the 5- and 7-year-olds were able to identify an appropriate characteristic of the random phenomenon in explanation, thereby providing additional evidence of their understanding of the physical nature of the phenomenon. Their reference to characteristics of the mechanism in explanation of the indeterminability of outcomes fits with the Piagetian view that an appreciation of causal factors underlies an understanding of randomness.

If children were able to use information about mechanism, they should have been able to predict successfully the colors that would fall from the marble tube in Phase 3. They might also be able to describe features of the tube mechanism. In fact, children predicted colors accurately. The observed proportions of children who predicted correctly on all 12 trials were .58, .92, 1.00, 1.00, for the 3-, 4-, 5-, and 7-year-olds, respectively. Proportions predicting correctly 8–11 times were .17 and .08 among the 3- and 4-year-olds, respectively. Thus, even the 3-year-olds showed a significant tendency to make correct predictions (binomial test, $N = 12$, $\theta = .0002$, $p < .0000$). Most of the children's explanations for why a color would fall referred to that color being "on the bottom" of the tube. While these results are consistent with an understanding of mechanism, another possibility is that children, in their brief preliminary experience with the phenomenon, simply learned as an empirical rule that the bottom marble comes out and gave their predictions and explanations on that basis.

In sum, children between the ages of 4 and 7 gave evidence of understanding randomness by indicating that they did not know what outcome would be produced by the random phenomenon in contrast to the determined phenomenon. Five- and 7-year-olds gave additional evidence by providing "appropriate" explanations of why they did not know the outcome of the random phenomenon. These results are consistent with an understanding of the physical nature of a random phenomenon and the unpredictability of its outcomes in young children. However, because the children had pretest experience observing the two phenomena produce outcomes, children's responses may have been simply based on having discovered an empirical rule for predicting outcomes for the marble tube but not for the marble cage. The second experiment was conducted to test this account for the 5- and 7-year-olds' data, the children who both differentiated the phenomena and provided appropriate explanations.

Experiment 2

Subjects.—Twelve 5-year-olds (5-0 to 5-11; M = 5-6) and 12 7-year-olds (7-0 to 8-1; M = 7-9) from the same population as above served as subjects. Half of the children at each age level were male and half were female.

Apparatus.—The apparatus included the same two physical phenomena as above, but with each now fixed so that it would not produce outcomes when operated. For the marble cage, a black piece of clay the size of a marble was placed in the metal cup through which marbles usually fell from the cage. The handle could be turned to make the marbles mix inside the cage, but no marbles could fall out. For the marble tube, a metal pin was inserted into the tube just above the knob mechanism. The pin held back the marbles, so that when the knob was turned, no marbles would be dispensed.

Other materials used in playing a simple preliminary game included two small plastic boxes with covers (one clear, one black); each was just large enough to hold one of three marbles (white, black, and green).

Procedure.—Children were tested individually in a two-phase experiment that lasted approximately 20 min. The session was tape-recorded for later transcription.

During Phase 1, children were given some preliminary experience designed to engage them in activity and to increase their likelihood of properly interpreting the experimental questions of Phase 2. The experience was intended to orient the child to the task, just as Phase 1 experience in Experiment 1 had done, but without providing experience observing outcomes being produced by the marble tube or cage mechanisms. The preliminary experience consisted of answering "questions about knowing" regarding the two plastic boxes and three marbles. The training in answering "questions about knowing" might increase children's likelihood of properly interpreting experimental questions, providing a more accurate assessment of children's understanding in Phase 2.

Over a series of trials, the experimenter mixed the three marbles in her hand and surreptitiously placed one in the clear box, one in the black box, and kept one hidden in her hand. Pointing to the clear box, the experimenter then asked children if they could *know* what color marble was in the box; children invariably answered "yes." Then the experimenter asked the same question for the black box. If children responded by simply stating a color, the experimenter repeated, "No, just say yes or no. Do you *know* which color marble is in the box?" If children said "no," then the procedure continued as described below. However, if children said "yes," the experimenter made comments designed to make it clear that "no" was the appropriate response to the question. For example, she said, "In this game, I want you to say you know something only if you really, really know something. Now do you know what color is in the black box? Yes or no?" If children still persisted that they knew which color was in the box, the experimenter made additional comments, such as asking whether another color could be in the box. Or she explained that they could not know for certain because they could not see inside the box and the marble inside could be either of two colors. When children finally said "no" for the black box, the experimenter went on to show them the marble that was in her hand. Children were then asked again whether they knew what color was in the black box, and they invariably responded "yes" and indicated the correct color. Children were then invited to open the black box to check to see that they were right. Thus the first trial of this "game" was concluded. A second trial followed, and if children correctly responded "no" for the black box on both trials, Phase 1 concluded. Otherwise, trials continued until the child initially responded correctly regarding the black box. All children responded correctly by the third or fourth trial.

In Phase 2, the marble cage and marble tube were introduced. For each mechanism in succession (order counterbalanced), the experimenter described and labeled its various parts and demonstrated its operation. However, since each mechanism was "fixed," neither produced any marbles. Children were then given an opportunity to operate the mechanisms, again with no marbles being produced.

Children were next questioned regarding the two phenomena in the same order as the phenomena had been originally presented. Children were asked a question or series of questions about "unfixing" each phenomenon (i.e., removing the clay or pin), which ended in them predicting that a marble would then fall out. The interview then proceeded as in Experiment 1, with children asked whether they *knew* which color would fall; if no, why not; and if yes, which color and why. If children correctly differentiated the phenomena in their responses, they were asked again why they said they did not know for the marble cage game but did know for the marble tube.

Results.—Children's responses to the "questions about knowing" for the marble cage and tube were coded as in Experiment 1: *yes*, *no*, and *ambiguous*. Children's *no/yes* responses were not significantly affected by either sex of child ($\chi^2[1, N = 17] = .54, p < .5$) or order of presentation of the phenomena ($\chi^2[1, N = 17] = 1.29, p < .5$).

A significant number of children in both age groups, 7 out of 12 5-year-olds and 10 out of 12 7-year-olds, correctly responded *no* for the marble cage and *yes* for the marble tube (binomial tests, $N = 12, \theta = .25, p < .05$ and $p < .001$, respectively). Because the children had no experience watching the phenomena produce outcomes, their correctly differentiating judgments must have been based on the different physical characteristics of the phenomena. Their responses thus provide evidence of some understanding of the physical nature and unpredictability of random phenomena.

Of the children providing correctly differentiating responses, 71% of the 5-year-olds and 100% of the 7-year-olds gave "appropriate" explanations (as coded in Experiment 1).

Summary and Discussion

The two experiments provide converging evidence that 5-year-olds and possibly 4-year-olds have some understanding of the uncertainty in the physical nature of random phenomena and the unpredictability of their outcomes. In Experiment 1, 4-year-olds correctly differentiated the predictability of the random and determined phenomena; in addition, 5- and 7-year-olds gave explanations mentioning "appropriate" characteristics of the random phenomenon. In Experiment 2, where responses had to be based solely on a consideration of mechanism, 5- and 7-year-olds again correctly differentiated the phenomena. This evidence suggests an earlier understanding of random phenomena than previously has been reported (i.e., Fischbein et al., 1975; Piaget & Inhelder, 1951/1975). Such factors in the experimental design as the use of a simple random mechanism, the presentation of a determined mechanism as a contrast, the formulation of the question, and the persistence in obtaining a yes-no response may have contributed to the result.

Despite the evidence of earlier understanding, results are consistent with Piaget and Inhelder's suggestion that the understanding of both random and determined phenomena depends on an understanding of causality. Children's correct differentiation of the two phenomena indicates a sensitivity to the physical nature of both mechanisms. To the extent that an understanding of random phenomena reflects an understanding of causality, then, the experiments can be interpreted as indicating an early understanding of causality in children, a conclusion that is consistent with other results in the literature (e.g., Schultz, 1982).

In Experiment 1, children who failed to differentiate the phenomena did not tend to behave as if they viewed all phenomena as predictable, with a hidden and arbitrary order. Thus Piaget and Inhelder's characterization of an early stage of development was not confirmed. The stage described by Fischbein et al., of having an "intuition" of uncertainty without a deep understanding of physical mechanism, may apply to the 4-year-olds in Experiment 1 who correctly differentiated the predictability of the two phenomena but failed to give explanations showing an understanding of mechanism. However, the 4-year-olds and perhaps some 3-year-olds may have understood the nature of the mechanisms but simply may have been limited in their ability to explain (Bullock et al., 1982). For the 3-year-olds, the even distribution of their responses in Experiment 1 is consistent with the view that they simply failed to understand the questions posed.

While the present experiments have focused on young children's understanding of the physical nature of random phenomena and the unpredictability of their outcomes, additional aspects to the understanding of random phenomena can be identified (Kuzmak, 1983a, 1983b). Some of these include understanding the types of outcome sequences one can expect from a random phenomenon and the level of success one can expect in trying to predict outcomes. Concerning the first issue, a study by Davies (1965) suggests that 3-year-olds have some sensitivity to outcome probabilities for a probabilistic mechanism. Given two gumball machine mechanisms containing balls of two colors in different proportions, children tended to use the machine with the highest proportion of the payoff color. Because balls fell from the two machines in identical proportions, characteristics of the mechanisms must have determined children's responses.

While some aspects of understanding random phenomena may be present at an early age, even adults lack certain important aspects of understanding random phenomena and probabilistic reasoning (Kuzmak, 1983a, 1983b; Nisbett & Ross, 1980). Thus, the developmental sequence that results in mature understanding of random phenomena is a long one, beginning in the preschool years and extending into adulthood.

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