DOCUMENT RESUME

ED 379 138 SE 053 586

AUTHOR	Bullock, Merry; Ziegler, Albert
TITLE	Producing Scientific Tests: What Develops and When?
PUB DATE	Mar 93
NOTE	12p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (New Orleans, LA, March 25-28, 1993). Some pages may not reproduce well.
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Cognitive Development; Cognitive Processes; Concept Formation; Elementary Education; Elementary School Students; Foreign Countries; Grade 2; Grade 5; *Hypothesis Testing; Research Methodology; Science Activities; *Science Education; *Science Experiments; Science Instruction; *Scientific Methodology
IDENTIFIERS	*Experimental Control; Germany

ABSTRACT

Developmental changes in the understanding and use of the logic of experimental control were addressed with three tasks in a longitudinal study. In all three tasks, understanding of experimental control was assessed by production measures (children were asked to test potential causal relations in a multivariable situation) and by choice/evaluation measures (children were asked to choose or evaluate tests made by hypothetical others). Tasks involved the rudder position on an airplane, the effect of the diameter of a spring on how far it stretches, and the determination of tree sickness. Children in Grades 2 to 5 produced experimental tests and chose/evaluated tests made by hypothetical others for those tasks. Cross-task and longitudinal analyses suggested that whereas the understanding of experimental control increased substantially between Grades 2 and 4, using this understanding to produce controlled tests lagged behind. On the basis of an analysis of some of the sources of individual differences, a training condition that facilitated the active representation and mental combination of variable dimensions was tested. Substantial test production improvement after training suggests that children's failure to produce controlled experiments arises from their failure to actively represent the problem space, rather than from a fundamental lack of understanding of the logic of experimental control. (Author/MDH)

ED 379 138

PRODUCING SCIENTIFIC TESTS: WHAT DEVELOPS AND WHEN? [1]

Merry Bullock and Albert Ziegler

Max Planck Institute for Psychological Research,

Leopoldstrasse 24, 8000 München 40, Germany

Abstract

Developmental changes in the understanding and use of the logic of experimental control were addressed with three tasks in a longitudinal study. Children in Grades 2 to 5 produced experimental tests and chose/evaluated tests made by hypothetical others. Cross-task and longitudinal analyses suggested that whereas the understanding of experimental control increased substantially between Grades 2 and 4, using this understanding to produce controlled tests lagged behind. On the basis of an analysis of some of the sources of individual differences, a training condition that facilitated the active representation and mental combination of variable dimensions was tested. Substantial test production improvement after training suggests that children's failure to produce controlled experiments arises from their failure to actively represent the problem space, rather than from a fundamental lack of understanding of the logic of experimental control.

[1]Poster presented at SRCD, New Orleans, March 1993

SE053 586

PRODUCING SCIENTIFIC TESTS: WHAT DEVELOPS AND WHEN?

There is some controversy over when the ability to generate systematic and controlled tests to assess the influence of one or several potential causal factors becomes available. When given the task of constructing empirical tests in a multivariable context, preadolescents generally produce incomplete, uncontrolled tests (e.g., Inhelder & Piaget, 1958; Kuhn et al., 1988). Yet, younger grade schoolers seem to understand some of the basic concepts of experimentation. For example, they understand that one must vary the presence or absence of a potential cause and can recognize when variables are not controlled (e.g., Bullock, 1991), and they can produce a critical test to distinguish between two potential causes when no other variables are present (e.g., Sodian et al., 1991).

There is also controversy over the reasons for children's failures to produce controlled tests: because they lack a conceptual understanding of experimental control, because they misconstrue the task to be one of hypothesis confirmation rather than hypothesis testing, or because they lack general analytic or representational skills.

To address these issues, three tasks assessing the understanding of the logic of experimental control were presented in an ongoing longitudinal project on children's scientific reasoning. In all three tasks, understanding of experimental control was assessed by production measures (children were asked to test potential causal relations in a multivariable situation) and by choice/evaluation measures (children were asked to choose or evaluate tests made by hypothetical others). To assess developmental changes, one task (story task) was presented in each of three measurement years (covering grades 2 to 5); to assess cross-task consistency, two complementary tasks (Springs and Forest tasks) were presented in the second measurement year (grades 3-4).

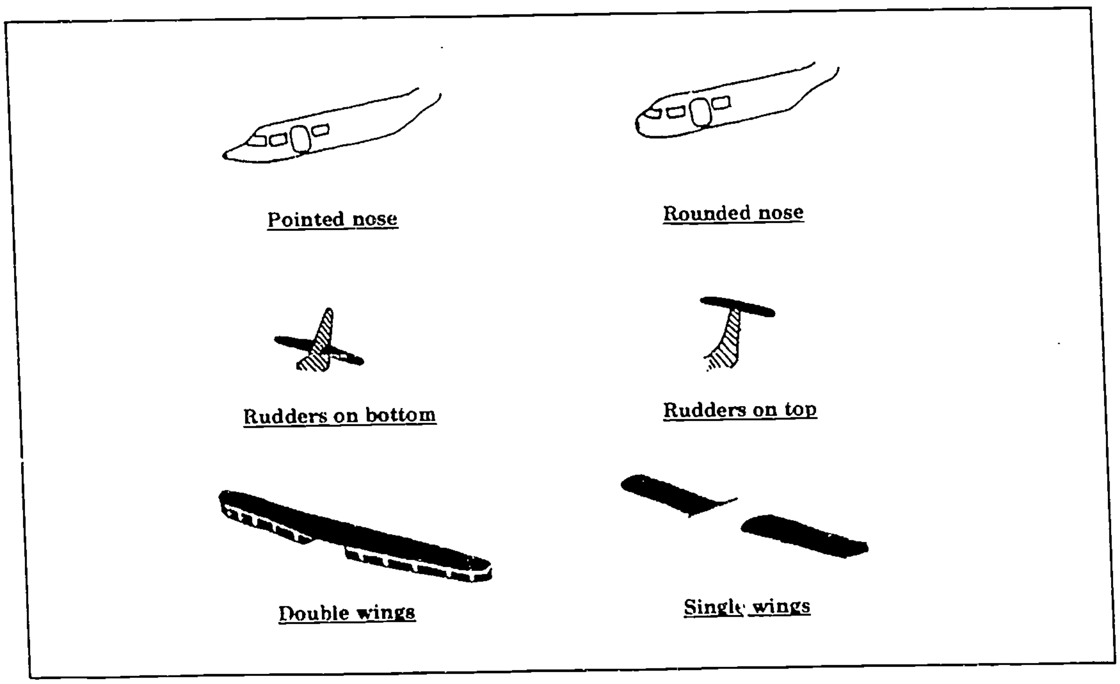
Task 1: Story Task

(presented in each measurement year with different contents)

Children were asked to test the causal role of one of three variable dimensions. The number of test production and test choice responses that were controlled (focal dimension varied, other dimensions held constant) were assessed.

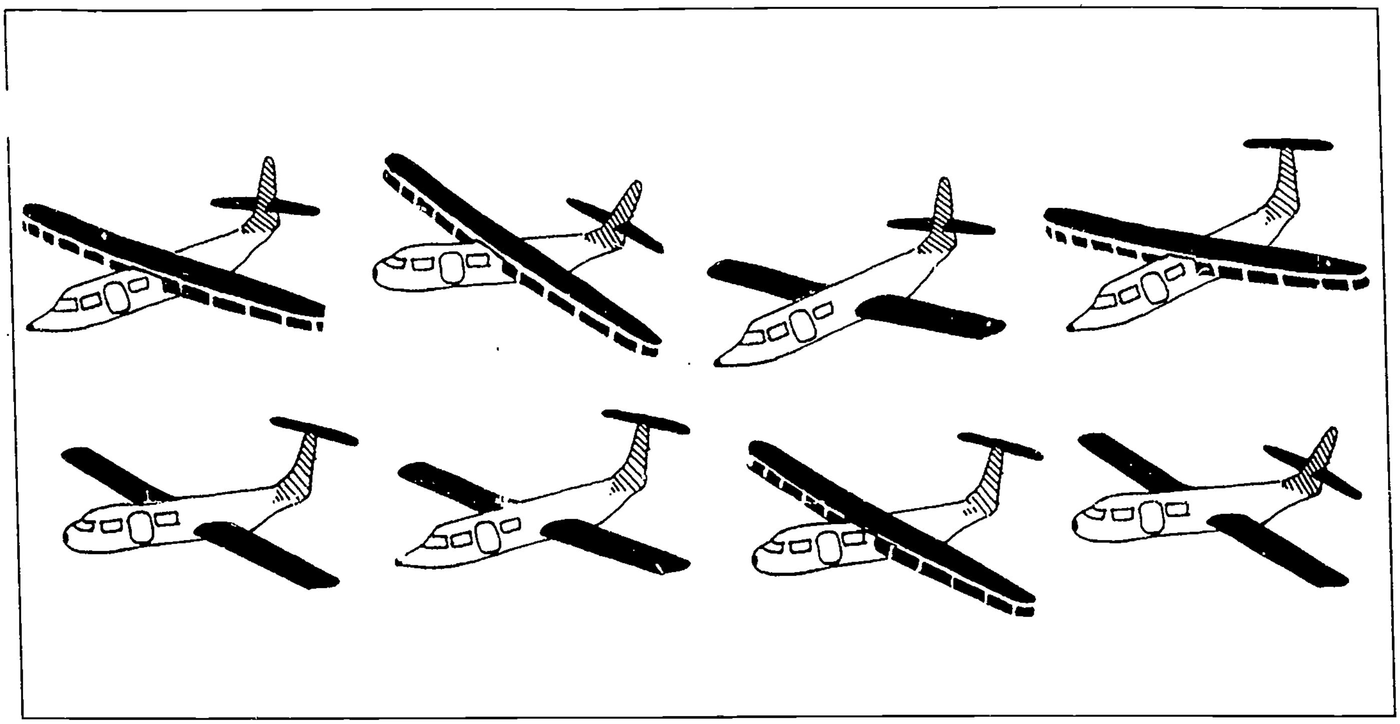
Test Production example:

Mr. Schmidt designs airplanes and wants to design a fuel-efficient airplane. He considers three things that might make a difference:



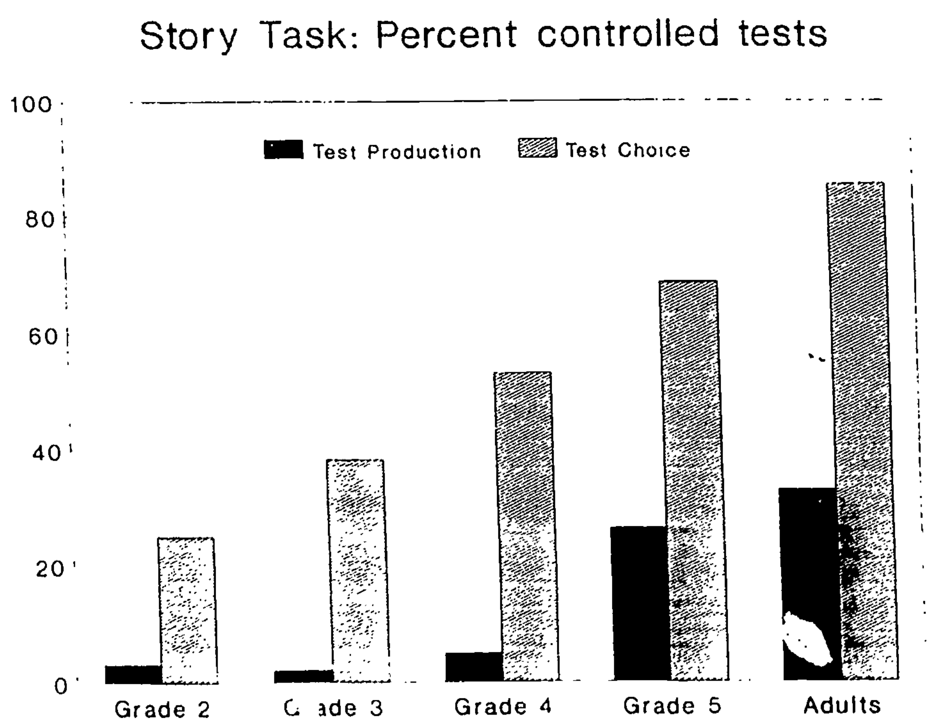
What should Mr. Schmidt do to see if the **rudder position** makes a difference?

Test Choice example:



Which of these airplanes should Mr. Schmidt make to see if the **rudder position** makes a difference?

Results

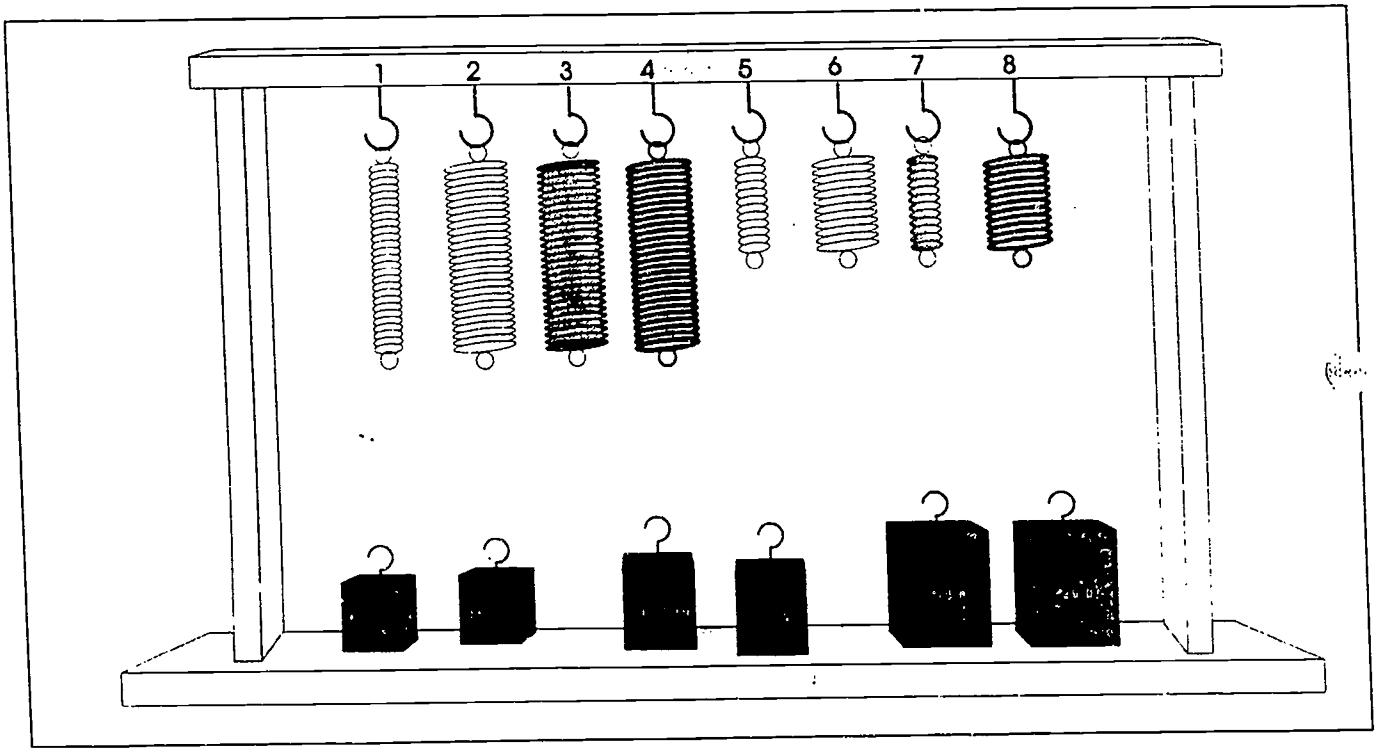


Task 2: Springs Task

(presented to 3rd and 4th graders)

Children were asked to test the causal role of each of three variable dimensions (weight, spring diameter, spring material) and to evaluate tests made by others. The number of controlled tests produced and chosen over three trials were assessed.

Test Production example:



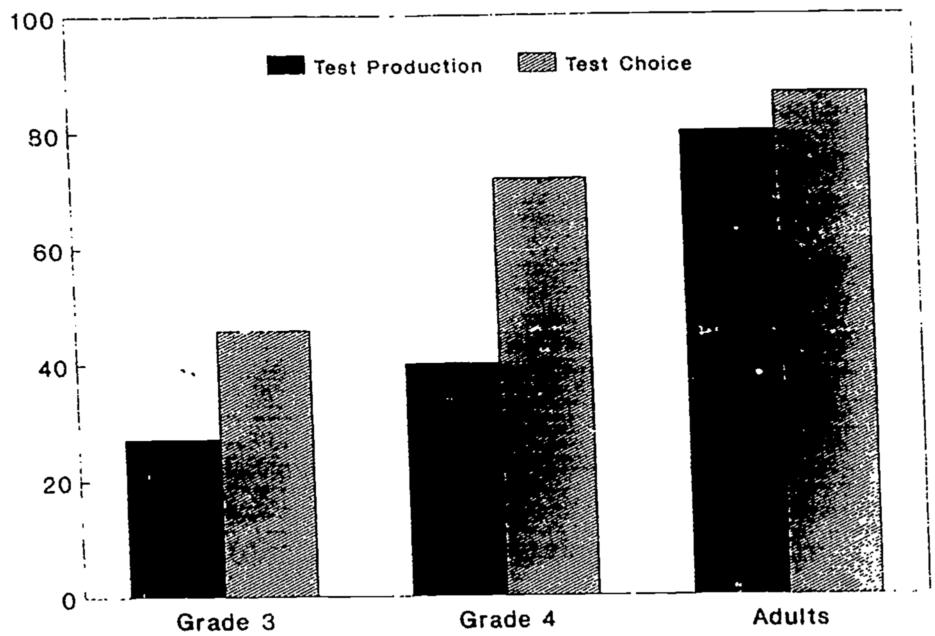
"Make a test to find out whether the diameter of a spring makes a difference in how far a spring stretches"

Test Choice example:

"Someone wanted to find out if spring diameter makes a difference and used springs 4 and 7, each time with the middle weight. Is this a good test? Why? "

Results

Springs Task: Percent controlled tests

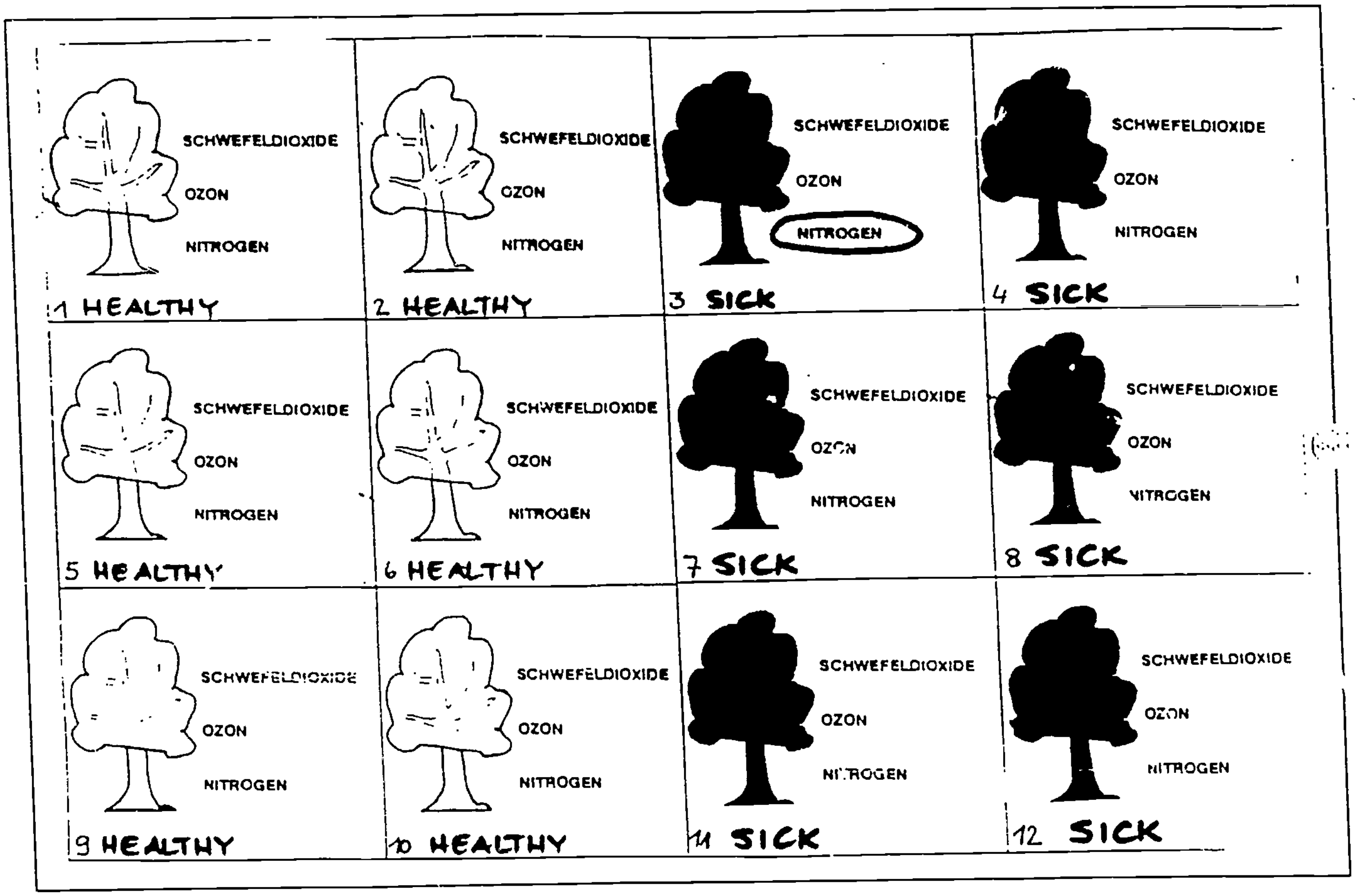


Task 3: Forest Task

(presented to 3rd and 4th graders)

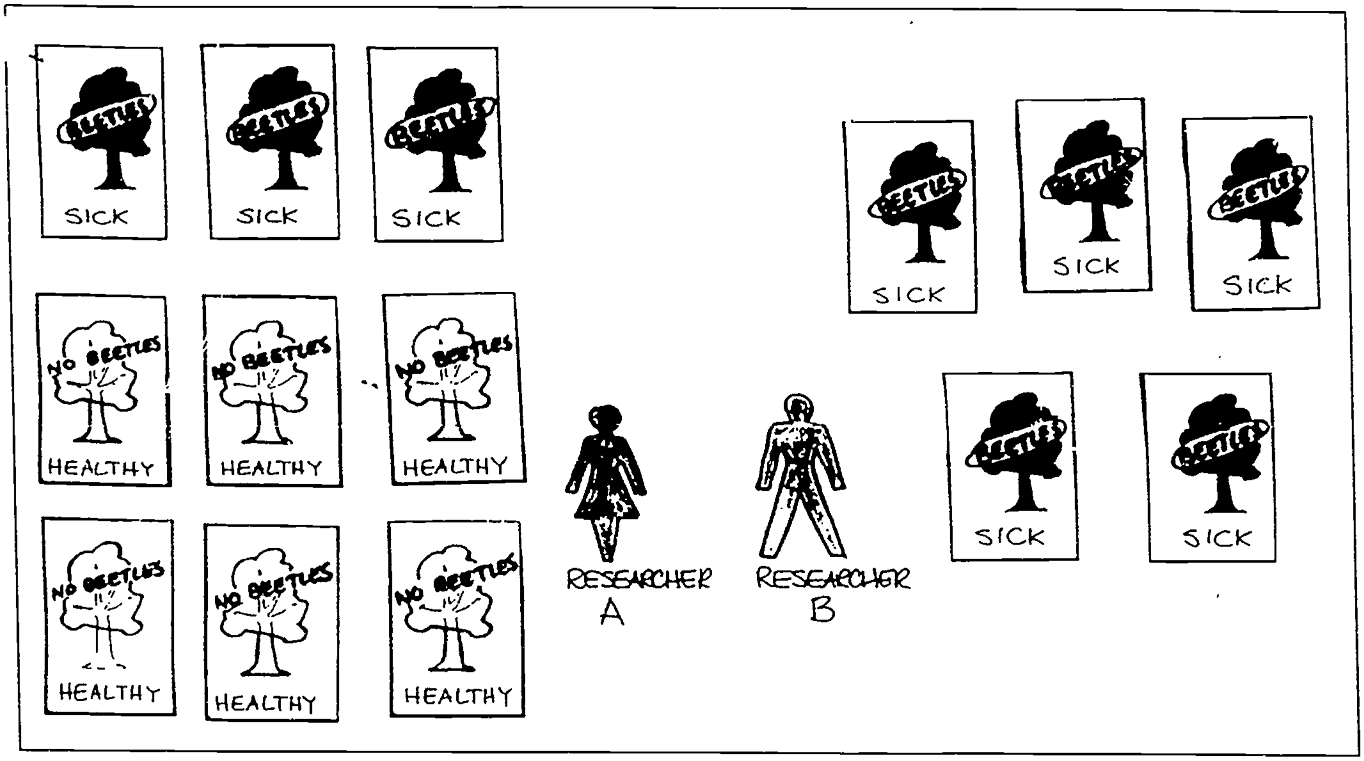
Children were asked to find out which of three chemicals made trees in a forest sick, and to evaluate tests made by others. The number of systematic and controlled tests produced (2 trials) and chosen (3 trials) was assessed.

Test Production example:



"Here are healthy and sick trees in a forest. You can test any tree for any of the three chemicals. Keep testing until you are sure you know which chemical is the cause." (Controlled strategy is to compare presence/absence of hypothesized cause in sick and healthy trees)

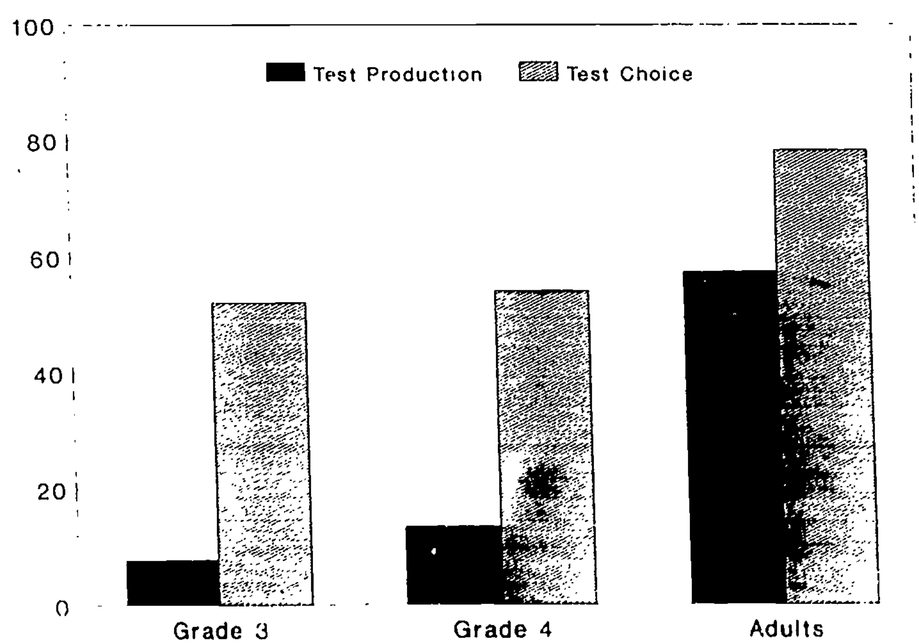
Test Choice example:



"Scientist A and B both concluded that beetles caused the trees to be sick. Who can be more sure of his/her conclusion and why?"

Results

Forest Task: Percent controlled tests



Summary over tasks

Several findings are of special note. First, although children often failed to produce controlled, unconfounded tests, a sizeable proportion not only discriminated a confounded from an unconfounded test, but also explicitly justified this discrimination by explaining the need for variable control or control groups.

Longitudinal analyses suggested that whereas an understanding of the importance of controlled tests increased substantially between the 2nd and 4th grades (8 and 10 years), the ability to apply this understanding when actually constructing tests lagged behind, and was not at ceiling even by the 5th grade (11 years). This suggests that although children possess the conceptual ability to construct controlled tests, they do not engage this understanding in their own production.

This conclusion was supported by the results concerning consistency as shown in the following table:

Proportion of children showing understanding of the logic of control across tasks

	No Tasks	One Task	Two Tasks	All tasks
Production	51.5	36.6	11.9	0
Choice	8.8	20.6	39.7	30.9
Justification	35.1	37.6	21.6	5.7

Why is test production performance worse and what can be done about it?

Production, choice and justification responses across the three tasks were correlated with general skills (IQ, word span), scientific reasoning skills (scale from similar tasks presented earlier), and specific associated skills (logical reasoning, combinatory skills, avoiding premature closure).

Correlations between scientific reasoning skills and other variables

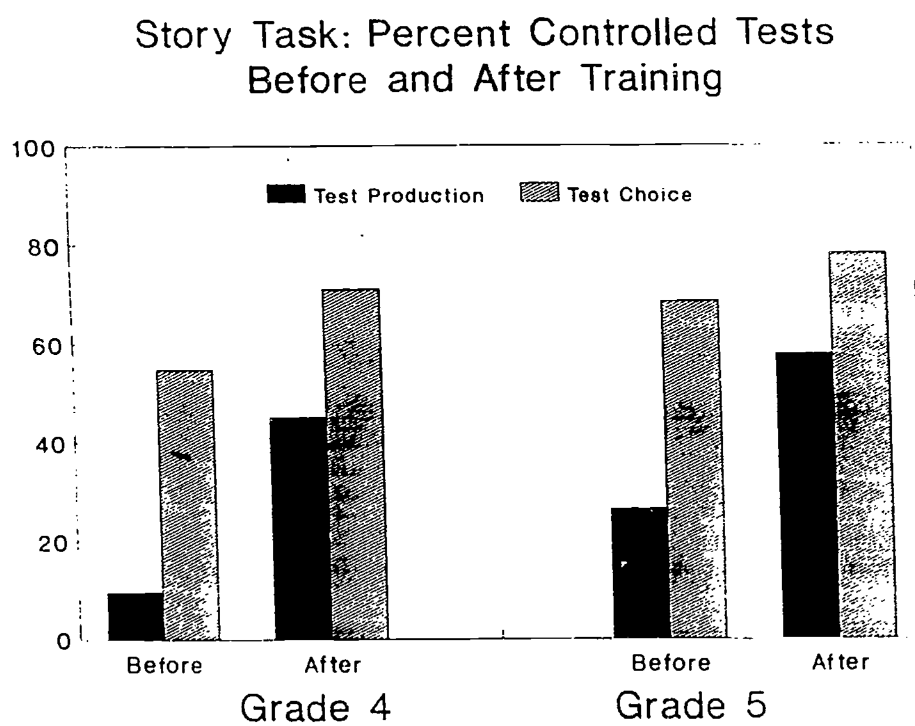
	IQ	SPAN	LOGIC	COMBI	APC	SCI
Production	.32	.20	.22	-	-	.21
Choice	.41	.32	-	.22	.21	.25
Justifications	.47	.41	-	.23	.24	.41

Each type of performance measure (production, choice, justification) was predicted by general ability and prior scientific reasoning skills. In addition, test understanding (assessed by choice/evaluation and justification tasks) was predicted by those skills that require active representation and manipulation of a problem space (memory span, combinatory thinking, avoiding premature closure). To see whether test production might be improved when a more salient representation of the problem space was available, a training manipulation was added to the story task presented to 4th and 5th graders. The purpose of the training manipulation was to facilitate the active representation of all the variables/dimensions and variable combinations relevant to test production in the subsequent story presentation.

Training

In the last measurement wave, the story task was presented twice, with different contents. The training manipulation preceded the second administration of the story task and concerned the variables to be used in the second story task. In the training, children were introduced to three variable dimensions, each with two values. They (1) actively constructed all exemplars that could be made from combining each value of the three variable dimensions and (2) mentally generated exhaustive combinations of each specific variable with all other variables.

Results



Conclusions

Children acquire a conceptual understanding of the logic of experimental control during the grade school years, but cannot apply this understanding when actively producing experiments. One reason for this seems to be that they do not spontaneously actively generate an appropriate representation of the problem space. When induced to do so through a brief training, performance improves.