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ABSTRACT

Cognitive preferences of 177 able, science-oriented high school students who participated in a secondary science training program at the University of Iowa in the summer were studied. A Biology Cognitive Preference Test (BCPT) was administered, in which 20 items required ranking and 20 items required rating on a four-point scale. The items were also categorized under different biological topics. Statistical analyses revealed that the students had a very high preference for Questioning (Q), high preference for Principles (P), and low preference for Recall (R). There were no significant relationships between cognitive preferences and most of the background variables (sex, year in high school, general achievement, achievement in high school biology, hobby, etc.), which may be attributed to the homogeneity of the sample. (Author/CS)

Cognitive Preferences in Biology of Students Participating in a Secondary Science Summer Program

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Many educators and researchers have recognized the presence of cognitive styles in many different forms of behavior. Cognitive preferences as suggested by Heath (1964) constitute a kind of cognitive style which is acquired as a result of certain life and learning experiences. The acquired cognitive preference style, in turn, interacts with other individual characteristics, such as abilities, thereby influencing further outcomes in subsequent learning under specific modes of instruction (Tamir, 1976). Once we have the means to identify cognitive preferences we shall be able to use this information in a variety of ways. For example, an emphasis on learning principles and their application as opposed to facts, or the development of intellectual curiosity and critical questioning of presented information are clearly desirable goals.

Brown (1975) Williams (1975) and Tamir (1975) summarized the results of a number of studies which provided ample evidence on the potential of cognitive preference tests as a means of assessing the achievement of these goals. Knowledge about cognitive preferences of particular groups or of particular students will enable teachers to utilize certain instructional approaches which will enhance the learning of these students. Guidance and career orientation are other areas where cognitive preferences may have some potential.

Tamir (1975) designed and validated a biology cognitive preference test (BCPT) using the four cognitive preference modes suggested by Heath (1964), namely:

1. Acceptance of scientific information for its own sake i.e. without consideration of its implication, application or limitations. This mode is designated as 'Recall' (R).
2. Acceptance of scientific information because it exemplifies or explains some fundamental scientific principle or relationship. This mode is designated as 'Principles' (P).

3. Critical questioning of scientific information as regards its completeness, general validity or limitations. This mode is designated as 'Questioning' (Q).
4. Acceptance of scientific information in view of its usefulness and applicability in a general, social or scientific context. This mode is designated as 'Application' (A).

These modes have formed the blueprint for several cognitive preference tests including BCPT. In these tests each item first presents some limited information or data of a scientific nature and then offers four extension statements, all correct, which correspond closely each to one of the four modes described above. In Tamir (1975) study as well as in others (e.g. Kempa and Dube, 1973) the students, were informed that all four options were correct, were asked to arrange the options within each item in an order of preference by allotting four votes to the most preferred option, three to the next preferred, two votes to the next and one vote to the least preferred response. The student's overall cognitive preference pattern is represented by his total score in each of the four cognitive preference area, namely R, P, Q, A. Based on the use of BCPT a number of educationally significant findings were obtained regarding high school students in Israel (Tamir, 1975) and Hawaii (Tamir and Yamamoto, 1977). It may be indicated that the response procedures utilized with studies involving BCPT are ipsative. Brown (1975) raised certain queries regarding some of the findings obtained with ipsative data. Williams (1975) decided for both statistical and psychological considerations to utilize a normative rather than an ipsative scoring procedure. His test retained the multiple choice format with each response being correct. However the respondents were asked to rate each response on a 6-point scale according to the likelihood that it would occur to them on being presented with the stimulus information. Williams (1975)

results did not pertain specifically to biology and included science, mathematics, language and social sciences.

Thus the question regarding the utilization of ipsative or normative procedures remained open. In previous studies performance on BCPT revealed, among other things, significant effects of the environment, the curriculum and the subject matter. (Tamir, 1975; Tamir and Yamamoto, 1977). The pervasiveness of these effects over different populations is of great interest to researchers. While, as already mentioned, significant effects of the subject matter were noticed, no attempt had been made to find their magnitude. This study attempts also to find an answer to this question.

Purpose of Study

1. To identify the cognitive preference in biology of able, science oriented high school students who voluntarily participated in a special summer science program at the University of Iowa.
2. To identify the relationships between cognitive preference patterns and certain background variables, namely sex, year in high school, general achievement, achievement in high school biology, nature of the high school biology course, geographical residential region, hobby, science reading, and prospective major field of study in college.
3. To compare the results obtained by normative with those obtained by ipsative procedures.
4. To identify the degree of cognitive preference dependence on specific biological topics.

Method

BCPT was printed in two forms. In Form A the first 20 items required ranking (ipsative) while the last 20 items required rating on a 4-point scale (normative). In Form B the order was reversed; the first 20 items required rating and the last 20 items required ranking. The tests were administered to 177 high school students who participated in a 6 week

Secondary Science Training Program (SSTP) in the summer of 1976 at the University of Iowa. These participants came from all over the United States and were selected on the basis of their high achievement and strong interest in science. 104 responded to Form A and 73 responded to Form B. The results were analyzed by a special computer program which yields mean scores, standard deviations and α Cronbach reliability coefficients for the total test and each subtest. Further analyses were performed using SPSS programs: intercorrelations, multiple regression analysis, analysis of variance, t tests. The following scores were computed: R, P, Q, A, Q-R, P-A (Q minus R and P minus A are derived scores). Each of these was computed for ipsative (i); normative (n); and combined, namely normative + ipsative, (c) scores.

A number of background variables were studied. These variables were selected on the basis of their potential relationships with cognitive preferences as demonstrated in previous studies (e.g. Kempa and Dube, 1973; Barnett, 1974; Tamir, 1975; Tamir and Yamamoto, 1977). The data on these background variables was obtained through a questionnaire administered at the same time BCPT was administered. The students reported on the following: sex; year in high school (Year); general achievement (GPA); high school biology grade (Biograde); nature of high school course (Text: Modern Biology, BSCS Green, BSCS Yellow, BSCS Blue, Other); geographical residential region (Region: Northest, Southeast, Central, West); hobby involving plants or animals (Hobby: yes or no); frequency of free-reading of scientific literature (Reading: no, once a month, once a week); Prospective major field of study in college (Major: non-science, physical science, engineering, biological science, pre-medical).

For the purpose of studying the effect of specific biological topics the items of BCPT were categorized under the following topics: botany, zoology, human biology, evolution, microbiology, biochemistry. In addition to that the

test was divided into two subtests one dealing with "Form and Structure" and the other with "Process and Function."

Findings

The mean scores obtained by the normative and ipsative procedures, their reliability and their intercorrelations are presented in Table 1.

Insert Table 1 here

It may be observed that three out of six mean scores do not differ at all while the differences between the other three pairs are relatively small. The intercorrelations are all positive and, with the exception of one, moderate and statistically significant. Both ipsative and normative procedures gave the same rank order of mean scores, namely: Q, P, A, R from highest to lowest, respectively. The reliabilities of the normative scales tend to be higher. However, taking into account that all α coefficients pertain to tests comprised of 20 items and that the whole BCPT comprises 40 items, allowance made for a test twice as long should increase the α coefficients considerably. Comparison of the results obtained with Form A with those obtained using Form B revealed no statistically significant differences. Therefore the scores of students who responded to Form A were combined with those of students who responded to Form B, thereby yielding mean scores based on 40 items. These scores were used in all subsequent analyses. An overall analysis of the relationship between cognitive preference scores and seven independent variables is provided by Table 2.

Insert Table 2 here

Table 2 reveals only weak relationships between these variables and cognitive preference scores whether ipsative or normative. More information about these relationships will be provided by further analysis reported below. Table 3 reveals some interesting relationships among five background variables.

Insert Table 3 here

Compared with boys, more girls had a hobby dealing with plants and animals. On the other hand, boys tend to read scientific literature more often than girls. Regardless of sex, students who read scientific literature more often tended to have a hobby dealing with plants and animals as well as to be high achievers in school. The positive correlation between the high school biology grade and the grade point average would have been expected. Not so, however, the negative, even though very weak, correlation between biology grade and biological hobby.

We turn now to results obtained by separate analyses each pertaining to a particular independent variable.

Achievement. The sample being highly selected, included only high achieving students. Therefore it was possible to compare only "A" and "B" students (See Table 4).

Insert Table 4 here

It may be observed that as far as our relatively homogeneous sample was concerned only one statistically significant difference was found: "A" students had a higher preference for principles.

Curriculum. Only 114 students were able to recall the textbook utilized in their high school biology course. Preliminary analysis revealed that the BSCS Blue and Yellow students had almost identical mean cognitive preference scores while the Green version students were quite different. Hence, the Blue and Yellow students were combined into one group in order to increase the power of the statistical test. While Table 5 presents the results pertaining to three groups, it should be noted that the Green version group

was too small for reaching definite conclusions regarding the effects of the Green version.

Insert Table 5 here

The important finding in Table 5 is the highest Q and lowest R score of BSCS Yellow and Blue compared with students who had studied the traditional course 'Modern Biology'.

Reading scientific literature. Table 6 presents the results relating cognitive preferences to the frequency of free-time reading of scientific literature.

Insert Table 6 here

It may be seen that the two extreme groups, namely non-readers and frequent readers differed from the middle group but were hardly different from each other. The middle group had a lower preference for application and somewhat lower preference for principles.

Prospective major field of study in college. Table 7 presents the distribution of cognitive preference scores according to the prospective desired field of study in college. Table 7 reveals only few statistically

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Insert Table 7 here

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significant differences, mainly in the normative scores. Nonscience majors have the lowest preferences for recall. Premedical students when compared in their normative scores with physical science majors had a higher preference for P and Q. Their Q normative score was higher than that of all other science students. When the ipsative scores are considered, the only difference found was the higher P score of premedical and biology students compared with engineering students.

Year in high school. The subjects were grouped according to their grade level: Freshmen -3, Sophomores - 42, Juniors - 108, and seniors -23. One way analysis of variance revealled that students in higher grades had on the average lower preference scores for R and higher preference scores for P. Statistically significant differences were found only in P ipsative scores ($F=3.42$, $p < 0.02$, $df=3,172$). The following mean scores in P ipsative were obtained (S.D. in brackets): Freshmen -2.50 (.15), Sophomores -2.55 (.31), Juniors -2.63 (.27), and Seniors -2.78 (.33).

Sex, Region, Hobby. There were no statistically significant differences in cognitive preferences among groups divided according to these independent variables.

Form and Structure vs. Process and Function. Table 8 compares the combined cognitive preference scores in two groups of items, namely those items dealing with form and structure contrasted with items dealing with process and function.

Insert Table 8 here

It may be observed that for 'Form and Structure' Q and A scores are higher, while for 'Process and Function' R and P scores are higher. The differences in the two last scores indicate that the students in this sample were more curious (a higher Q-R score) and more interested in applications (a lower P-A score) when confronted with information pertaining to form and structure. Conversely, with regard to processes and function they preferred the 'pure' to the 'applied' aspects (a higher P-A score) and were less inclined to criticize or question the information provided to them (a lower Q-R score).

Specific biological topics. Table 9 presents the mean cognitive preference scores in six biological topics.

Insert Table 9 here

Substantial differences between different topics may be observed. Following are some examples: the students in this sample were much more curious about information of biochemical nature than about that dealing with microbiology. They preferred the applied aspects of botany, but with regard to evolution they preferred the pure scientific over the applied aspects. Table 10 presents the partial correlations obtained in a multiple regression analysis between the scores in each topic and the total test scores.

Insert Table 10 here

The results show that subject matter specificity within biology accounts, on the average, for 32% of the variance, ranging between 22% and 41% in different topics. This implies that close to 70% of the variance may be attributed to biology as an entity while about 30% should be attributed to the separate effects of specific topics.

Discussion

In 1959 the National Science Foundation initiated a program designed to foster increased relevance in academic studies, enhance student understanding, encourage student initiative and accelerate the growth of scientific talents. Special science training programs have been studied in a variety of ways since the first program 15 years ago. These studies are cited by Cody and Pizzini (1976). The purpose of the present study was to identify the cognitive preferences of this self-selected group of high school students and to study the relationship between these cognitive preferences and certain background variables.

The results show that SSTP students were indeed a selected group. Their cognitive preference style may be characterized as high Q, high P, medium A, low R. It is interesting to compare their cognitive preference style with that of other populations who responded to the same cognitive preference test (see Table 11).

Insert Table 11 here

The students in our sample were exceptionally high in their preference for critical questioning and exceptionally low in their preference for recall. Such a pattern represents distinctly high intellectual curiosity and a desire to learn more. When compared with Israeli students, especially with the Israeli high achievers who are more similar to them than the total Israeli sample, they appear to be much less inclined toward principles and to have somewhat higher preference for application. The relatively strong inclination of Israeli students toward the pure aspects of science has already been noticed (Tamir, 1975, Tamir and Kempa, 1976). The general weak correlations reported in Table 2 may be a result of the relative homogeneity of our sample. It is not surprising, therefore, that there were no statistically significant differences in cognitive preferences among groups who were classified according to sex, geographical region, and hobby. The few significant differences found in relation to other independent variables are, therefore, of special interest. Two of the findings are in close agreement with previous reports, namely the higher preference for P which characterizes high achievers (Kempa and Dube, 1973; Tamir and Kempa, 1976) and the higher Q and lower R cognitive preference score of BSCS students (Blue and Yellow) compared with that of students who studied traditional courses (Tamir, 1975). This Q-R pattern was found consistently in studies beginning with Heath (1964), which compared 'new' and 'old' curricula in science (see a summary of these findings in Tamir 1975).

Generally the findings obtained with normative scores were quite similar to those obtained with ipsative scores. In Tables 6 and 7, however, there were somewhat more statistically significant differences in the normative scores. One possible explanation for this discrepancy may be that certain kinds of students respond by rating consistently higher than others. A good

example is the pre-medical students whose normative scores in all areas were relatively high. The same phenomena may be observed in Williams (1975) data which showed that high achievers had tended to have higher preference scores in all areas. It is therefore suggested that when the purpose is to identify the relative preferences toward certain attributes, like the four cognitive preference modes, the ranking (ipsative) procedure should be preferred over the rating (normative) procedure. The higher preference for P of upper classmen is an example of the discrimination power of ipsative scores. Lastly, the findings revealing a distinct effect of subject matter specificity on cognitive preferences are in full agreement with those of Tamir (1975). The present study offers an important supplement regarding the magnitude of this effect which was found to account for approximately 30% of the total variance.

Summary and Conclusions

Cognitive preferences of high school students who participated in a secondary science training program at the University of Iowa in the summer of 1976 were studied. It was found that these high ability students as a group had very high preference for Q and very low preference for R. The preference pattern represents an exceptionally high level of intellectual curiosity andadesire to learn more, which could have been expected of the select group of students who participated in this program. This correspondence between expectations and performance provides strong support to the validity of the cognitive preference test, as well as to the construct of cognitive preferences. Similar support was provided by the findings regarding the preference patterns of traditional and BSCS students. The lack of significant relationships between cognitive preferences and most of the background variables may be attributed to the homogeneity of the sample.

The finding that about 30% of the variance in cognitive preferences may be accounted for by specific biological topics while the other 70% represent a cognitive preference in biology as an entity is an important contribution to our understanding of cognitive preferences. Finally, the similarity of the results obtained with ipsative and normative procedures also have important methodological implications.

References

1. Barnett, H.C. An Investigation of Relationships Among Biology Achievement, Perception of Teacher Style and Cognitive Preferences, Journal of Research in Science Teaching, 11, 141-147, 1974.

2. Brown, S.A. Cognitive Preferences in Science: Their Nature and Analysis, Studies in Science Education, 2, 43-65, 1975.

3. Cody, J.T. and Pizzini, E.L. The Effects of a Secondary Science Program on the Methods, Procedures and Processes of Science, Science Education, 60, 193-198, 1976.

4. Heath, R.W. Curriculum Cognition and Educational Measurement, Education and Psychological Measurement, 24, 239-253, 1964.

5. Kempa, R.F. and Dube, G.E. Cognitive Preference Orientations in Students of Chemistry, The British Journal of Educational Psychology, 43, 279-288, 1973.

6. Tamir, P. The Relationships Between Cognitive Preferences, School Environment, Teachers' Curricular Bias, Curriculum and Subject Matter, American Educational Research Journal, 12, 235-264, 1975.

7. Tamir, P. and Kempa, R.F. Cognitive Preferences Styles Across Three Science Disciplines, Paper Presented at the 49th Annual Meeting of NARST, San Francisco, April, 1976.

8. Tamir, P. and Yamamoto, K. The Effects of the Junior High FAST Program on Students' Achievement and Preferences in High School Biology. Paper to be presented at the 50th Annual Meeting of NARST, Cincinnati, March 1977.

9. Williams, C. A Study of Cognitive Preferences. Journal of Experimental Education, 43, 61-77, 1975.

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TABLE 1

Mean scores, standard deviations and intercorrelations of normative and ipsative cognitive preference scores (N=177)

		Form A + B		∝ Cronbach reliability		Intercorrelation	t
		$\bar{X}$	S.D.	Form A (N=104)	Form B[a] (N=73)		
R	normative	2.44	0.52	.84	.83	0.34**	3.11**
	ipsative	2.31	0.44	.77	.71		
P	normative	2.65	0.40	.77	.71	0.34**	0.74
	ipsative	2.63	0.29	.65	.60		
Q	normative	2.69	0.51	.81	.87	0.35**	0.73
	ipsative	2.66	0.53	.84	.74		
A	normative	2.52	0.41	.77	.75	0.10	2.84**
	ipsative	2.41	0.36	.60	.55		
Q-R	normative	0.25	0.73	not available		0.51**	1.60
	ipsative	0.35	0.88				
P-A	normative	0.13	0.39	not available		0.35**	2.20*
	ipsative	0.22	0.52				

a) Each form has 20 ipsative and 20 normative items

* $p < 0.05$ ** $p < 0.01$

TABLE 2

Summary of stepwise multiple regression analysis
in order of entering independent variables
(N=177)

Dependent Variables												
R ipsative			P ipsative			Q ipsative			A ipsative		
predictor	S	M	predictor	S	M	predictor	S	M	predictor	S	M
GPA	-.16	.16	Year	.22	.22	Year	-.11	.11	Reading	.14	.14
Year	.09	.19	Reading	.14	.28	Sex	.08	.19	GPA	.10	.19
Hobby	.09	.25	Major	.16	.32	Reading	.07	.24	Sex	-.03	.20
Sex	-.06	.25	GPA	.12	.34	Hobby	-.07	.27	Biograde	-.01	.21
Biograde	-.05	.26	Hobby	.07	.34	Biograde	-.05	.30	Major	.00	.21
Major	.04	.26	Biograde	.08	.34	GPA	.07	.32	Hobby	.01	.22
						Major	.03	.34	Year	.01	.22
R normative			P normative			Q normative			A normative		
Major	.22	.22	Major	.20	.20	Reading	.16	.16	Major	.22	.22
Hobby	.10	.29	Hobby	.13	.25	Sex	.11	.21	Hobby	.20	.28
Biograde	.05	.33	Biograde	.09	.28	Year	-.11	.24	GPA	-.02	.29
GPA	.03	.36	GPA	.07	.29	Major	.15	.28	Biograde	.03	.31
Reading	.07	.38	Year	.00	.29	Hobby	.11	.29	Reading	.10	.33
Year	.04	.40	Sex	.00	.29	GPA	.04	.30	Sex	.03	.34
Sex	.00	.40				Biograde	.05	.30			

s = simple correlation m = multiple correlation

Critical value of R: $p < 0.05 = .13$
$p < 0.01 = .17$

TABLE 3

Intercorrelations among background variables
(N=177)

	Sex	Hobby	Biology Grade	GPA
Hobby	.12			
Biology Grade	-.04	-.14*		
GPA	.09	-.02	.43**	
Reading Science	-.16*	.18**	.11	.21**

* $p < .05$ ** $p < .01$

TABLE 4

Cognitive preference patterns of students grouped according to their achievement in high school

Cognitive preference area	Grade Point Average B (N=41) $\bar{x}$	S.D.	A (N=128) $\bar{x}$	S.D.	t	Biology Grade B (N=28) $\bar{x}$	S.D.	A (N=129) $\bar{x}$	S.D.	t
R_c	2.37	.38	2.36	.40	.08	2.39	.39	2.37	.40	.23
P_c	2.58	.28	2.66	.29	1.54	2.53	.25	2.67	.30	2.30*
Q_c	2.71	.36	2.67	.45	.56	2.77	.43	2.66	.43	1.17
A_c	2.46	.32	2.47	.28	.14	2.50	.29	2.46	.28	.74
R_i	2.35	.40	2.28	.43	1.00	2.29	.45	2.31	.44	.18
P_i	2.54	.33	2.66	.28	2.30*	2.48	.29	2.66	.29	2.90**
Q_i	2.71	.48	2.66	.55	.52	2.77	.49	2.64	.54	1.20
A_i	2.40	.35	2.38	.36	.66	2.46	.37	2.40	.36	.72
R_n	2.39	.52	2.45	.53	.64	2.49	.51	2.44	.54	.47
P_n	2.63	.36	2.66	.41	.48	2.59	.33	2.68	.43	1.13
Q_n	2.72	.45	2.69	.54	.31	2.77	.51	2.69	.52	1.84
A_n	2.55	.41	2.51	.41	.46	2.55	.38	2.52	.42	.33

*p < .05 ** p < .01

c = combined; i = ipsative; n = normative

TABLE 5

Cognitive preference patterns of students grouped according to their high school biology courses

Cognitive preference area	1 Modern Biology (N=62) $\bar{x}$	S.D.	2 BSCS Green (N=13) $\bar{x}$	S.D.	3 BSCS Yellow&Blue (N=39) $\bar{x}$	S.D.	F df= 2,111	t[a] 1:2	1:3	2:3
R_c	2.45	.39	2.42	.37	2.27	.36	2.82+		2.35*	
P_c	2.67	.27	2.71	.28	2.66	.25	.19			
Q_c	2.64	.44	2.52	.51	2.79	.41	2.38+		1.70+	
A_c	2.50	.27	2.50	.22	2.42	.25	1.26			
R_i	2.37	.47	2.35	.41	2.22	.41	1.36			
P_i	2.63	.29	2.79	.30	2.65	.30	1.54			
Q_i	2.59	.57	2.41	.54	2.79	.45	3.20*		2.01*	2.32*
A_i	2.42	.36	2.50	.34	2.36	.30	.99			
R_n	2.54	.53	2.48	.54	2.33	.42	2.26			
P_n	2.71	.40	2.65	.33	2.68	.32	.20			
Q_n	2.69	.52	2.63	.58	2.78	.47	.62			
A_n	2.58	.40	2.49	.30	2.48	.37	.99			

a) only statistically significant t values are included

+ $p < .10$ * $p < .01$

c = combined; i=ipsative; n = normative

TABLE 6

Cognitive preference of students grouped according to their free-time reading of scientific papers

Cognitive preference area	1 No and Seldom (N=51) $\bar{x}$	S.D.	2 Once a Month (N=72) $\bar{x}$	S.D.	3 Once a Week (N=49) $\bar{x}$	S.D.	F df=2,169	t[a] 1:2	1:3	2:3
R_c	2.37	.36	2.33	.40	2.42	.41	0.89			
P_c	2.63	.26	2.59	.27	2.71	.32	2.76+			2.34*
Q_c	2.62	.38	2.67	.47	2.73	.40	0.77			
A_c	2.52	.31	2.40	.25	2.50	.30	3.33*	2.40*		1.85+
R_i	2.30	.43	2.32	.43	2.31	.45	0.03			
P_i	2.58	.29	2.61	.27	2.69	.32	1.88			
Q_i	2.61	.50	2.68	.55	2.68	.52	0.34			
A_i	2.50	.34	2.38	.38	2.38	.35	1.89			
R_n	2.46	.50	2.34	.53	2.54	.52	2.12			
P_n	2.68	.38	2.57	.39	2.73	.42	2.87+			2.30*
Q_n	2.64	.47	2.65	.57	2.78	.43	1.09			
A_n	2.55	.48	2.42	.35	2.61	.39	3.37*	1.75+		2.46*

a) only statistically significant t values are included

+ $p < 0.10$ x $p < 0.05$ ** $p < 0.01$

TABLE 7

Cognitive preference patterns of students grouped according to their prospective major field of study in college

Cognitive preference area	1 Non Science N=18 $\bar{x}$ S.D.	2 Physical Sciences N=29 $\bar{x}$ S.D.	3 Engineering N=15 $\bar{x}$ S.D.	4 Biol. Sciences N=36 $\bar{x}$ S.D.	5 Pre Medical N=74 $\bar{x}$ S.D.	F df=4, 167	t (a) 1:3	1:4	1:5	2:4	2:5	3:5	4:5
R_c	2.20 .40	2.30 .33	2.54 .43	2.37 .39	2.43 .40	2.16+	2.5*		2.2*				
P_c	2.58 .37	2.53 .29	2.60 .31	2.65 .28	2.71 .23	2.61*				1.7+	3.0**		
Q_c	2.76 .50	2.62 .45	2.58 .36	2.61 .47	2.72 .40	.85							
A_c	2.33 .33	2.44 .31	2.51 .29	2.45 .27	2.50 .27	1.56			2.4*				
R_i	2.29 .49	2.28 .33	2.45 .46	2.25 .42	2.35 .47	.73							
P_i	2.63 .31	2.52 .30	2.55 .38	2.68 .32	2.68 .24	2.11+				2.1*	2.5*		
Q_i	2.79 .53	2.70 .54	2.63 .58	2.63 .56	2.62 .51	.47							
A_i	2.88 .45	2.47 .37	2.48 .35	2.43 .35	2.38 .33	1.10							
R_n	2.11 .57	2.33 .47	2.62 .53	2.50 .48	2.52 .53	3.22*	2.8*	2.6*	3.1**				
P_n	2.53 .53	2.54 .40	2.66 .38	2.63 .37	2.74 .36	2.04+					2.4*		
Q_n	2.74 .59	2.54 .49	2.54 .52	2.60 .55	2.82 .46	2.57*					2.6*	2.0*	2.2*
A_n	2.37 .41	2.41 .41	2.54 .40	2.49 .35	2.62 .43	2.41*			2.4*		2.4*		

a) only statistically significant t values are included

+p < .10 *p < .05 **p < .01

c= combined; i= ipsative; n= normative

TABLE 8

Mean cognitive preference scores in Form and Structure and in Function and Process (combined scores, N=177)

Cognitive preference area	Form and Structure (16 items) $\bar{x}$	S.D.	Function and Process (22 items) $\bar{x}$	S.D.	t (correlated)
R	2.33	.47	2.41	.38	3.09**
P	2.61	.32	2.66	.33	1.98*
Q	2.73	.48	2.64	.44	3.75***
A	2.52	.33	2.43	.31	4.36***
Q-R	0.40	.81	0.23	.69	4.30***
P-A	0.09	.42	0.23	.43	4.22***

*p < .05 **p < .01 ***p < .001

TABLE 9

Mean cognitive preference scores in different topics
(combined scores, N=177)

Cognitive preference area	1 Botany (13 items) $\bar{x}$	S.D.	2 Zoology (6 items) $\bar{x}$	S.D.	3 Human body (4 items) $\bar{x}$	S.D.	4 Evolution (6 items) $\bar{x}$	S.D.	5 Micro-biology (4 items) $\bar{x}$	S.D.	6 Bio-chemistry (5 items) $\bar{x}$	S.D.	t a) (correlated) groups	t
R	2.32	.52	2.44	.54	2.45	.58	2.39	.51	2.47	.61	2.29	.50	5:6	3.57***
P	2.56	.39	2.54	.47	2.70	.52	2.82	.48	2.73	.54	2.62	.51	2:4	6.14***
Q	2.70	.52	2.75	.66	2.66	.70	2.60	.57	2.43	.55	2.81	.49	5:6	7.47***
A	2.52	.41	2.43	.45	2.42	.55	2.44	.45	2.45	.50	2.43	.55	1:3	2.00*
Q-R	0.38	.88	0.31	1.02	0.21	1.05	0.21	.85	-0.04	.94	0.52	.76	5:6	7.15***
P-A	0.04	.55	0.11	.66	0.27	.76	0.38	.58	0.28	.79	0.19	.82	1:4	5.93***

a) Correlated t values are reported only for the two extreme mean scores in each cognitive preference area

*p < .05 ***p < .001

TABLE 10

Partial correlations of cognitive preference scores in different topics with the total test score (N=177)

Topics	No. of items	Cognitive Preference Areas				Mean[a] r	% of[b] variance
		R	P	Q	A		
Botany	13	.66	.55	.72	.59	.63	41
Zoology	6	.57	.55	.68	.49	.57	33
Human biology	4	.53	.42	.56	.43	.49	24
Evolution	6	.63	.67	.66	.58	.63	41
Microbiology	4	.53	.51	.45	.37	.47	22
Biochemistry	5	.51	.64	.50	.56	.55	30

a Mean r was obtained by averaging the correlation coefficients of the four cognitive preference areas;

b % of variance accounted by each topic obtained as Mean r square;

TABLE 11

Mean cognitive preference scores in biology of different groups of students[a]

State	Grade Level	N	R $\bar{x}$	R S.D.	P $\bar{x}$	P S.D.	Q $\bar{x}$	Q S.D.	A $\bar{x}$	A S.D.	Reference
Iowa	10 to 12	177	92.8	17.2	105.2	11.6	106.0	20.8	96.4	14.8	present study
Hawaii	10 to 12	624	98.0	12.8	104.8	9.2	98.4	14.0	98.8	9.2	Tamir and Yamamoto, 1977
Israel	12	989	97.2	16.7	112.2	14.3	95.8	18.3	95.0	12.3	Tamir, 1975
Israel high achievers	12	263	93.6	17.4	112.8	14.5	99.6	19.7	93.6	12.4	Tamir, 1975

(a) A score of 100 in this Table equals a score of 2.5 in the previous tables