Developmental changes in children's concepts of probability[1]

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255 boys and 258 girls enrolled in grades 3 through 7 and grade 9 were shown a film containing a series of questions concerning probabilistic events associated with two populations differing in the relative proportions of two characteristics. Significant developmental changes in frequency of correct response occurred, but the level of response differed greatly among questions. Particularly difficult were questions involving knowledge of purported prior events.

Most investigations of the development of the concept of probability have been concerned with the question of whether probabilistic concepts are present prior to the stage of formal operations (Piaget & Inhelder, 1951). In these studies children as young as four years have been found to show some evidence of a concept of probability, but the experimental conditions have been found to be a critical factor in determining the degree to which such a concept is manifested (Davies, 1965; Goldberg, 1966; Yost, Siegel, & Andrews, 1962). Only a few studies (Pire, 1958; Ross, 1966) have used older Ss; thus there is little information about the later development of children's ability to utilize such concepts. The present study was undertaken to provide such information. Developmental changes in children's responses to a series of questions dealing with the application of probabilistic concepts were studied from the elementary through the junior high school years.

Subjects

The Ss were 255 boys and 258 girls enrolled in grades 3 through 7 and grade 9 in 18 classrooms of two elementary schools and one junior high school in Minneapolis. The mean CA at grade 3 was 8.8 years and increased by yearly intervals in successive grades. The average IQ (Lorge-Thorndike Verbal IQ) for each grade varied from 101 to 113. All Ss in attendance in each classroom visited were included in the sample.

Method

The task was presented to intact classrooms by means of a sound, color film. A narrator in the film gave all instructions for the task and Ss responded in booklets. The narrator showed the Ss two transparent containers, one with 30 red pegs and one with 30 white pegs. He then interchanged 10 pegs from each box, leaving two complementary 2:1 ratios of the different colors in the two boxes. Seven questions were asked about various probability relations one might expect if, when blindfolded, one drew pegs from the boxes in various manners. At least two monitors were present to answer questions and to insure that no cheating occurred. The booklets contained blanks for answering the questions and at the top of the booklet there was a schematic drawing of the containers with their respective numbers of red and white pegs. The following seven questions were asked:

(1) If I wanted to reach into one of these boxes and get a red peg with my eyes closed, which box would I choose, the one labelled A or the one labelled B?

(2) Now, if I reached into Box A without looking and picked out three pegs, how many of the pegs do you think would be red?

(3) If I reached into Box B without looking and picked out three pegs, how many do you think would be red?

(4) Let's say I reached into Box A and picked out two pegs and they were red. Now I am going to draw one more peg from Box A with my eyes closed. What color do you think it would be?

(5) Let's say I picked out five pegs from Box B without looking. Now I am going to reach in and get one more peg. What color do you think it will be?

(6) If I reached into Box A without looking and got five pegs and reached in Box B without looking and got five pegs, I would end up with 10 pegs. How many of them do you think would be white?

(7) Now I am going to dump all the pegs together in one box. If I reached into the box and picked out four pegs, how many of them do you think would be red?

Results and Discussion

As might be expected, the mean number of correct responses increased between grades 3 and 9. The increases tended to be uneven, for while the increase between grades 3 and 5 and grades 7 and 9 were significant for both boys and girls ($t \leq 2.13$, $df \leq 71$, $p < .05$), the increase between grades 5 and 7 was not ($t < 1.00$). The total scores were not higher for boys than for girls ($t < 1.00$), as has been reported by Pire (1958).

The pattern of change in the total number of correct responses was not replicated in an analysis of the responses to each question. Practically all Ss answered the first question correctly; even at grade 3 over 85% of the Ss were correct. Questions 2 and 3 were also answered correctly by a high proportion of the Ss, and for both questions the proportion of correct responses increased with age (see Fig. 1). Questions 4 and 5 were of the same type as Questions 2 and 3, but were preceded by information about previous events. In Question 4 the results of these events were given, but such information was not provided in Question 5. There were relatively few correct responses to either question and only in a few instances did performance exceed a chance

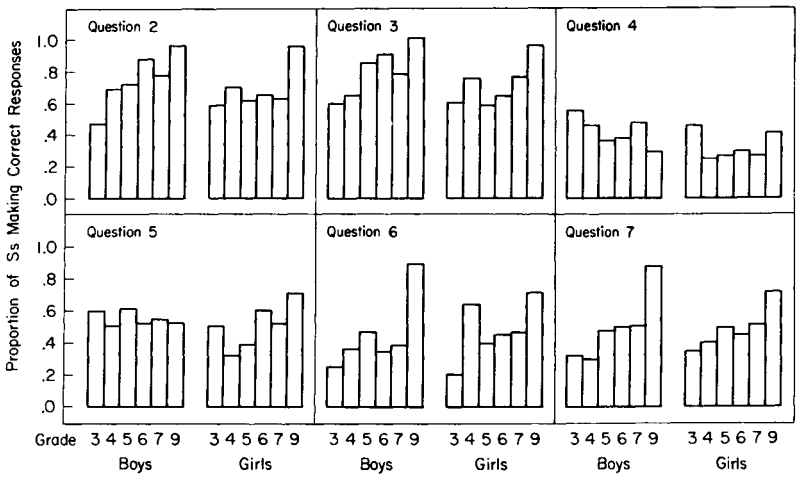

Fig. 1. The mean number of correct responses to individual questions as a function of grade and sex.

level. The added information apparently confused the Ss, who appeared to be unable to assess the probabilities in the modified situations. The results for Question 4 reflect a negative recency effect; Ss were more likely to choose the less probable alternative after the occurrence of the more probable event.

Questions 6 and 7 were the only questions requiring Ss to deal simultaneously with both populations. The poor performance on Question 6 might be attributed to the large number of alternative answers, but since the Ss also performed poorly on Question 7, where there were relatively few alternatives, this interpretation does not seem likely. Not until grade 9 was there clear evidence that children could deal effectively with the combination of probabilities.

Responses to Questions 1, 2, and 3 were significantly correlated with each other (median $r_t = .37$) but not with the remaining questions. Questions 4 and 5 were significantly related (median $r_t = .55$), as were Questions 6 and 7 (median $r_t = .42$). Again, the correlations of these questions with the other questions were generally not significant. In addition, the median correlation between questions tended to increase with increasing age. The median correlation among the questions was .12 at grade 3, while at grade 7 it was .31, and at grade 9 it was .48. Individual differences in children's concepts of probability thus tended to be more consistent for questions formulated in a similar manner, but the stability of the differences increased with increasing age. There was no indication that within a grade the brighter Ss responded more effectively to any of the questions than the average or dull Ss; the median correlation between IQ and response to individual questions was .04.

The demonstration of an understanding of the concept of probability is obviously dependent upon the types of questions asked. Practically all children in this sample were capable of responding correctly in a two-choice situation when the perceptual cues led directly to the appropriate answer. Children also did well when they were asked to deduce the consequents of a series of events occurring within a single population. When they were presented with information that potentially could modify the characteristics of the populations, however, their answers tended to be at a chance level, and, in some instances, the incidence of correct response decreased with increasing age. Finally, questions involving deductions about the characteristics of two populations did not result in a high level of response until grade 9. The lack of a consistently high level of response indicates that sophisticated applications of probabilistic concepts may await direct tutoring in the meaning of probability.

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Note

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