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ABSTRACT

This study investigated the effects of K. J. Klauer's (1989) inductive reasoning training program of teaching children. Effects of training and the range of transfer of the training were assessed. The subjects were 34 third-grade Dutch children of average ability, matched on age, sex, and IQ. Children from the training condition (N=17) received one week training of five 30 minute sessions. Results demonstrated a significant, positive effect on training children's performance of inductive reasoning tasks. A near-far transfer was observed with children able to solve tasks not taught in training. These effects persisted for 4 months. Far-far transfer was not observed because children were not able to solve mathematics tasks that relate to inductive reasoning, for which they had received no training. Implications for training children within the context of regular schools and the range of transfer are discussed. (EH)

Training in Inductive Reasoning

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Running Head: Training in Inductive Reasoning

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Abstract

The study investigated the effects of Klauer's (1989b) inductive reasoning training program of teaching children. In the experiment effects of the training and the range of transfer of the training were assessed. The subjects were 34 third grade elementary school children of average ability. The children could be matched on age, sex, and IQ. Children from the training condition ($\underline{N}$ = 17) received a one week training (five 30 minutes sessions). Results demonstrated a significant, positive effect for training on childrens' performance of inductive reasoning tasks. A near-far transfer was observed, i.e. children were able to solve tasks not taught in training. These effects persisted for four months. Far-far transfer, however, was not observed, because the children were not able to solve mathematics tasks which relate to inductive reasoning, for which they had received no training. Implications for training children within the context of regular schools and the range of transfer are discussed.

Since time immemorial we have been trying to solve all sorts of problems. In the beginning these problems were concrete ones, which, if adequately solved, increased our chances of survival. No wonder problem solving is seen to be a crucial human activity that should have a central place in the curriculum of schools.

Since the early sixties, cognitive development has devoted a great deal of attention to experiments in which children for instance are trained to acquire concepts described in Piaget's theory. The majority of this research has focused on the empirical aspects of the Genevan perspective on learning, i.e. concepts of mid-childhood (Brainerd, 1978a, 1978b; Tomic, Kingma & TenVergert, 1993).

Problems calling for solutions are of various types (Plomp, 1990; Gephart, 1972). Most problems in any field require different reasoning strategies to be applied for their solution. One important problem solving strategy is inductive reasoning.

Induction is the process whereby one generalizes across a number of instances in order to find a description that applies to them all. By applying inductive reasoning one is able to make inferences, which, as it were, exceed the knowledge we possess at the moment (Holland, Holyoak, Nisbett, & Thagard, 1986). Induction is obviously a process that is very important in allowing us to find regularities in and make predictions about novel environments. Intelligence tests of inductive reasoning ability, for instance, typically ask children to complete a series consisting of such items as pictures or numbers.

Measuring inductive reasoning is important in the psychometric notion of intelligence and was already conceptualized as reasoning ability by Spearman (1904). An early study on visual inductive reasoning was already carried out by Luria in central Asia in the 1930s (Luria, 1976).

In order to assess inductive reasoning tasks one can make use of analogies, number series, categorization and discrimination tasks. Klauer's (1990a, 1990b, 1992) assumption is that inductive reasoning tasks require the children to perform mental comparisons. Comparison processes are connected with discovering perceivable differences and similarities. According to Klauer, the process of comparison consists of both cognitive and metacognitive components, such as strategy choice, selective encoding, etc. The assumption is that the solution procedures can be learned and that tasks can be solved adequately. Without inductive reasoning it is hardly possible to bring tasks to a favourable conclusion like seriation, classification and spelling, were a frequent appeal must be made to the principle of analogy.

Research into thinking processes in general and research into the effects of special designed training programs that influence the childrens' performance on induction problems in particular, is theoretically and practically relevant, and therefore still receives a lot of attention.

Klauer's (1989a, 1990a, 1992) research in training inductive reasoning includes attempts to improve childrens' performance on induction problems. Klauer's approach to inductive reasoning training was applied in the present study. The decision to employ the approach mentioned, was based on the rather well-researched nature of Klauer's training program (see: Klauer, 1989a, 1990a, 1992; Phye & Sanders, 1993; Resing & Verbraeken, 1993), and the suitability for instruction. However, we still remain unsure as to whether the results for inductive reasoning training performed in a particular educational context can be replicated in another educational context.

Transfer is considered to be an indication that a more or less long lasting change has occurred in the child's ability to solve a certain type of problem induced by a training program. To evaluate the success of training, stringent transfer standards can be used. There is a standard for transfer of training which goes from less stringent to stringent criteria. The Genevan and Russian standard consists of near-near, near-far and far-far transfer tasks (Piaget, 1957, 1964, 1975; Inhelder, Sinclair, & Bovet, 1974; Galperin, 1957, 1966, 1967; Tomic, Kingma & Ten Vergert, 1993). Progress on far-far transfer tasks is considered particularly credible evidence that a change in the child's cognitive structure has occurred. However, for educational purposes observation of near-far transfer is sufficient. Measuring the range of transfer is thus important. For this reason we included in the posttests some mathematics tasks that relate to inductive reasoning not included in training.

The purpose of the present study is to investigate the effects that Klauer's training program may have on childrens' performance of inductive reasoning tasks. In addition to any effects, it seemed important to investigate the durability of the training program. An important concern was to determine the range or types of induced transfer of Klauer's training program. In the experiment the range of transfer of inductive reasoning training was investigated to performance of arithmetic tasks.

Method

The purpose of the experiment was to determine the effects of Klauer's training program on third graders' performance of inductive reasoning tasks and to assess far-far transfer of training to childrens' mathematics tasks.

Design

During the pretest, third grade elementary school children were administered the Culture Fair Intelligence Test, Form 1, abridged version (Cattell, 1950). One day after training, the first posttest was administered (consisting of the Culture Fair Intelligence Test, Form 1, abridged version and an arithmetic test) to the trained children and their counterparts in the control group. The same tasks were also given in the second posttest, four months after the first posttest.

Subjects

Thirty-four third-grade primary school children enrolled in a class, served as subjects in the experiment, who were administered the Culture Fair Intelligence Test, Form 1, abridged version. The third grade level was chosen for comparison purposes with similar populations in previous training studies (Klauer, 1989a, 1990a, 1992; Phye & Sanders, 1993; Resing & Verbraeken, 1993). The children could be matched on IQ, age and sex. In each matched pair one child was assigned at random to the training group and the other to the control group. The training group (N = 17, 6 boys and 11 girls) had a mean age of 86.1 months, s.d. = 3.4, and a mean IQ of 109.1, s.d. = 14.6. The control group (N = 17, 6 boys and 11 girls) had a mean age of

85.9 months, s.d. = 3.5 and a mean IQ of 109.4, and s.d. = 15.1. (see Table 1).

Insert Table 1 about here

Materials

Pretest and posttests. The pre- and posttests consisted of the Cattell (1950), Form 1, abridged version. We only used scores on test items that are related to inductive reasoning. The Culture Fair Intelligence Test, abridged form (Cattell, 1950), was scored according to the instructions given in the test manual. The Cattell was administered prior to the training (pretest), after training (first or immediate posttest), and four month following training (second or delayed posttest).

Arithmetic tasks. After the Culture Fair Intelligence Test, Form 1, abridged version, an arithmetic test consisting of four parts and 21 items was administered during the posttest as a far-far transfer measure of inductive reasoning. The mathematics test was administered immediately after training, and four month following training. An introductory trial was given to familiarize the child with the arithmetic problems.

The Cattell and the mathematics test were not administered on an individual basis, but as a group test by the researcher. This administration procedure was necessitated by the time and budget constraints.

Previous research shows (Klauer, 1989a, 1990a, 1992; Tomic, et al., 1993) that all materials and the training procedure employed in the experiment are appropriate for third-grade average children.

Training. Klauer (1989b) designed a training program for the development of inductive reasoning and fostering problem solving strategies in the domain of inductive reasoning. The rationale of the training program is that the aptitude of inductive reasoning consists of cognitive processes of generalization, discrimination, and a metacognitive monitoring strategy that involves the checking of objects and relationships for similarities and/or differences.

Klauer (1992) distinguishes a few thinking paradigms encompassing all kinds of inductive thinking. In his training program there are six item forms of inductive reasoning tasks, namely generalization (similarity with attributes), discrimination (difference with attributes), cross-classification (similarity and difference with attributes), recognizing relations (similarity with relations), discriminating relations (difference with relations) and system formation (similarity and difference with relations).

Procedure

The pretest and posttests were administered in-class. Testing took place in one session. The pretest session focused on the Cattell (1950) Form 1 tasks.

Training. Following the pretest, the children assigned to the training group received treatment each school day for a period of one week. Each of the five training sessions took about 30 minutes. The children assigned to the training group ($N = 17$) were trained in three groups of 6, 6 and 5 by three researchers, who were not involved in administering the pretests and posttests. At the beginning of the first training session, the child was given the opportunity to become familiar with the questions. When the child gave an incorrect response in a training trial, the researcher asked: "How do you know that?" or "Can you demonstrate that?" The child was then asked to perform the item again until he or she gave a correct response. Within the same time frame, the control group counterpart of a trained child had to complete tasks from the school program.

Results

To investigate the effects of Klauer's training program on third graders' performance of inductive reasoning problems, scores on the Cattell pretest and immediate and delayed posttests were analyzed.

Training Effects

Insert Table 2 about here

Analyses were conducted to determine the main effects of training on immediate and delayed posttest performance. To test the significance of differences between trained and untrained children an analysis of variance was carried out. The significance level was set at 5%. Overall comparisons among groups indicated that the total scores of the training group on the Cattell tasks were significantly higher than those of the control group on the first posttest. On the second posttest, the Cattell performance of the training group differed significantly from that of the control group. Thus, it is clear that training in inductive reasoning successfully induced near-far transfer in Cattell skills, and that this transfer effect persisted at least four months after training (i.e., the second posttest). An effect that persists for four months is sufficient for educational purposes.

To assess the far-far transfer of Klauer's training program on childrens' inductive reasoning skills, childrens' scores on the mathematics test administered following training were analyzed. Concerning the total scores on the mathematics tasks the ANOVA at the 5% level did not result in significant findings. The training group did not have significantly higher scores on the two mathematics posttests than the control group. These results demonstrated that training in inductive reasoning did not induce a far-far transfer, i.e., the children were unable to generalize their newly acquired skills to different concept areas. There was no significant transfer of training to inductive reasoning in the domain of mathematics tasks.

Discussion

The experiment was conducted to examine the effects of Klauer's training program on average-ability third graders' performance of inductive reasoning. Training in inductive reasoning based on Klauer's program (1989b, 1990a) was shown to be successful in teaching third grade elementary school children. The average gain evidenced in the raw scores of the control children may be attributable to the in-class instruction initiated during the four month period by the teacher. The durability of the training was demonstrated in this study. The training also produced a near-far transfer, which is sufficient for educational purposes. The difference between the trained and untrained children is significant, and, what is more, interesting. These results confirmed the earlier findings of Klauer (1992), Phye and Sanders (1993), and Resing and Verbraeken (1993), and strengthen their findings.

Although the children were only involved in five training sessions of thirty minutes, the result is acceptable. The results indicate that such training can have positive significant effects when conducted in the context of the regular school. It remains to be seen whether Klauer's training program is affected by the age or ability of the children to whom it is applied. It is worthwhile to attempt Klauer's training with younger and older children of average ability. It is also necessary to investigate whether the effects would be markedly different when applied to pupils more cognitively diverse than the ones in this or earlier experiments.

Unlike Klauer (1992), who also investigated far-far transfer and observed this sort of transfer in his training research, the training program in our study did not induce far-far transfer. There was no differential performance on the mathematics test between trained and untrained children.

The question remains why this training program did not induce far-far transfer in this study. Considering earlier research in this domain, we have no grounds to assume that the nature of the training program is responsible for the fact that inductive reasoning skills were not transferred to mathematics tasks in which the children were not trained. Nevertheless, it is known that all types of transfer will more readily occur when one systematically teaches for them (Kingma & Ten Vergert, 1993, Obuchowa, 1962, 1972). In our opinion, there are a few possible explanations for the finding that far-far transfer of training was not supported in this study. They relate to some characteristics of the design of the study. First, the duration of the training. The children assigned to the training group received a treatment of five practice sessions that took about thirty minutes each. Obviously, the training was to short, for in most training research, training involves ten or more sessions (Phye & Sanders, 1993; Klauer, 1992; Resing & Verbraeken, 1993; Tomic, et al., 1993). To induce abstract verbal transfer, one needs more time. Second, in our study the children were trained in three groups of six and five. Although the average age of the trained children was 7.2 years, the question is whether children of the age could be successfully trained in groups of six. The experience of Phye and Sanders (1993) coupled with our observations during the training sessions suggest that children of this age should be trained individually. Training on a one-to-one basis is also conducive to concentration and motivation of the children. The same point applies for testing the children. In a future study we must take account of the points above mentioned. Besides, development of a follow-up or intermittent phase is advisable to reinforce and extend the instruction provided in initial training.

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TABLE 1

Ages in Month, and IQs of the Matched Pairs of Trained and Control Children

	Trained Children		Control Children	
	months	IQ	months	IQ
Mean	86.1	109.1	85.9	109.4
SD	3.4	14.6	3.5	15.1

TABLE 2

A Survey of the Mean Total Scores for Training and Control Groups on the Two Posttests

Posttest No	Condition	Task: Cattell	Task: Arithmetic
1	Training	31.8	16.6
	Control	29.9	15.8
2	Training	34.6	17.8
	Control	33.2	16.4