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ABSTRACT

Two scales designed to measure cognitive preferences were constructed; this study was designed to validate these scales, and to investigate the relationship between instruction and cognitive preference. Items for both scales had elementary mathematics content. One scale was intended to measure deductive-inductive preference, the other figural-symbolic preference. Each scale was balanced in the sense that it contained equivalent items in each of the two relevant modes. After pilot testing, the scales were administered to 92 students in a mathematics course for elementary teachers, 38 students in an elementary mathematics methods course and 40 inservice elementary teachers. Validity was assessed by examination of reliability coefficients (KR-20's ranged from .85 to .91) and deviation from normality of score distribution (skewness, kurtosis). Analyses of variance showed that subject groups differed significantly (p less than .01) in their preferences. The authors discuss limitations as well as implications of the study. (SD)

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DEVELOPMENT AND VALIDATION OF TWO COGNITIVE PREFERENCE SCALES

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The purpose of this paper is to report the development and validation of two cognitive preference scales and a comparison of two populations based on these scales.

Research has been done with the purpose of maximizing learning for groups of people whose aptitudes or cognitive styles are similar. The amount of attention given to the problem of maximizing learning based on learners' aptitudes is clearly evidenced by research in the area of aptitude-treatment-interaction (ATI) (See Bracht, 1970; Cronbach and Snow, 1969). Research using cognitive style variables as predictors of learning success has also been undertaken (See for example, Wyett, 1967; Ohnmacht, 1967).

The term cognitive preference used herein is distinct from aptitude and cognitive style. The term aptitude is most frequently used to refer to the potential for learning. Vernon (1952) communicates his conception of cognitive style when he states that

> Certain individuals perceive typically in certain ways in all perceptual situations; whereas, others perceive typically in a different manner [p. 247].

The term cognitive preference as used in this paper refers to a conscious decision which the Ss in this study were forced to make. The Ss indicated their choice (or preference) for one of two possible modes of presenting concepts of mathematics.

Investigation of the potential for cognitive preference and associated scales for measurement was undertaken by the authors for two reasons. First, it was considered highly probable that the scales would discriminate between subjects and thus certain groups of people would exhibit similar cognitive preference scores; moreover, it was hypothesized that these scores would serve as good predictors for the mode of instruction from which groups of subjects would learn best. Second, it was considered probable that the cognitive preference scores of prospective or inservice teachers might be changed through instruction; it would then be of considerable interest to determine whether measurable changes in cognitive preference would result in observable (or measurable) changes in teachers' classroom behavior.

Travers (1967) constructed an instrument which was used to measure the cognitive preference of 115 seventh-grade students. In his scale Ss were presented mathematical concepts in three modes--graphic, verbal, and symbolic. The Ss were instructed to choose one of the three correct ways of presenting each concept; their choice was to reflect the mode in which they would prefer having their teacher present it to them. The data of Travers' study suggested that the scale items functioned as intended and appeared to discriminate between Ss. Because of psychometric problems arising from the ipsotive scoring of the scale further study of the scale was recommended.

For this study the authors constructed two separate cognitive preference scales. One scale was intended to measure a deductive-inductive preference, the other was intended to measure a figural-symbolic preference. The instructions for both scales directed Ss to choose, from among two correct modes of presenting mathematical ideas, the mode in which he would prefer to learn the idea. Further discussion of the construction and validation of the scales is given in the procedures section of this paper.

In order for the scales to be of potential value for measurement purposes, investigation related to the validation of the scale is necessary. Minimally, it should be demonstrated that the scale has a satisfactory reliability. A measure of internal consistency for the scales is the appropriate reliability to consider in this case. Moreover, since each scale was assumed to measure a bipolar construct (deductive-inductive cognitive preference and figural-symbolic cognitive preference), measures of deviation from the normal distribution are of interest.

This necessitates the reporting of a measure of internal consistency, KR-20 reliabilities are reported herein, and measures of the deviations of the distributions from the normal. Therefore measures of skewness and kurtosis are also reported herein.

Procedures

Using the scale developed by Travers (1967) as a point of departure, the investigators constructed two cognitive preference scales. One scale was called the Figural-Symbolic (FS) scale and the other the Inductive-Deductive (ID) scale. The purpose of the scales was to determine whether subjects show a measurable difference in their preference for learning mathematical concepts in a figural or a symbolic mode, and in an inductive or a deductive mode. Each of the two scales, FS and ID, consisted of items which presented concepts from several mathematical areas: arithmetic, algebra, number theory, and geometry. Each concept was about the seventh or eighth grade level of difficulty. Some, but not all, items on both the FS and ID scales presented exactly the same mathematical concepts. Each item of the FS scale presented a mathematical concept in both a figural and a symbolic mode;

similarly each item of the ID scale presented a mathematical concept in both an inductive and a deductive mode. The four modes were operationally defined as follows: in the inductive mode the verbal statement of the concept presented was preceded by two exemplars; in the deductive mode the verbal statement of the concept was followed by two exemplars; in the figural mode the concept was represented by a picture or diagram; in the symbolic mode the concept was presented symbolically.

In Figure 1 one sample item from each of the scales is given.

Figure 1 about here

Scoring of the FS scale was accomplished by assigning the value one for each item on which the subject chose the figural mode and zero otherwise. Similarly for the ID scale, a choice of deductive mode on an item was given a value of one, and zero otherwise.

To determine whether any scale order effects could be expected, the scales were administered to a sample population. The 92 subjects were randomly assigned to be administered the scales in the order FS, ID or ID, FS. The proportion of Ss choosing the inductive mode for a particular item when they received the ID scale before the FS scale was compared to the proportion of Ss choosing the inductive mode for that item when they received the FS scale before the ID scale. Although some differences in these proportions were found, it was also apparent that differences in these proportions existed for items which were not common to the two scales. It was therefore concluded that the order in which the two scales was administered would not significantly affect the distribution of scores on either the FS or ID scales.

In order to determine whether the two tests would discriminate between subjects according to their preference for a mode of learning mathematical concepts, the two scales were administered to three groups of subjects. The first group consisted of 92 college freshman and sophomore preservice elementary school teachers who were enrolled in a mathematics content course (MATH); the second group consisted of 38 junior and senior preservice elementary school teachers enrolled in a laboratory oriented methods of teaching mathematics course (METH); the third group consisted of 40 inservice elementary school teachers from the DeKalb, Illinois public schools who volunteered to be subjects (INSER). The distribution of scale scores and relevant test statistics are given in the Results Section of this paper.

Finally to determine whether these three different populations differ on the FS or ID measures of cognitive preference, FS and ID mean scale scores were compared across the three groups.

Results

Table 1 reports the measures of reliability for each group on each test. These measures indicate that the scales are homogeneous; that is, all items contribute to the measure of a single construct.

Table 2 indicates that the kurtosis of the distribution of scores of each of the tests for all three groups was not significant at the .05 level. The distributions of the ID test scores were significantly skewed ($p < .01$) in a negative direction for the inservice teachers and for the elementary mathematics content students.

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Insert Table 1 and Table 2 here

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The frequency distribution in Table 3 shows that nearly the full range of possible scores appeared -- 1-37 on the FS scale and 3-32 on the ID scale. The possible range on the FS and ID scales was 0-39 and 0-32, respectively. This demonstrates that subjects do differ on their preference for figural or symbolic modes of presentation of mathematical concepts. Moreover, subjects range in their preference from very figural to very symbolic. Similarly subjects range in their preference on a deductive or inductive mode from very deductive to very inductive.

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Insert Table 3 about here

- -

Tables 4 and 5 present the results of a 3 x 1 analysis of variance to determine whether the three groups differ in their mean scores on the FS or ID scales.

- -

Insert Tables 4 and 5 about here

- -

In both cases the F-value was significant at the .01 level. In order to determine where the real differences were in the data a post-hoc analysis of treatment means was conducted. The results of the Newman-Keuls tests are indicated in Tables 6 and 7.

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Insert Tables 6 and 7 about here

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The underscoring in Tables 6 and 7 indicates the following: any two means underscored by the same line do not differ significantly and any two means not underscored by the same line do differ significantly. Hence Table 6 indicates that both university junior and senior preservice teachers and inservice teachers are significantly more figural in their preferences than are preservice university freshmen. Table 6 indicates that both inservice teachers and preservice freshmen are more deductive in their preferences than preservice juniors and seniors.

Conclusions and Discussion

The data indicate that the Cognitive Preference Scales will discriminate between subjects according to their cognitive preference. In each of the three populations used in the validation of the scales, the distribution of scores support this. Moreover, since differences were obtained between the mean scores of the three groups it appears that some support exists to substantiate the conjecture that groups of people with different experiences or training exhibit a different Cognitive Preference.

The junior and senior preservice teachers (METH) were in a methods of teaching elementary school mathematics course; this course emphasizes the use of manipulative devices such as Cuisenaire rods, Dienes blocks, geoboards, etc. Moreover, numerous laboratory exercises are provided which give the students the opportunity to draw generalizations from presented or discovered data. That is, the subjects in the groups had been presented mathematical ideas in a mode that employed manipulatives, diagrams, and induction. Furthermore, the instruction in the course emphasizes this approach as an important strategy for presenting mathematical ideas to elementary school children.

The subjects in the METH group were probably comparable in mathematical training and experience to those in the MATH group except for the instruction in the methods class. Thus, the conclusion that subjects' cognitive preference can be altered through instruction appears plausible. However, this conclusion is indeed tenuous. The METH group had been exposed to other experiences such as classroom contact with elementary school children and other courses in education which could also have caused some of the differences in cognitive preference. And, of course, since the two groups are samples of different populations, there is no way to be sure that the cognitive preference of the METH and MATH groups were the same at the beginning.

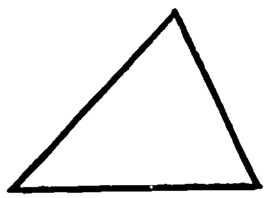
There are limitations to conclusions that can be drawn from the Cognitive Preference Scales. First it is important to recognize that the instruments represent essentially a first effort at cognitive preference measurement. Further development and refinement of the instruments is necessary. Indeed, in this first development of the instruments concern was given to presenting each mathematical concept in two modes; particular attention was not given to the question of whether each of the two modes represented a comparable level of sophistication. In every case the level of sophistication was, however, within the range of subjects comprehension. In retrospect it does appear that attention should be given to this. For example, one item on the FS scale presented the concept of the volume of a cube. The symbolic mode presented the usual formula, $V = S^3$; whereas, the figural mode presented this concept in terms of the graph of $V = S^3$. The question arises about whether a subject chooses a particular presentation because of the presentation mode or according to which of the two presentations is most easily assimilated by the subject. This problem and other problems need to be investigated in order to determine the fullest potential of cognitive preference scales. It would be interesting, for example, to determine the correlations between cognitive preferences for a figural mode and the spatial visualization ability of the Ss as measured by an aptitude scale. Also the question of whether or not cognitive preferences are highly correlated with mathematical achievement under instruction in the preferred mode is a question which will be of interest to researchers in the area of Trait-Treatment-Interaction. The authors are currently investigating this latter question.

i)

A

Example 1: 

This is a simple closed curve.

Example 2: 

This is a simple closed curve.

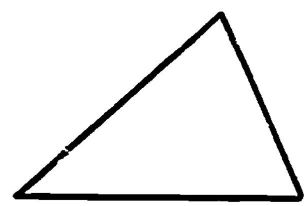
Idea: A simple closed curve is a curve which does not intersect itself.

B

Idea: A simple closed curve is a curve which does not intersect itself.

Example 1: 

This is a simple closed curve.

Example 2: 

This is a simple closed curve.

ii)

a) Perimeter = 2(C + T)

where C = length of rectangle

T = width of rectangle

b)

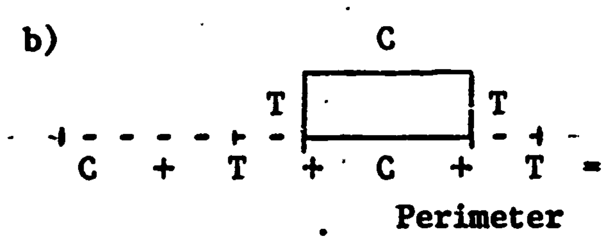


Figure 1

Sample items from the Inductive-Deductive (i) and Figural-Symbolic (ii) Scales

Table 1

Reliability Coefficients for Preference Tests *

TEST	GROUP		
	INSER	MATH	METH
FS	b	.90	.89
ID	b	.91	.85

a) KR-20 reliabilities are reported

b) The reliabilities for the INSER group were not obtained due to error. However, there is no reason to believe the reliabilities would differ signifcantly from the other groups.

Table 2

Test Statistics for the FS and ID
Cognitive Preference Scales

TEST	Group	Mean	Std. Dev.	Range	Kurtosis	Skewness	N
	INSER	21.425	11.142	37.000	-1.149	-0.202	40
FS	MATH	15.609	8.649	37.000	-0.410	0.342	92
	METH	20.947	7.946	32.000	-0.455	0.006	38
	INSER	23.675	8.337	29.000	-0.140	-0.926**	
ID	MATH	24.935	7.297	28.000	-0.057	-0.967**	
	Meth	19.316	6.921	29.000	-0.231	0.196	

**$p < .01$

Table 3

Frequency Distribution of Scale Scores
for the Three Populations

Score	MATH (N=92)		METH (N=38)		INSER (N=40)	
	FS	ID	FS	ID	FS	ID
1	2	0	0	0	0	0
2	2	0	0	0	0	0
3	3	0	0	1	0	1
4	1	1	0	0	0	0
5	3	0	1	0	1	0
6	2	1	0	0	0	0
7	5	0	2	0	2	0
8	3	1	0	0	0	0
9	1	1	0	1	0	1
10	5	1	1	1	1	1
11	2	1	1	2	1	2
12	5	1	1	1	1	1
13	4	0	0	1	0	1
14	5	3	2	1	2	1
15	4	3	2	0	2	0
16	3	3	0	3	0	3
17	4	0	3	5	3	5
18	6	2	0	[illegible]	0	6
19	5	5	4	1	4	1
20	0	1	1	2	1	2
21	3	2	1	2	1	2
22	2	4	4	0	4	0
23	2	5	0	1	0	1
24	4	2	2	2	2	2
25	3	1	3	1	3	1
26	3	2	2	0	2	0
27	1	1	0	1	0	1
28	2	8	1	1	1	0
29	0	7	1	0	1	2
30	0	10	2	1	2	1
31	1	8	1	1	1	0
32	0	18	0	3	0	3
33	2		1		1	
34	1		0		0	
35	0		0		0	
36	1		0		0	
37	1		2		2	
38	0		0		0	
39	0		0		0	

Table 4

Analysis of Variance For the FS Criterion Scores

Source	SS	df	MS	F
Between Groups	1320.47	2	660.23	7.88**
Within Groups	13985.45	167	83.75	
Total	15305.92	169		

*Significant at .01 level

Table 5

Analysis of Variance For the ID Criterion Scores

Source	SS	df	MS	F
Between Groups	853.55	2	426.77	7.64**
Within Groups	9328.54	167	55.86	
Total	10182.09			

*Significant at .01 level

Table 6

Newman Keuls Post-hoc Analysis of Treatment means of FS Scales

Treatment Group	Pre-service Teachers (Freshman)	Pre-service Teachers (Seniors)	Inservice Teachers
Treatment Mean	15.61	20.95	21.45**

**Significant at .01 level

Table 7

Newman Keuls Post-hoc Analysis of Treatment Means of ID Scales

Treatment Group	Pre-service Teachers (Seniors)	Inservice Teachers	Pre-service Teachers (Freshman)
Treatment Mean	19.32	23.68	24.93**

**Significant at .01 level

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