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The purpose of this study was to determine the effects of age differences and differences in memory load on concept identification (CI) tasks of varying levels of complexity. Previous studies with young children found increasingly better performance on CI tasks with increasing age. This was in part due to the fact that older subjects categorize stimulus information to a greater extent than younger subjects. Perhaps a reduction of the memory load required in the task would benefit the younger children more than the older children, because it would reduce the irrelevant stimulus dimensions of the task which bother younger children. The subjects for this study were 54 kindergarten and 54 second grade children. They were administered CI tasks of three levels of complexity and three levels of memory load. The results from the subjects' performances on these tasks indicated that the younger children were more adversely affected by increased concept complexity than the older children. No significant age-memory load interaction occurred. (WD)

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Concept Identification Strategies

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Concept Identification Strategies.

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It has been established that concept identification (CI) in adults is facilitated by procedures which decrease the memory load of the *S* (Bourne, Goldstein, and Link, 1964; Cahill, and Hovland, 1960; Dominowski, 1965; Pishkin, and Wolfgang, 1965). A recent investigation (Pishkin, Wolfgang and Rasmussen, 1967) extended these findings to adolescents, and found that the younger *Ss* benefited from the reduction of memory load to a greater extent than the older *Ss*.

Developmental studies of CI with young children have typically found increasingly better performance with increasing age (Meyer and Offenbach, 1962; Osler, and Kofsky, 1965, 1966). Osler and Kofsky (1965, 1966) have shown that one reason for these age differences is that younger children respond to the irrelevant aspects of the task to a greater extent than the older children. Osler and Kofsky (1966) also demonstrated that older *Ss* categorize stimulus information to a greater extent than younger *Ss*.

The purpose of the present investigation is to determine age differences in the effects of memory load on CI tasks at varying levels of complexity. The fact that older children seem to spontaneously categorize stimulus information to a greater extent than younger children (Osler and Kofsky, 1966) suggests that less of a memory load is placed upon the older *Ss*; that is, failure to categorize requires the *S* to recall the association between each separate stimulus and the correct response, while categorization of stimuli requires only that the *S* recall the association between a combination of stimuli and the correct response. Thus, it seemed plausible to expect that a reduction of the memory load required by the task would be of greater benefit to the younger than the older children. A corollary of

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this hypothesis is that reduction of the S's memory load would reduce responding to the irrelevant stimulus dimensions of the task for all age groups but to a greater degree for the younger as opposed to the older children.

Method

Subjects

The Ss were 108 boys and girls from kindergarten (K) and second grade (SG) classes at a suburban, Central New York school. The K sample contained 32 boys and 22 girls ranging in age from 5.6 to 6.7 years, with a mean of 5.9 years. The SG sample contained 30 boys and 24 girls ranging in age from 7.4 to 8.11 years, with a mean of 8.0 years. The 54 Ss within each age level were assigned at random to one of nine groups, resulting in six Ss per cell. The children are generally lower-middle class with generally average intellectual ability.

Stimuli

Concept identification tasks at three levels of stimulus complexity were constructed. Each level required the identification of one relevant concept, and complexity was varied by including either 0, 1, or 2 irrelevant concepts. In information theory nomenclature the problems contained either 1, 2, or 3 bits of information. Three bi-value concepts were combined to yield 12 possible problems shown in Table 1. Within each level of complexity, the relevant concept was assigned to each S at random.

The positions of the correct responses were sequenced according to criteria outlined by Fellows (1967). These sequences are designed to control responding on the basis of position perseveration, position alternation, win-stay, lose-shift, and win-shift, lose-stay strategies at a chance level. Thus, stimuli were sequenced so that within a block of trials (a) each stimulus appeared equally often, (b) correct responding involved selection of the right and left buttons equally often,

Table 1

Characteristics of the Experimental Problems

Characteristics[a]			
Bits of Information	Relevant Dimension	Irrelevant Dimension(s)	Number of Stimuli
1	Form	-	2
	Color	-	2
	Size	-	2
2	Form	Size	4
	Color	Form	4
	Size	Color	4
3	Form	Color Size	8
	Color	Form Size	8
	Size	Form Color	8

[a]Values of the concepts used were: form-circle, square; color-red, blue; size-one to two ratio.

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and (c) shifting sides was rewarded equally as often as staying on the same side. Sequences 1 and 3 (121122211122 - 112221112212) from Fellows (1967) were combined to form a block of 24 correct response positions.

Design and Procedure

The basic design was a 3 x 3 x 2 fixed effects model varying three levels of complexity (1, 2, or 3 bits of information), three levels of memory load reduction (0, 1, or 2), and two grade levels (K or SG). The procedure consisted of three parts; pretesting, pretraining, and the experimental task. To prevent fatigue, the pretesting and pretraining were conducted on one day, and the CI task was administered the following day. All Ss were run individually.

During the pretesting each S was presented with several pictures, and was questioned by the E to determine ability to discriminate the forms, colors, and sizes used in the experiment. Subjects who were unable to make any one of these discriminations were not used in the experiment. One K and one SG S failed the pretesting.

Both the pretraining and CI tasks were presented visually on the same apparatus. The S was seated at a table in front of a milk glass screen, and the stimuli were rear projected on the screen terminating upon the child's response. A procedure of successive presentations was employed. Two buttons were placed on the table in front of the S, one to the right and one to the left of center. Activation of the correct response button operated an M&M dispenser (Davis Scientific Instruments, Model MMd-1). which delivered a candy to a box in view of the S. The equipment was automatically sequenced by means of a Gerbrands Program Timer (Model No. 1001).

For the memory load conditions in which 1 or 2 previous instances were available, a lighted display box was placed behind each of the response buttons. Following a correct response in these conditions, a print identical in content and size to the original projected stimulus was placed by the E in the box behind the appropriate response button. In conditions where one instance was available, the print remained in the display box until the S made another correct response, at which time it was removed and the new instance was placed behind the appropriate button. The procedure was the same for the conditions in which two previous instances were available, except that two prints were displayed at any one time. Following a third correct response, the earliest instance of the two displayed was removed. Only previously correct instances were used since other investigations (Pishkin, Wolfgang, and Rasmussen, 1967) have shown previous instances facilitate performance only if they are positive. For the 0 condition, no stimuli were given.

During the pretraining task, the Ss were shown pictures of a boy and a girl. The task was to press the left button whenever the girl appeared on the screen, and to press the right button for the boy. The E first showed the S which buttons to press, and explained the nature of the task. In the conditions where appropriate, the E also displayed the previously correct instances and explained their function. The Ss were encouraged to attend to these stimuli. Following the instructions, a series of the two pretraining stimuli were presented in blocks of eight trials with a correct response sequence of 12112221. The interstimulus interval was four seconds. Reinforcement was verbal, with the E saying "right" for correct responses and "wrong" for incorrect responses. The Ss were run to a criterion of 8 consecutive correct responses or 72 trials, whichever came first.

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Subjects who failed to reach criterion within 72 trials were dropped from the experiment. The range of errors on this task was small (0 to 5), and only one SG S failed to reach criterion.

Prior to the CI task on the following day, the instructions were repeated and eight additional practice trials were given to all Ss using the pretraining stimuli. In the CI task, the S was required to respond without aid from the E. Only one problem was given to each S in which the task was to consistently place one value of the relevant dimension to the right, and the other value to the left by pressing the appropriate buttons. Successive presentations were used with an interstimulus interval of six seconds. Correct responses were reinforced with M & Ms, and no candy was delivered for an incorrect response. The Ss were run to a criterion of 10 consecutive correct responses or 144 trials, whichever came first.

Results

Total errors to criterion for each of the 18 groups are shown graphically in Figure 1 and Table 2. This table, as are all analyses, is based on data with a cut-off point of 50 rather than 144 trials. This cut-off point was used since the median number of trials to criterion was 14, and only 4 of the 23 Ss who went beyond 50 trials reached criterion before reaching 144 trials. Thus, analyses of the data based on a maximum of 50 trials accurately reflects the results of the experiment.

Analysis of variance on the error scores yielded a significant bits effect ($F = 5.88$, $d.f. = 2,90$; $p < .005$) which accounts for 8% of the total variance. The analysis also indicated a significant memory load effect and accounts for 9% of

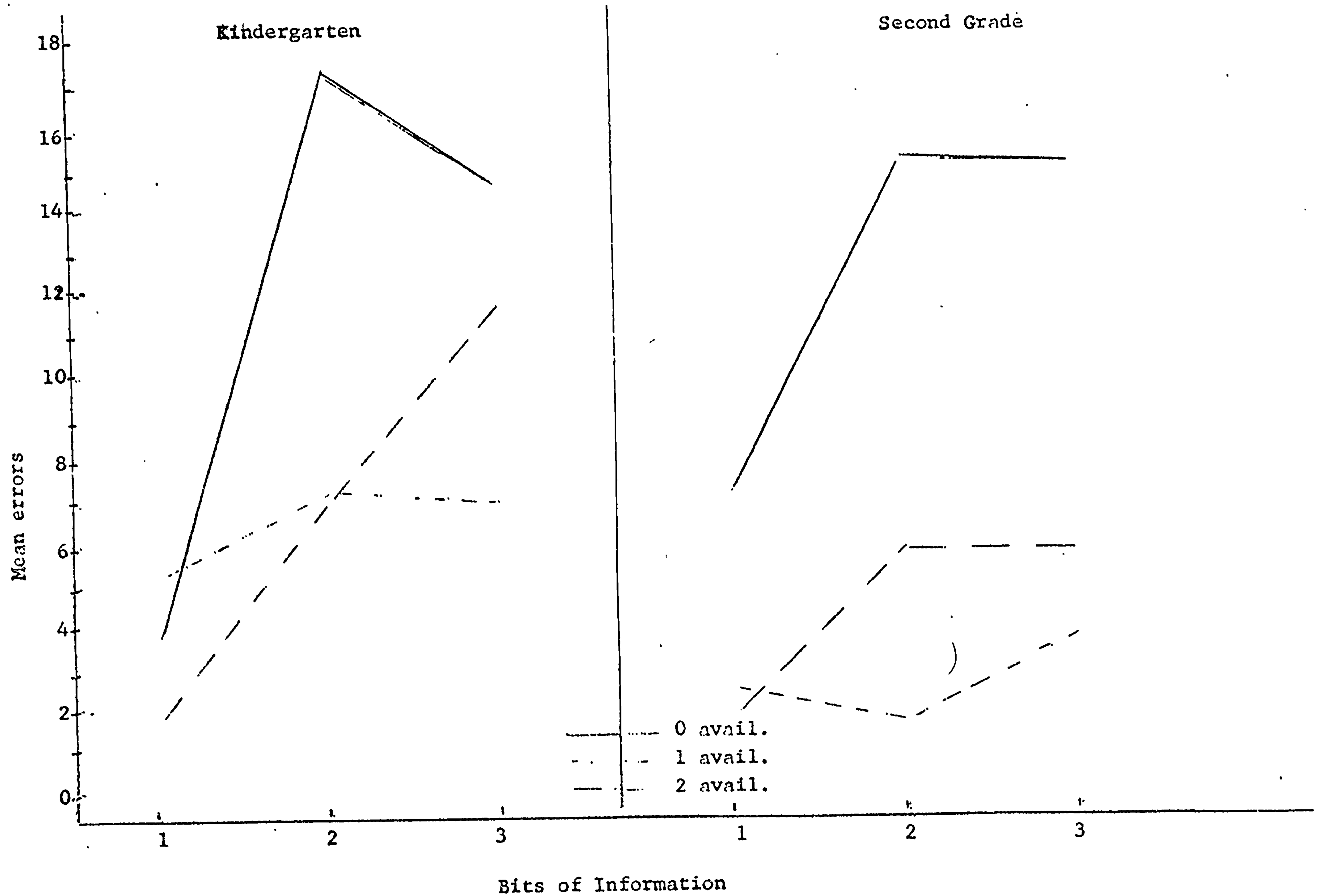

Figure 1
Mean errors for kindergarten and second grade groups at 1, 2, and 3 bits of complexity and 0, 1, and 2 available instances.

the total variance ($F = 6.74$; d.f. = 2,90; $p < .005$). No other main effect or interaction was significant.

Analysis of the simple effects for bits of information, and number of available instances was done to locate the sources of variation contributing to the significant main effects. The analysis for bits of information indicated a significant bits effect at 0 available instances ($F = 5.16$; d.f.= 2, 90; $p < .01$), but not at 1 or 2 available instances (see figure 2). Further comparisons with the 0 available instances indicated greater numbers of errors were made at the 2 and 3 bit levels, than at the 1 bit level ($F = 10.14$; d.f.= 1,90; $p < .005$).

Analysis of the simple effects for memory load yielded a significant effect at the 2bit level ($F = 6.18$; d.f.= 2,90; $p < .005$), but not at the 1 or 3 bit levels, although the comparison at the 3 bit level was significant at the .10 level (see figure 3). Further comparisons within the 2 bit level indicated fewer errors were made with 1 and 2 available instances than when no instances were available ($F = 12.02$; d.f.= 1,90; $p < .005$).

Since both bits of information, and number of available instances represent equal intervals of quantitative variables, trend analysis was performed on these factors by analyzing the sums of squares of the main effects into linear and quadratic components. It was found that the linear component accounted for 91% of the total sums of squares due to bits of information ($F = 10.67$; d.f.= 1,90; $p < 005$), while the quadratic component accounted for the remaining 9% of the variance which is not statistically significant. The linear component for the number of available instances was also significant ($F = 9.73$; d.f.= 1,90; $p < .005$) and accounts for 72% of the quadratic component accounted for the remaining 28% and was not significant.

A chi-square analysis of trials to criterion was carried out according to a technique described by Bresnahan and Shapiro (1966) in which an overall contingency

Table 2 - Means and variances of errors

			Kindergarten			Second		
			# available			# available		
			0	1	2	0	1	2
B I T S	1	$\overline{X}$	3.8	5.2	1.5	7.2	2.7	1.8
		SD	6.1	9.8	1.2	10.0	4.2	1.7
	2	$\overline{X}$	17.2	7.2	7.0	15.2	1.5	5.8
		SD	11.1	9.6	9.4	12.3	2.3	8.7
	3	$\overline{X}$	14.3	12.0	11.8	15.0	3.8	5.8
		SD	10.7	13.8	9.5	12.2	3.2	6.4

F max = 127.73
F max, .01,5 = 88.0

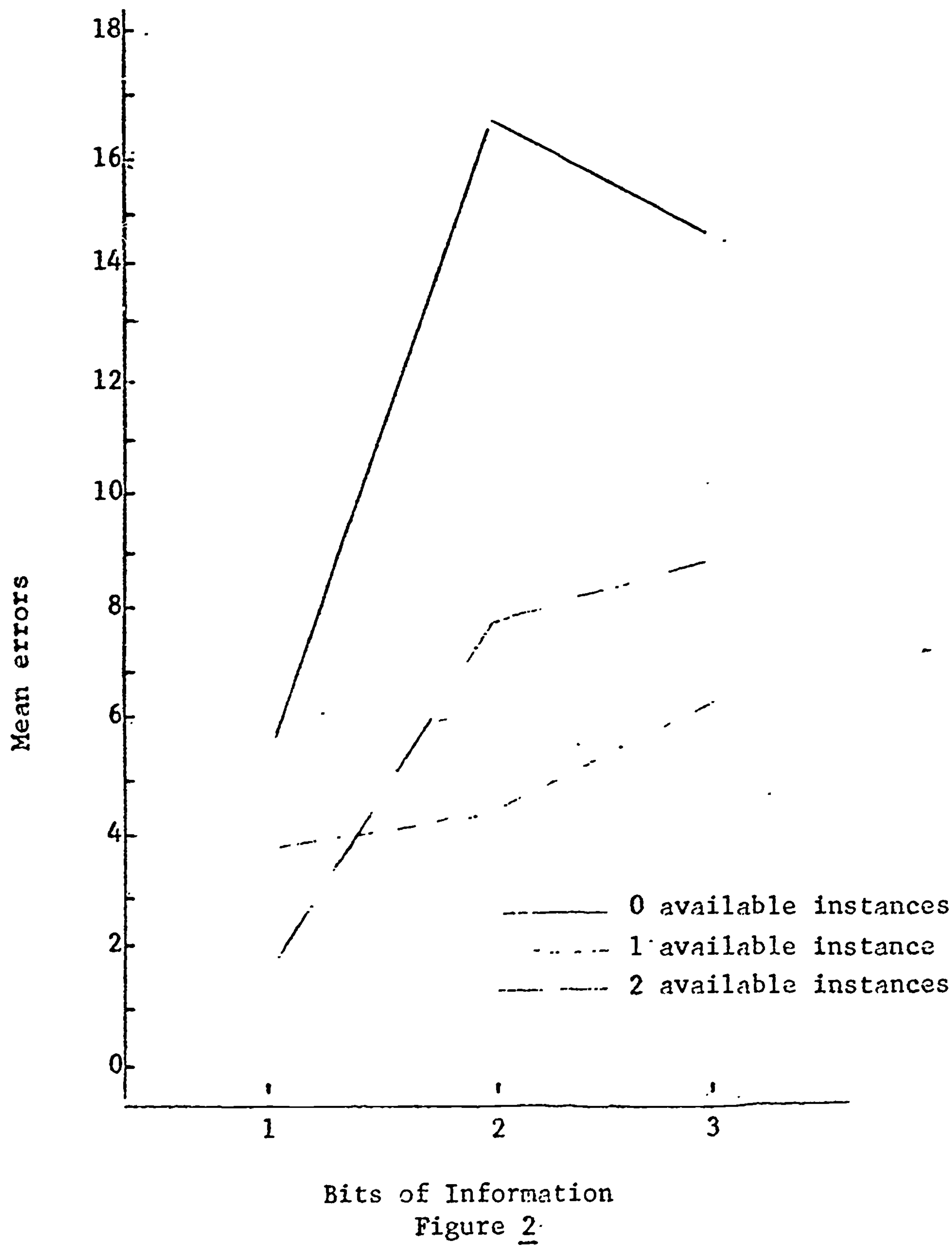

Figure 2

Mean errors for kindergarten and second grade groups combined at 1, 2, and 3 bits of information and 0, 1, and 2 available previous instances.

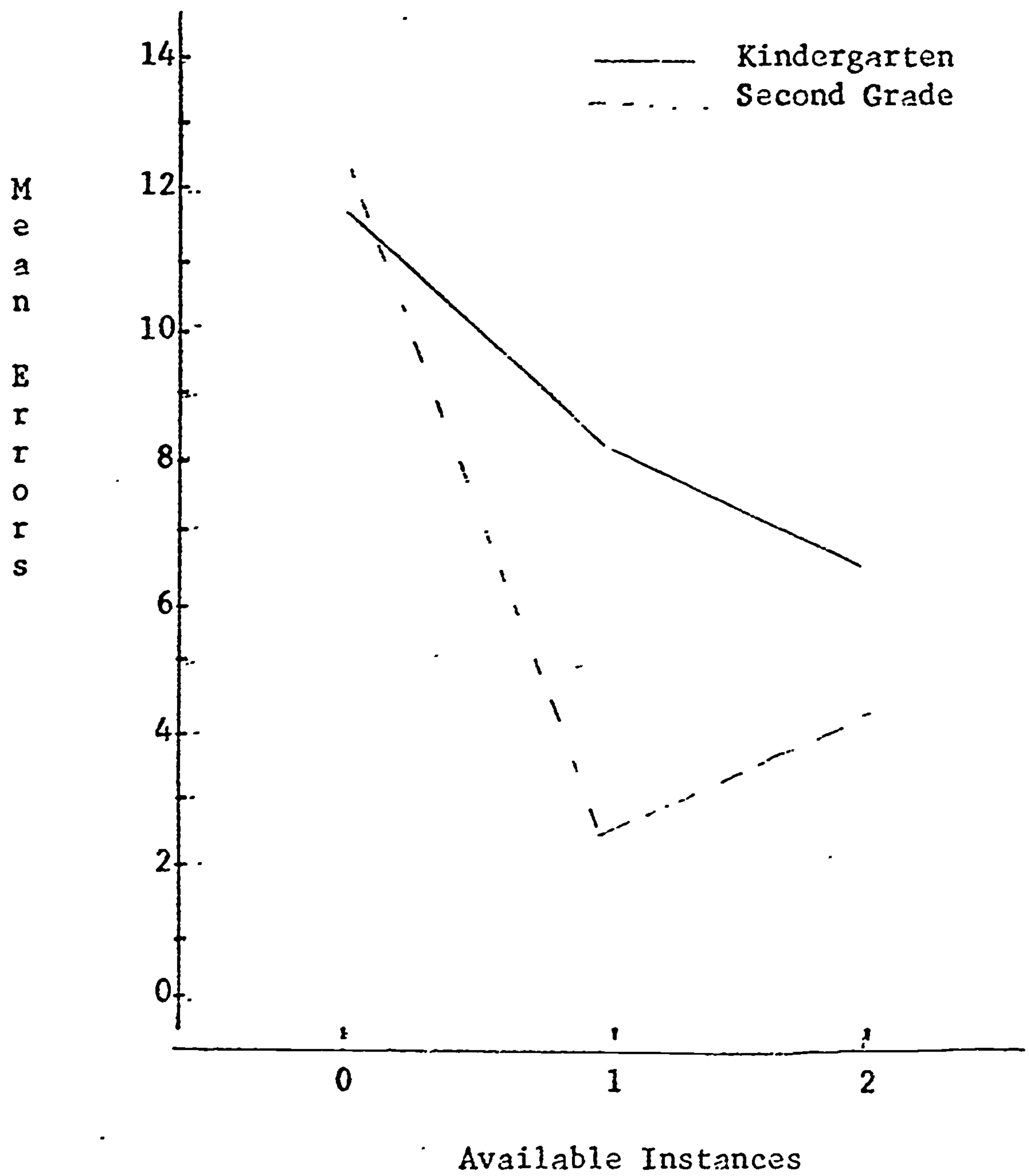

Figure 3

Mean errors for Kindergarten and Second Grade groups at 0, 1, and 2 available previous instances.

table with more than 1 d.f. may be partitioned into orthogonal components, each distributed as chi-square with 1 d.f. This permits precise analysis of the source of nonindependence which may be found in the overall contingency table. This analysis was carried out for several reasons. First, it was necessary to analyze the trials to criterion measure by non-parametric measures since a number of Ss did not reach criterion. That is, there was no way to determine the number of additional trials these S would have required to reach criterion, and thus, these Ss constituted only a category. Second, a non-parametric analysis was considered informative since the variances of the error scores were unequal (F_{MAX} = 127.73; d.f.= 5; $p < .01$). Since trials to criterion correlated .97 with errors, analysis on the former measure should provide a replication of the error analysis of variance results. Thus, while the F test has been shown to be robust with respect to the assumption of equal variances, replication of the parametric analysis by the non-parametric would increase confidence in the results of the experiment. Finally, the trials to criterion measure was used since it permitted comparisons of criterion Ss with non-criterion Ss, as well as further comparisons within the criterion group alone. Although these comparisons were possible analysis of variance of error scores, the procedure would have resulted in unequal numbers of Ss within the cells, which, with unequal variances, seriously violates the assumptions underlying the F test.

Categories were formed by dividing the criterion Ss into quarters on the basis of the number of trials required to reach criterion. Subjects not reaching criterion formed a fifth category. The experimental groups conform to the requirements for the analysis (Bresnahan & Shapiro, 1966). Table 2 shows the overall contingency table, analysis of which indicated significant non-independence

(χ^2 = 62.20, d.f. = 44; $p < .05$). The overall contingency table was partitioned into 10 orthogonal components in an attempt to locate the sources of the non-independence indicated by the overall analysis. It was decided *a priori* to calculate these orthogonal components for criterion versus non-criterion Ss, and for a median split on trials to criterion within the criterion group alone. The results show that proportionally more Ss failed to reach criterion at 3 bits than at 1 bit, and that at 2 and 3 bits, proportionally more Ss reached criterion when 1 and 2 previous instances were available than when none were available. None of the other partitions yielded significant chi-square values. Thus, this analysis lends support to the results of the error analysis of variance, except that it indicates a significant effect due to available instances at 3 bits, while this effect only approached a low level of significance in the error analysis.

The partitions for the comparison of the criterion Ss alone, divided into those above and below the median on the trials to criterion measure, revealed that proportionally more Ss were above the median on the trials to criterion measure at 3 bits than at 1 bit. No other comparisons were significant. The effects found previously for the number of available instances were not found in this analysis, suggesting that these effects were due entirely to Ss failing to reach criterion.

Information theory suggests another data analysis strategy. Essentially, the question asked is how much of the information contained in the stimuli is actually transmitted to the child. For example, in information theory terms, a problem may contain one bit of information (two equi-probable events). In the case of perfect transmission, the S will consistently make one response for one event, and a second response for the other event. No information is transmitted if the S responds randomly to the two events. Thus, transmitted information may be thought

Table 3

Overall Contingency Table Tabulating Trials

To Criterion For All Treatment Groups

Experimental Group			Trials				
			10	11-12	13-16	17-43	Non-Criterion
1 Bit	0	K	3	1	0	2	0
		SG	0	2	1	2	1
	1+2	K	3	6	2	0	1
		SG	4	3	3	2	0
2 Bits	0	K	0	0	2	0	4
		SG	2	0	0	1	3
	1+2	K	2	1	3	4	2
		SG	2	4	3	2	1
3 Bits	0	K	0	1	0	2	3
		SG	0	1	1	1	3
	1+2	K	3	0	1	4	4
		SG	1	1	5	4	1

For this Table and other Tables of the chi-square analysis the following symbols will be used: c= Criterion Ss; NC= Noncriterion Ss; 0= No available Instances; 1+2= The sum of the 1 and 2 available Instance conditions; K= Kindergarten; SG= Second Grade.

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of as the amount of reduction of uncertainty produced by the S's response to the stimulus events. In this study, the analysis was concerned with the amount of information transmitted from the relevant and irrelevant stimulus dimensions and permits a direct assessment of the amount of systematic responding to the relevant and irrelevant dimensions. The use of error measures does not permit direct assessment because they may be caused by wholly random responding as well as by responding to irrelevant cues.

Details for computing the information transmission index are described by Attneave (1959, pp. 42-67). Essentially the computations are concerned with a comparison of the maximum possible uncertainty with actual uncertainty. Maximum possible uncertainty occurs when the subject is responding on a purely random basis. The difference between maximum uncertainty and actual uncertainty is the amount of reduction of uncertainty provided by the subjects responses.

Table 4 and figure 4 show the mean amount of information transmitted from the relevant and irrelevant dimensions for both the criterion and non-criterion Ss of the various experimental groups. The values represent transmission scores between a maximum of 1.00 (perfect transmission), and a minimum of .00 (random responding). The significance of these values (difference from zero) was calculated by means of the chi-square formula: $X^2 = 1.3863\ N\ (T - d.f./\ 1.3863\ N$, where N equals the total number of responses, T equals the mean transmission score, and d.f. equals the degrees of freedom (Attneave, 1959, pp. 63-66).

The findings suggest that criterion Ss discarded the irrelevant cues rapidly, and responded mainly to the relevant cues. For the criterion Ss, 96% of the transmission was accounted for by the relevant cues, while only 4% was accounted for by the irrelevant dimensions. On the other hand, 20% of the non-criterion Ss' trans-

Table 4

Mean Amount of Information Transmitted
From Relevant and Irrelevant Stimulus Attributes

Condition	Criterion Ss			Non-Criterion Ss		
	n	relevant	Irrelevant[1]	n	relevant	Irrelevant
Kgn 1 Bit 0 Available	6	.635[d]	-	0	-	-
Kgn 1 Bit 1 Available	5	.678[d]	-	1	.000	-
Kgn 1 Bit 2 Available	6	.562[d]	-	0	-	-
Kgn 2 Bits 0 Available	2	.286[c]	.000	4	.000	.040
Kgn 2 Bits 1 Available	5	.482[d]	.050[b]	1	.000	.000
Kgn 2 Bits 2 Available	5	.482[d]	.079[c]	1	.000	.000
Kgn 3 Bits 0 Available	3	.199[d]	.012	3	.029[b]	.030[b]
Kgn 3 Bits 1 Available	4	.648[d]	.041	2	.007	.045[b]
Kgn 3 Bits 2 Available	4	.325	.022	2	.008	.001
2nd 1 Bit 0 Available	5	.445[d]	-	1	.000	-
2nd 1 Bit 1 Available	6	.569[d]	-	0	-	-
2nd 1 Bit 2 Available	6	.570[d]	-	0	-	-
2nd 2 Bits 0 Available	3	.641[d]	.008	3	.000	.020[a]
2nd 2 Bits 1 Available	6	.680[d]	.000	0	-	-
2nd 2 Bits 2 Available	5	.524[e]	.008	1	.015	.082[b]

Table 4
(continued)

Condition	Criterion Ss			Non-Criterion		
	n	relevant	Irrelevant	n	relevant	Irrelevant
2nd 3 Bit 0 Available	3	.378[d]	.036	3	.009	.021[a]
2nd 3 Bit 1 Available	6	.367[d]	.089[d]	0	-	-
2nd 3 Bit 2 Available	5	.413[d]	.019	1	.044	.193[d]

[1] The irrelevant dimension which transmitted the greatest amount of information for each S was used in computing the mean.

a $p < .05$

b $p < .025$

c $p < .005$

d $p < .001$

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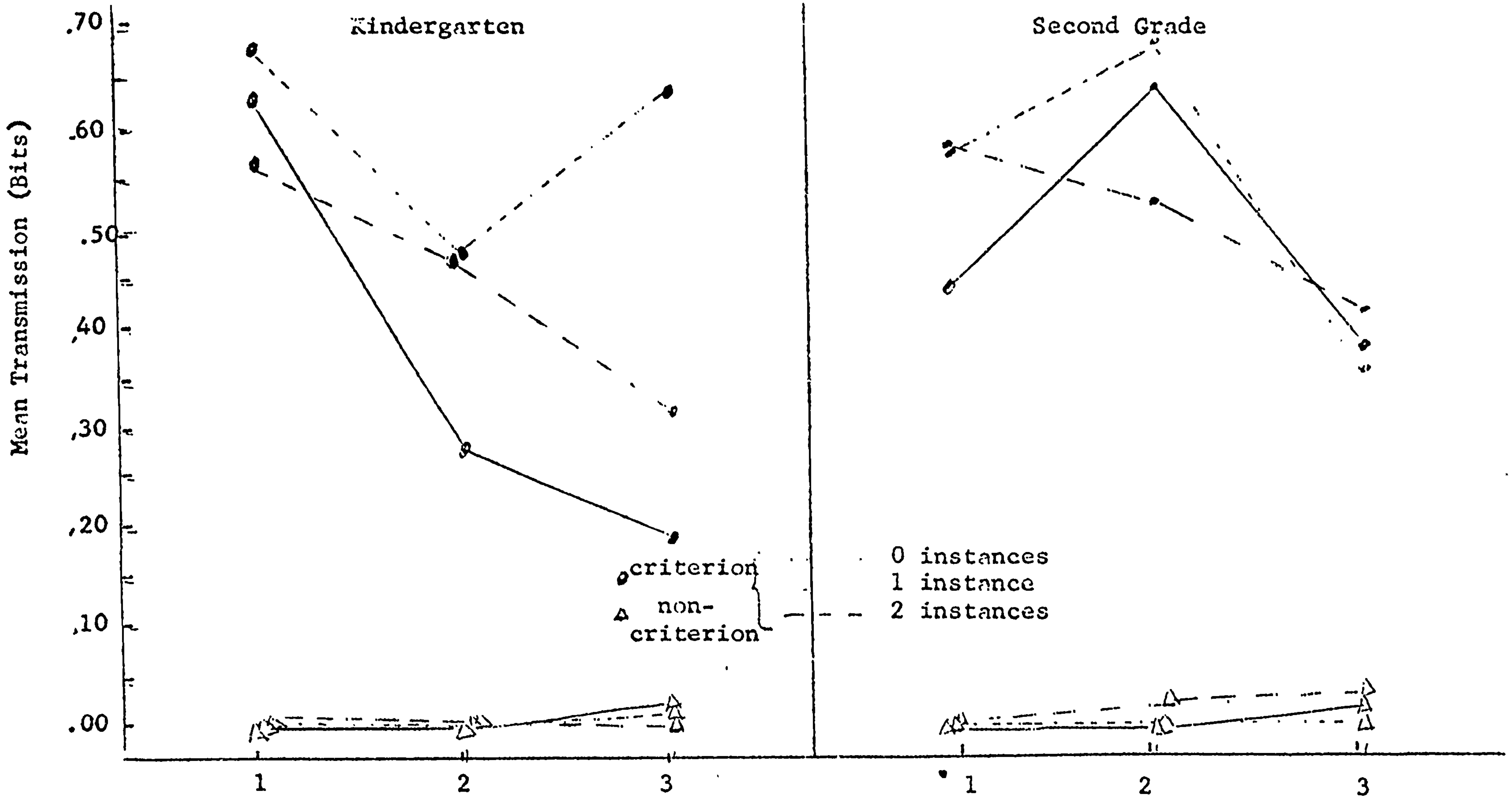

Figure 4

Mean Transmission (Bits) on relevant dimension for criterion and non-criterion Kindergarten and Second Grade groups as a function of stimulus complexity and number of available instances.

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mission was accounted for by the relevant dimension, while 80% was accounted for by response to the irrelevant cues. Thus, it appears that response to irrelevant cues was a major factor in the failure of Ss to reach criterion.

Discussion

A major purpose of this study was to examine the interaction of age and task complexity where complexity was defined in terms of stimulus uncertainty. Although the stimulus complexity effect was statistically significant, the interaction failed to attain an acceptable level of statistical significance. Examination of figure 5 suggests, however, that the younger children were more adversely affected by the increase in stimulus uncertainty than the older children. The major reason, as suggested by the data, for the nonsignificant interaction effect is apparently the extreme variability of the children's performance. Inspection of the individual performance scores suggests that many of the children entered the learning task with the correct hypothesis already formed and, therefore, required relatively few learning trials. Other children either had no hypothesis or contrary hypothesis resulting in many more trials to achieve criterion. With only six Ss in a cell, the effect of the variability was to eradicate statistical significance.

It should be noted, however, that the general direction of our age x complexity interaction is entirely consistent with that reported by Osler and Kofsky (1965). Considering the two studies together, there is support for the conclusion that concept learning is adversely influenced by higher levels of stimulus uncertainty. The conclusion is further warranted that younger children are more adversely influenced by higher levels of stimulus complexity than older children.

One reasonable interpretation offered by Osler and Kofsky (1965) for the age x complexity interaction is that younger, as opposed to older children rely more

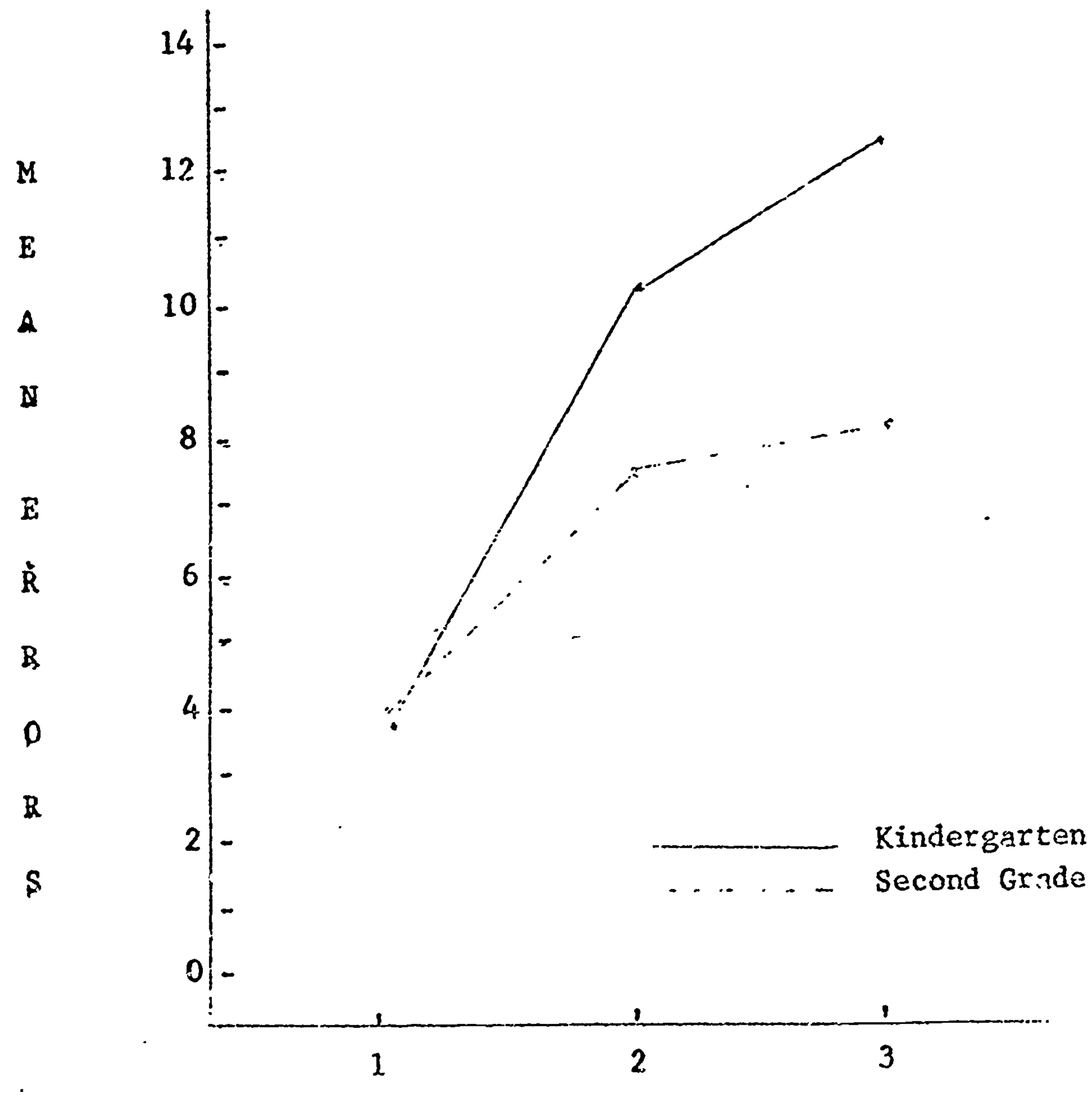

Figure 5

Mean errors for Kindergarten and Second Grade groups at 1, 2, and 3 bits of information complexity.

on associating specific stimuli with specific responses. Older children, conversely, are probably dimensionalizing the task placing less of a load on their memory capacities. This hypothesis was examined in this study by providing the children with varying amounts of mamory aids. We anticipate an age x memory aid effect but, again, it failed to attain an acceptable level of significance. The effect attributable to the memory aid variable was statistically significant with the zero availability group performing less well than the one and two availability group. The interaction of stimulus complexity x memory aid was also not statistically significant.

Inspection of figures 1 and 3 suggest that the general trends are not consistent with the age x memory aid hypothesis. Figure 1 indicates that the second grade group improved more with the memory aid than the kindergarten group. Similarly, figure 3, which compares age groups for pooled complexity levels, indicates greater improvement for the older children. In terms of the original hypothesis these results suggest that the memory aid is more effective when the children dimensionalize the stimuli. Thus, in the task used in this study, the children dimensionalizing the stimuli, as opposed to the S-R learners, maintain their memory load advantage. Indeed, it can be argued that the memory aids provide a greater percentage reduction in memory load, because of dimensionalizing for the older, as opposed to, the younger children. This revised hypothesis will be examined in our next study.

A finding of particular interest from the information analysis concerns the performance of the <u>non-criterion Ss</u>. Although the number of non-criterion children in lack of the cells is small, it should be noted that they uniformly perseverated in their responses to the irrelevant dimensions. Another possibility, observable

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from this analysis, was for the children to respond randomly. This tendency toward perseveration was noted by Osler and Kofsky (1965) who also found a greater tendency among their younger Ss (four-year-olds) for that type of behavior. (Our data do not permit an age comparison because of too few Ss in the cells.) One might speculate that the children showing the perseverative behavior were satisfied with the approximately 50 1/0 reinforcement they received by continuously responding to the irrelevant dimension.

In view of the subject variability encountered in this study, we plan to change the design. Clearly, one feature of the design must include a greater number of Ss in each cell. Approximately 20 subjects per cell should be adequate. Secondly, we plan to include only two levels of stimulus complexity; one bit vs. 3 bits. Thirdly, the memory aid variable will include zero available instances as opposed to one available instance. Essentially the revised design is a 2 x 2 x 2 with two levels of stimulus complexity, two levels of memory aid, and two age levels.

Another modification derived from the present study involves the procedure. Instead of using only one relevant dimension, we plan to counterbalance, within groups, the relevant dimension. In this way it should be possible to counteract response preferences and it also makes it possible to partial out the effects of stimulus preferences, if they should occur.

Finally, e are planning to use "culturally deprived" children in our sample and compare their performance with another sample of middle-class children.

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