DOCUMENT RESUME

ED 248 266 TM 840 569

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TITLE. The Effects of Task Demands on Children's Metamemorial Decisions.
PUB DATE Apr 84
NOTE 28p.; Paper presented at the Annual Meeting of the American Educational Research Association (68th, New Orleans, LA, April 23-27, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Age Differences; Cognitive Development; *Cognitive Processes; *Developmental Stages; Elementary Education; Elementary School Students; *Encoding (Psychology); Epistemology; *Memory; *Metacognition; *Questioning Techniques
IDENTIFIERS Counting Span Test

ABSTRACT

Using five metamemory question types and the Counting Span Test (CST), this research investigated the effects of metamemory task demands, and the relationship of the amount of information one can hold in working memory to metamemory question performance. One hundred twenty kindergarten, first, third, and fifth grade children served as subjects. The amount of information in each metamemory question was systematically varied by the number of options and the number of metamemory variables nested within each option. In the analysis of metamemory data, the main effects of grade level and question type were significant, as was the interaction. The measure of information storage capacity (CST results) increased with age, and was significantly related to metamemory performance. Effects of gender and gender-grade interaction were not significant. It was concluded that an explanation which incorporates the complex relationships between knowledge, tasks, and information processing constructs is most appropriate. The results support Brown's (1978) contention that systematic investigation of task demands is a critical aspect of future theoretical work in metamemory. (Author/BS)

The Effects of Task Demands on Children's Metamemorial Decisions

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Running head: TASK DEMANDS OF METAMEMORIAL DECISIONS

ABSTRACT

To date, systematic investigation of metamemory task demands have been sparse. The present research systematically varied the amount of information contained in each question by varying the number of options and number of metamemory variables nested within each option. An attempt was also made to relate the amount of information one can hold in working memory to performance on five metamemory question types. Kindergarten, first-, third-, and fifth-grade children served as subjects. The main effects of grade and question type were significant, as was the interaction. The measure of information storage capacity was significantly related to metamemory performance. It is concluded that an explanation which incorporates the complex relationships between knowledge, tasks, and information processsing constructs is most appropriate.

The Effects of Task Demands on Children's Metamemorial Decisions

The purpose of this research was to systematically assess the effects of different types or formats of questions on metamemorial performance. Brown (1978) wrote that an understanding of the task demands underlying metamemory research is necessary for drawing appropriate conclusions. Conclusions have been drawn about the presence or absence of knowledge for children of different age levels without a critical examination of task demands. This lack of concern had resulted from an implicit assumption that metamemorial knowledge can be accessed without creating great demands on a child's information processing system. This assumption pervades the literature on metamemory irrespective of the type of task employed to assess the knowledge one possesses about memory. The plethora of tasks includes interview questions with forced-choice questions, interview with open-ended questions, rating tasks, predicting performance prior to study or recall, predicting performance after completing retrieval, and several forms of training studies. In reaction to this diversity, there have been several pleas for the examination of the tasks employed (e.g., Brown, 1978; Brown, Bransford, Ferrara, and Campione, 1984; Cavanaugh and Perlmutter, 1982).

Brown et al. (1984) argue that the initial stage of theory building is now over. During this stage, a proliferation of demonstrative studies occurred. Researchers attempted to show what knowledge children did and did not possess and the relationship of knowledge to behavior such as predicting and memorizing. Studies explored areas of metamemory, meta-attention, metacommunication (e.g., Yussen and Bird, 1979), metacomprehension (e.g., Markman, 1981), metacognitive knowledge of reading (e.g., Myers and Paris, 1978), and monitoring of social cognitive enterprises (e.g., Flavell, 1981) to name only a few of the areas.

Brown et al. (1984) believe that the second stage of research should be devoted to building theories explaining the various aspects of metacognition. Once systematic work is completed on separate parts of the area, then theoretical work must continue to provide an understanding of the full domain of metacognition. This latter part of theory building constitues the third stage.

It is under the second stage that this paper would be classified. The goal of this research is to investigate one aspect of metamemory, namely, the relationship between the task demands of various metamemory tasks, an information processing characteristic of children, and performance on metamemory tasks.

The metamemorial tasks to be used in this study will be limited to those requiring a decision between two or more options. Hereafter, options refer to the number of alternatives from which the subject is to make a choice. Studies have required a child to choose between two options (e.g., Kreutzer et al. 1975). For example, each child was to decide whether a story or a list of words was easier to remember. Other studies have presented three options from which a child was to choose (e.g., Wellman, 1978). In that study, each child was to order three boys who had to remember lists of items of differing lengths. In the story, one boy had to remember three items, one 9 items, and another 18 items.

The classic study which sparked research in the metamemory area is Kreutzer, Leonard, and Flavell (1975). In that study, 20 children from each of grades K, 1, 3, and 5 were interviewed about 14 memory related topics. Of the questions asked, 8 of 14 problems required decisions between two options. For example, the children had to decide if it was easier to remember a phone number if they dialed it immediatlely or if they got a drink of water and then dialed the number. In this particular example, the decision was between two options. Five of the 14 required the subject to generate one or more strategies which could solve the problem.

Wellman (1977) extended the findings of Kreutzer et al. (1975) to preschool children. The 3-, 4-, and 5-year-olds were asked to make decisions between pairs of pictures which protrayed characters in different memory related situations. The following variables are some of the ones presented in the stories: list length, noise, age, study time, and color of the person's hair. Each child had to decide which of the two characters had the hardest time and explain why. The results were discussed in terms of the patterns of the emergence of knowledge.

Other studies have also used questions involving decisions between two options. For example, Cavanaugh and Borkowski (1980) conducted a study in which the entire questionnaire used by Kreutzer et al., (1975) was given. They concluded that their findings replicated Kreutzer et al., (1975) and, therefore, the interview technique was reliable. Yussen and Bird (1979) also required children to choose between two options. In that study, knowledge of variables as each related to memory, attention, and communication was assessed. They concluded that children have similar knowledge of variables across different types of cognitive activities.

Overall, the interpretations that have been drawn on the basis of these studies were that all children have some knowledge of memory, but that only the older children have knowledge of many other memory relevant variables. Other interpretations are possible, however. Since the task demands have not been assessed, one cannot conclude that the tasks were of equal difficulty for all children. It is possible that some tasks were too difficult for the young children to use their knowledge. In other words, the problem itself may have placed a great demand on the processing capacity of the child and, therefore, overtaxed his or her system. The young child would appear not to possess the relevant knowledge. In short, there may be a confound between the level of knowledge and information processing ability.

Many metamemory studies have assessed childrens' knowledge of memory-relevant and irrelevant variables in isolation. In "isolation" means that only one variable at a time is manipulated in a metamemory question (Wellman, 1978). Few studies, on the other hand, have assessed childrens' knowledge of variables in interaction with each other. Wellman (1978) presented four stories in which variables were in isolation and five stories contained two variables interacting. In one option, each of the two variables took on one value. In a second option, the value of one variable was changed while the second value remained constant. In the third option, the value of the first variable did not change while the value of the second variable changed. Therefore, each option contained a unique combination of the values of each variable. Wellman (1978) found that the 5- and 10-year-olds were equally accurate when the memory-relevant variables were presented in isolation. When the relevant variables were presented interacting, the 10-year-olds wer more accurate that the 5-year-olds.

Two explanations of these results are possible. One, the children of different ages have different levels of knowledge about the interaction of memory variables. Two, decisions about the interactions require more information to be stored in the limited capacity system while making a decision than do decisions about variables in isolation. Since young children may have less efficient processing abilities, the capacity for storage of information might be less (Case, Kurland, and Coldberg, 1982). As a result, the young children could solve the simple problems, but not the ones with larger processing demands. Since older children may have more efficient processing, their processing system may be able to meet the demands placed on it by the simple and complex problems. Hence, the developmental differences may be due to differences in information processing abilities rather than differences in knowledge per se.

Ericsson and Simon (1980) point out that introspective probes may not access stored knowledge directly. Retrospective probes are ones which are asked after the cessation of the initial processing of the information. As a result of the time span between the initial processing and the request for that information, various processes may occur which recode the information. In some cases, the information may be reproduced without any transformations occurring. In other cases, certain intermediate processes, such as inferencing, may be required to respond to the probe. The produced verbal report would be a product of the intermediate processing rather than a direct access of stored information. If so, young children may have the relevant knowledge, but be faulty in their intermediate processing and appear to not possess that knowledge.

In addition to investigating the role of question format on metamemory performance, one measure of an information processing construct was included. Case (1978) proposed the three hypothetical constructs of total structural capacity of working memory, operating capacity, and information storage capacity to explain strategic development. Total storage capacity is divided into the capacities for storing the operations and information necessary to complete a task. With development, the amount of information one can hold is purported to increase. The increase may be due to increased efficiency in processing and hence, a decrease in the amount of total capacity required to store the operations, or due to growth in total capacity (Kail and Bisanz, 1982). Case, Kurland, and Goldberg (1982) developed the Counting Span Test in order to measure information storage capacity. This measure was modified and used in the present study.*

There were five different types of problems used in this study. One type of problem required each child to decide between two options of one metamemory variable (T12). In order to get a measure of internal consistency, two parallel forms of this type were included (T12A and T12B). A second type of problem contained three options with one metamemory variable varying between options (T13). The third type of problem contained four options with one metamemory variable varying between options (T14). The last two problem types contained two metamemory variables in each option. One type required decisions between three options (T23) while the other required decisions between four options (T24).

Two hypotheses can be tested by this design of metamemory questions. The Knowledge Hypothesis states that if the direct retrieval of stored knowledge is the only entity required in answering metamemory questions, then performance across questions with different numbers of options should not vary (i.e., T12A=T12B=T13=T14 and T23=T24). On the other hand, the Processing Hypothesis predicts that performance across questions with differing numbers of options will not be identical, since the different types place different demands on the information processing system. This prediction is in reality trivial, unless the type of question interacts with the developmental level of the children. Such an interaction would have direct consequences for studies which draw conclusions about the knowledge children of various ages possess. The Processing Hypothesis also predicts that scores on the Counting Span Test will have positive relationship with performance on the metamemory questions.

Methodology

Subjects

The subjects for this study were drawn from Kindergarten, first, third, and fifth grades. In all, 120 students served as subjects. Fourteen males and 15 females were drawn from Kindergarten and their mean age was 6 years, 4 months. Fifteen males and 15 females were selected from first garde with a mean age of 7 years, 2 months. The mean age for third-graders was 9 years, 1 month and 14 males and 16 females served as subjects. Fifteen males and 15 females were selected from fifth grade and their mean age was 11 years, 2 months.

Instruments

The Counting Span Test (Case, Kurland, and Goldberg, 1982) was used to assess the childrens' information storage capacity. The test materials used in this study were similar, but not identical to the materials developed by Case et al. (1982). For this test, 49 cards (5 x 8) contained one to seven green dots and one to seven yellow dots. Each dot was approximately 20 millimeters in diameter. Only two trials were given at each set size, whereas, Case et al., (1982) gave 5 trials at each set size. The administration of this test proceeded as described by Case et al., (1982).

The metamemory questions required the subjects to decide between two, three, or four options. Options refers to the alternatives in the question from which subjects are to choose. Within each option, one or two metamemory variables were presented. Options containing one value were used to assess knowledge of variables in isolation (Wellman, 1978). For example, each child had to decide whether 3 items or 11 items are harder to remember. The knowledge of the interaction of two varibles was assessed by having two metamemory variables presented in each option (Wellman, 1978). For example, each subject was required to decide whether it was harder to remember 3 items given 5 minutes to study them, 3 items given 17 minutes to study them, or 18 items given 5 minutes to study them. As a result, 4 types of problems were constructed by crossing the two levels of the number of alternatives in a question (3 or 4 options) with two levels of the amount of information contained in each option (either one or two metamemory). One other question type was constructed by having questions with two options which contained one metamemory variable. In order to have a measure of internal consistency, two sets of this type were used.

Several, but not all, of the problem types have been employed in previous studies. Kreutzer et al., (1975), Wellman (1977), and Yussen and Bird (1979) asked questions which wold be characterized as having two options with one variable. Wellman (1978) used questions that had three options with one variable and questions that had three options with two variables. Two problem types had not been used prior to this study, They were: four options with one variable and four options with two variables.

The knowledge of person and task variables were assessed in each of the 5 problem types described above. Specifically, knowledge about the age of a learner (i.e., grade), the length of the list of things to be remembered, and the amount of time given to study the list were assessed within each problem type. Thus, each child was asked three sets of questions in each of the six problems types for a total of 18 sets of questions. Within each of the 18 sets, each subject was asked which hypothetical character within the story had the hardest time and which had the easiest time remembering. A simple line drawing of each character accompanied each option in the metamemory problems.

The scoring of the metamemory questions proceeded as follows: subject's responses were compared to answers based on a consensus of four graduate students who had taken courses in development and learning. Scores of 1 were assigned when the responses matched and 0 when the responses did not match. Since each child was asked two questions about each metamemory problem, the scores for each question set were added. Hence, each subject received a score of 0, 1, or 2 for each of the 18 metamemory problems. The scores of the sets with the same format or type were then added to form a composite problem type score. For example, the three scores for the questions containing three options with one metamemory variable were added together. The range of each problem type score was 0 to 6. A total type score was computed by adding the six type scores and dividing by six. As a result, each subject was assigned six problem type scores and a total type score.

Procedure

General instructions were given first to each subject. Subjects were told that they would be asked several questions concerning their knowledge of their own memory. It was emphasized that there were no wrong answers and that this was not a test like their teachers would give. Subjects were asked to do as best as they could and it was explained that their answers would not affect their grade in the classroom.

Each student was then asked to complete two tasks. The first assessed the amount of information the student could hold in working memory. The Counting Span Test proceeded as follows: The subject was instructed in the dot counting procedure. This required the subject to perform the simple operation of counting the green dots and remembering the number. Training was given to familiarize the subject with the procedure. Following this training, the test sets were presented to the subject. Testing of information capacity discontinued when the subject missed two trials at any one set size. The number of cards in the largest set correctly recalled was assigned as the information capacity score.

The second task consisted of the actual metamemory questions. The experimenter read each situation and questions from a card and the subject's responses were recorded by the experimenter. The questions were presented in a different random order for each subject to avoid confounds with practice effects or any effects which might have been inherent to any one order (Kirk, 1968).

RESULTS

Counting Span Test

The Counting Span Test (CST) is purported to be a measure of the amount of information a person can hold in working memory with concurrent processing. Each child was assigned a score of 1 to 6 on this measure. The analysis of variance revealed a significant effect of grade, $F(3,112) = 35.03$ (p .05). The mean scores for Kindergarten, first-, third-, and fifth-graders were 2.17, 2.73, 3.13, 4.03, respectively. The effect of gender and the interaction of gender and grade were not significant, $F(1,112) = .46$ (p .05) and $F(3,112) = .60$ (p .05), respectively. The percentage of variance accounted for by grade was 48%. Post hoe analyses using the Scheffe' method revealed that Kindergarten scores differed from both third grade and fifth grade, first grade differed from fifth grade, and third grade differed from fifth grade. Also, a combined score of Kindergarten and first grade differed from a combined score of third and fifth grades. A test-retest measure of reliability was computed using the Pearson Product-Moment correlation. The resulting coefficient was $r = .61$. In general, the results show that performance on the Counting Span Test increase with age. This study does not, however, indicate whether the increase is due to a growth in total amount of resources available or in the efficiency of processing. These two possibilities are discussed in depth by Kail and Bisanz (1982).

<u>Metamemory Questions</u>

A repeated measures analysis of variance was conducted on the metamemory data. Grade and gender were between-subject variables with type scores being a within-subject variable. The main effect of grade was significant, $F(3,112) = 37.51$ (p .05). Figure 1 plots metamemory scores by grade. Gender was not significant, $F(1,112) = 1.44$ (p .05) and the interaction of gender and grade was also not significant, $F(3,112) = 2.53$ (p .05). The effect of type of metamemory question was significant, $F(5,560) = 46.15$ (p .05) as was the interaction of type and grade, $F(15,560) = 2.40$ (p .05). Metamemory scores by type are plotted Figure 2. Table 1 contains metamemory scores by type and grade and is plotted in Figure 3. The interaction between type and gender was also significant, F(5,560) = 2.83 (p .05), but the three-way interaction between type, grade, and gender was not significant, F(15,560) = 1.43 (p .05).

Insert Table 1 about here

Post hoc analyses (Scheffe' method) revealed that on the metamemory questions Kindergarten scores differed from fifth grade scores. All other pairwise comparisons of grades were not significant. The combined score of Kindergarten and first grade was significantly different from the combined score of third and fifth grades. These results are consistent with past research in that older children demonstrate better performance on metamemory tasks than younger children. For the question type scores, T12A did not differ from T12B. The correlation between T12A and T12B was r = .58. This shows that the parallel types were similar in nature. T12A and T12B each differed from all other types. In addition, T13, T14, and T23 did not differ from each other, but each differed from T24. Post hoc analyses showed that as the number of options increased, performance decreased. Performance of questions assessing the knowledge of one variable was higher than performance on questions with two variables. These latter results show that type of question is important when considering performance on metamemory tasks.

The percentages of variance accounted for by the various effects (eta square) were computed. Grade accounted for 48% of the variance, gender 1%, type of question 27%, grade by gender interaction 3%, grade by type interaction 4%, type by gender interaction 2%, and the three-way interaction 2%.

Relationship between Metamemory scores and CST

Due to the extremely unequal frequencies for the CST scores, a non-parametric test was computed on the individual type scores. A one-way Kruskal-Wallis test revealed a significant effect of CST on total type scores, chi-square (corrected for ties) = 41.85 (p .05). Identical analyses were computed on each of the six problem types. The resulting chi-square (corrected for ties) values were: for T12A, 25.84 (p .05); for T12B, 25.07 (p .05); for T13, 28.28 (p .05); for T14, 35.29 (p .05); for T23, 27.88 (p .05); and for T24, 10.27 (p .05). All values are significant at the .05 level except for T24. The metamemory scores broken down by CST can be found in Table 2 and visualized in Figure 4. From this analysis it can be concluded that performance of CST is significantly related to metamemory performance on most types of problems.

Insert Table 2 about here

Discussion

Overall, there was a significant effect of grade on performance on metamemory questions. As grade increased, scores on metamemory questions tended to increase. When exploring the pairwise differences between specific grades, only the Kindergarten scores differed from the fifth-grade scores. The combination of Kindergarten and first-grade scores differed from a combination of third- and fifth-grade scores. These findings are consistent with previous research in that knowledge of memory-related phenomena increases with age.

In addition to the overall effect of age, there was a main effect of the type or format of metamemory questions. Questions with two options were easier to answer than questions with three options and questions with three options were easier to answer than questions with four options. The number of variables presented in an option is also important. Questions with two variables (i.e., questions about the interaction of two metamemory variables) were more difficult than questions with one variable in each option. It can be concluded, then, that the type of question employed to assess knowledge of memory-related phenomena affects performance on those questions.

The interaction of developmental level (grade) and question type was also significant. The difficulty of the different question types was not equal across the grades. This is critical in that to draw conclusions about the specific knowledge children of a particular age may or may not possess, one must consider the age of the child and the method in which that knowledge was assessed.

Developmental increases were found on the Counting Span Test. Third-graders performed better than Kindergartners and fifth-graders performed better than each of the other three grades. A combined score of Kindergarten and first grade was significantly lower than the combined score of third and fifth grade. This parallels the finding that third- and fifth-graders performed better on the metamemory questions than the Kindergartners and first-graders combined.

Of particular interest is the relationship between metamemorial knowledge and information storage capacity as measured by the CST. For each type of metamemory question (except T24), there was a significant effect of CST. As scores on CST increased, performance of the metamemory questions increased. This held even when age was partialled out of the metamemory scores (except T12A and T13). These findings point to a relationship albiet of small magnitude between information storage capacity and performance.

As stated above, there was a significant effect of grade on metamemory performance. This is consistent with previous research in that for many metamemory variables developmental differences have been found. These differences have been explained in terms of the knowledge children of different ages possess. This explanation has been used from the earliest works (e.g., Moynahan, 1973; Kreutzer et al., 1975) to the most recent (e.g., Miller, 1982). Although this is one viable explanation of those results, it is neither the only explanation nor the most comprehensive one possible. The explanation assumes that as children grow older, they have more specific experiences with situations requiring intentional acts of memory. As an outcome of these acts, they acquire both general and specific knowledge of memory-related phenomena. These acquisitions can be easily accessed via questions and the resulting differences (or lack of) can be explained in terms of diffrering acquired knowledge.

The knowledge-based explanation can account for developmental differences in this and previous studies, but it cannot account for differences between studies which use different methods. It is possible that a developmental trend found in one study employing certain methods may not be found in another study employing different methods. A knowledge-based hypothesis would predict that developmental trends would be found irrespective of the methods used. If knowledge was the only variable of importance, then no differences should have been found for question type. In this study, metamemory performance was affected by the type or format of the questions. By applying the rules of modus tollens, we can conclude that knowledge is not the sole factor in metamemory performance. The type of metamemory question increases in importance when considering the interaction of type and grade. Since the interaction was significant, a developmental trend may be apparent given one type of question (e.g., T23), but not given a second task (e.g, T24). Statements about the amount of knowledge attributed to children of variaous ages must include the method in which it was assessed. Otherwise, researchers risk drawing inaccurate conclusions about metamemorial performances. These results support Brown's (1978) contention that the task demands affect metamemory performance.

An more comprehensive explanation should take into account the knowledge one may or may not possess, demands of the metamemorial task, processing resources of the information processing system, cognitive processes, and strategies which may be used to respond to the particular task. In this study, the only information processing construct which was measured was information storage capacity as described by Case (1978). Other constructs may be important in metamemorial performance, but this cannot be determined from this study. It was found, nonetheless, that performance on an instrument purported to measure information storage capacity was significantly related to performance on all question types except questions with two metamemory variables nested within four options. If knowledge was the only critical variable, then the information processing construct would not have related to metamemorial performance.

There are several aspects of this study which make it important. The study serves as an informal replication of earlier work in this area. Overall, performance on metamemory questions increases with age. Although the data were not broken down by specific knowledge categories (e.g., list length), there was an increase across grades in a composite metamemory score. The age trend can be interpreted as an increasing amount of general knowledge.

Another important feature of this study is that the effects of different tasks on metamemory performance were systematicallly investigated. By designing questions which which required decisions between two or more options and which contained one or two metamemory variables, the amount of information presented to each child differed for th five question types. The difficulty of the question types was assumed to vary directly with the amount of information presented in the questions.

Another feature of this study which makes it unique is that a measure of one human information processing construct was included. While previous research has focussed on the knowledge children of different ages possess, this study sought to discover a relationship between metamemorial performance and one characteristic of the information processing system. If the Counting Span Test measures information storage capacity, then as the ability to store more information increases, children should be better able to answer questions which contain more information. Apparent age trends may be due to differences in the ability to store information rather than different amounts of memory-related knowledge. At worst, the Counting Span Test may not measure resource allocation directly, but rather, be a measure of some other general processing ability. This general processing ability, then, may be related to metamemory performance, but may or may not mediate metamemory behavior. This cannot be determined on the basis of this study. Other concerns about the information storage capacity construct have been raised elsewhere (e.g., Steuck, note 1).

In summary, the present research supports Brown's (1978) contention that systematic investigation of task demands is a critical aspect of future theoretical work in the area of metamemory. Drawing conclusions about young childrens' knowledge from studies in which the task demands are not known may lead to an inaccurate understanding of those children. A more comprehensive picture of young childrens' cognitive processing must be constructed.

Notes

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Table I.

Means for Metamemory Questions by Type and Grade.

	Grade				
Type	K	1	3	5	Total
T12A	3.20	4.00	5.00	5.47	4.42
T12B	3.47	3.47	4.93	5.27	4.28
T13	1.93	2.97	4.37	4.87	3.53
T14	2.13	3.10	4.30	4.77	3.58
T23	2.37	2.93	4.03	4.57	3.48
T24	2.03	2.07	2.53	3.03	2.42
Total	2.52	3.09	4.19	4.66	3.62

Table 2.

Means for Metamemory Questions by Type and CST Score.

	CST					
Type	1	2	3	4	5	6
T12A	4.00	3.39	4.64	5.22	5.56	5.00
T12B	2.00	3.39	4.45	5.22	5.33	5.00
T13	2.00	2.47	3.66	4.50	4.89	6.00
T14	3.00	2.36	3.79	4.33	5.33	[illegible]
T23	2.00	2.56	3.57	4.28	5.00	5.00
T24	2.00	1.92	2.47	2.78	3.11	4.00
Total	2.50	2.68	3.76	4.39	4.87	5.08
N	2	36	53	18	9	2

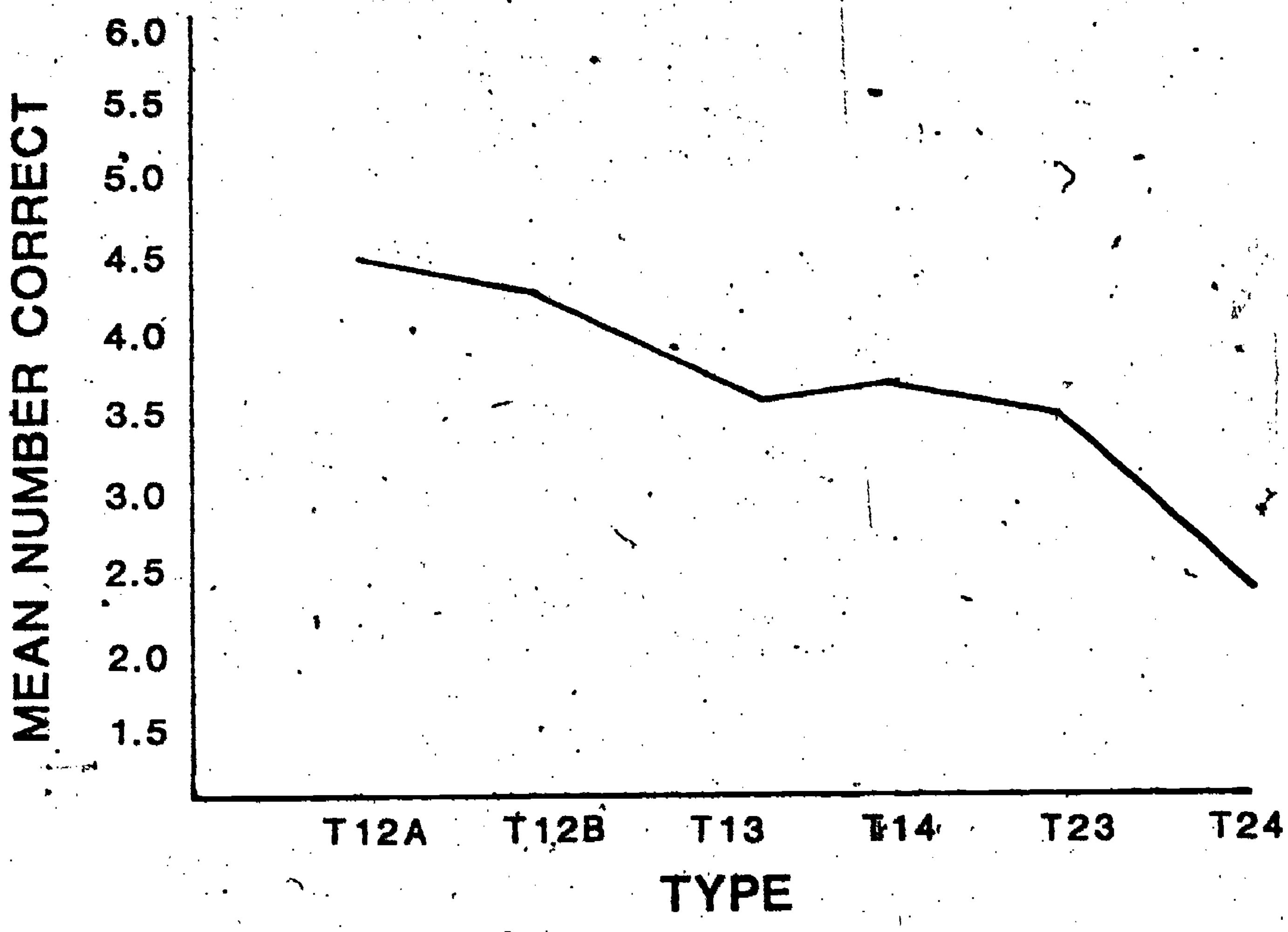

Fig. 2 METAMEMORY SCORES BY TYPE

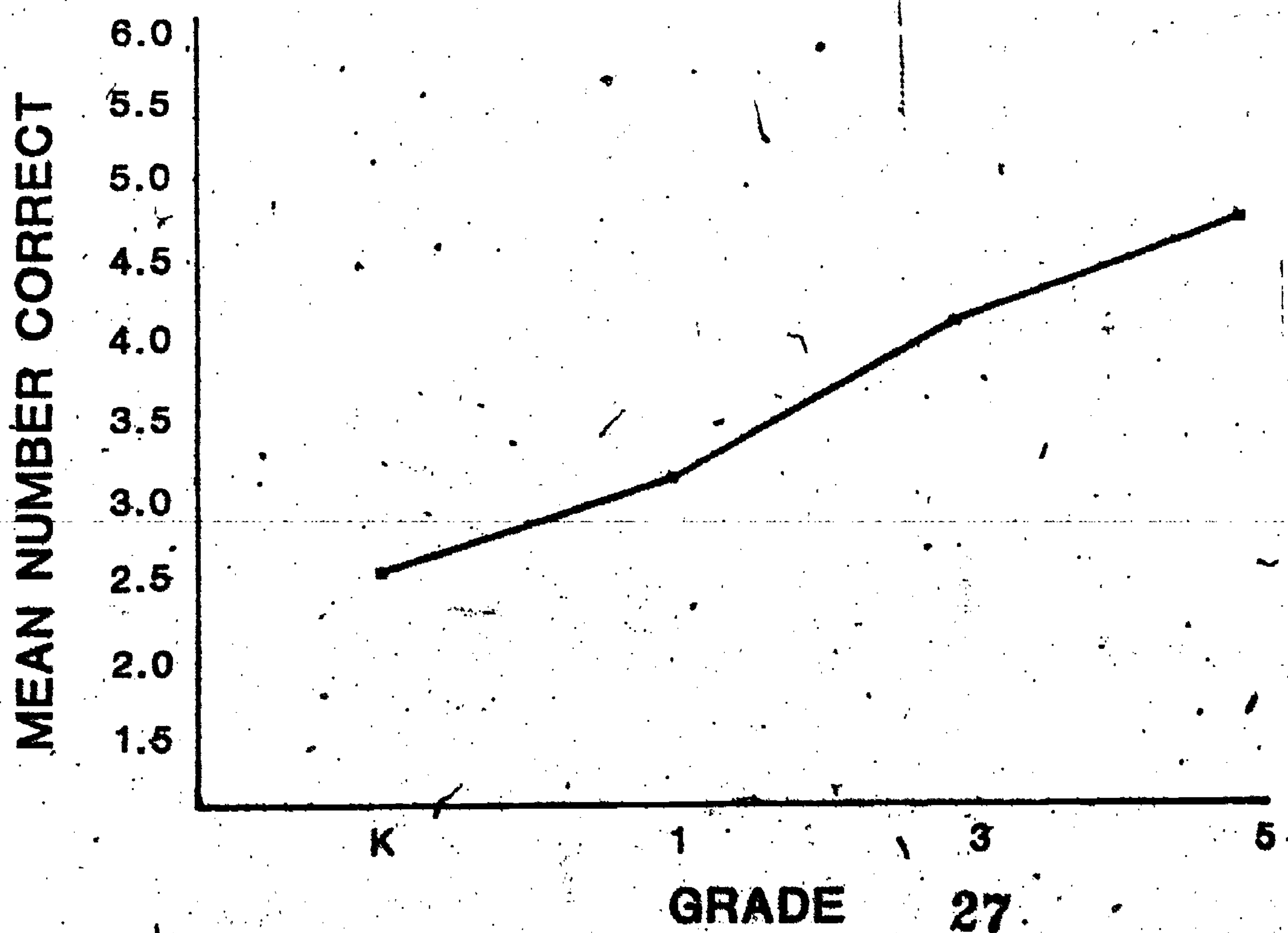

Fig. 1 METAMEMORY SCORES BY GRADE

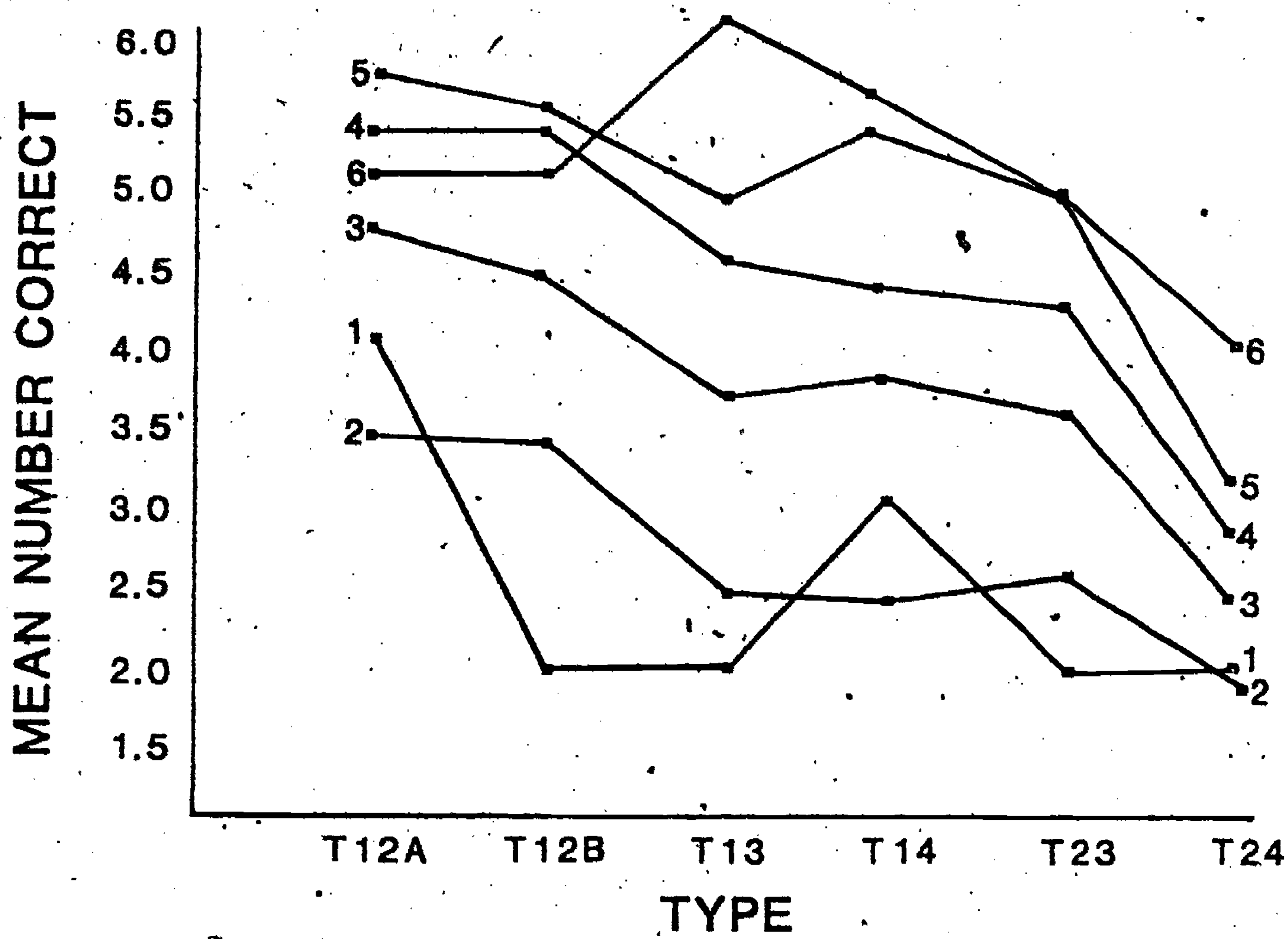

Fig. 4 METAMEMORY SCORES BY TYPE AND CST

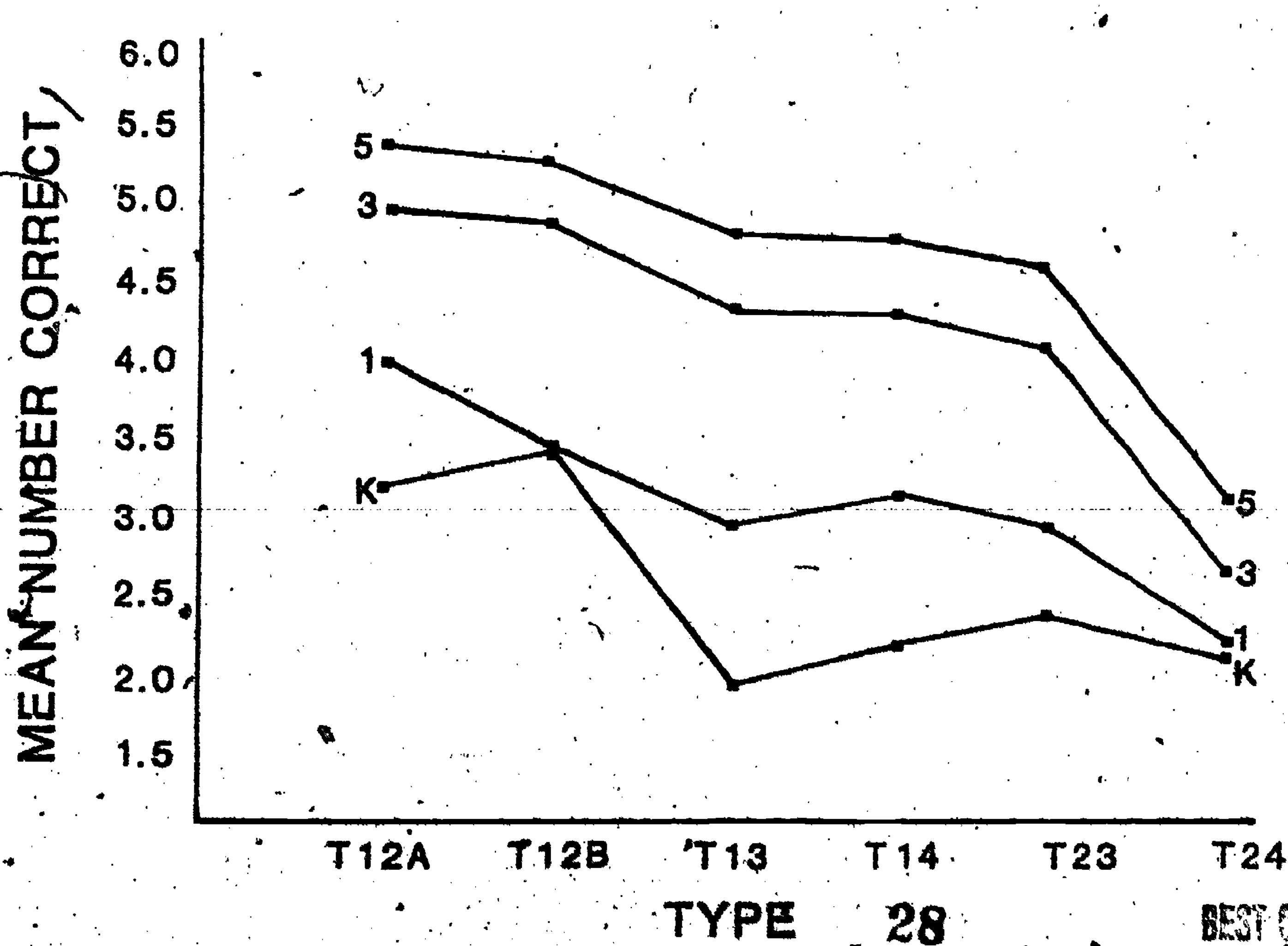

Fig. 3 METAMEMORY SCORES BY TYPE AND GRADE