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ABSTRACT

Scores of high school students responding to the same biology cognitive preference test using both normative and ipsative procedures were compared. All subtests, whether ipsative or normative, had high alpha Cronbach coefficients. A number of similarities were found in the mean scores obtained by the two procedures, as well as moderate positive correlations in each of the cognitive preference areas. It was concluded that when ipsative scores are preferred in terms of the construct validity of cognitive preference tests, the danger of distorted relationships is not severe. This conclusion has significant implications for the findings of a number of previous studies. (Author)

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A Comparison of Ipsative and Normative Procedures in the Study of Cognitive Preferences

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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 aims.

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 <u>'Recall'</u> (R).
2. Acceptance of scientific information because it exemplifies or explains some fundamental scientific principle or relationship. This mode will be designated as <u>'Principles'</u> (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, 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 areas, 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 should be indicated that the response procedures utilized with studies involving BCPT are ipsative. Brown (1975) in her critical review of research on cognitive preferences points at the difficulty in interpreting relationships found among ipsative scores. She cites Hicks (1970) to support her claim regarding the doubtful validity of certain findings such as the two bipolar scales identified by Kempa and Dube (1973). These authors performed on the individual cognitive preference scores R factor analysis with varimax rotation. As a result they obtained two bipolar scales, Q ←---→ R and P ←---→ A: the first was designated as the Curiosity Scale and the second as the Utility Scale. Kempa and Dube's results were replicated later by Tamir (1975), Tamir and Kempa (1976) and Tamir and Kempa (1977). Some, like Wish (1964) tried to use unfolding analysis in order to overcome the problems caused by the ipsative nature of the data. Brown (1975) analyzed the results obtained by the unfolding procedure and convincingly concluded that "there is little point in purusing this line of analysis further" (p. 61).

While the normative procedure suggested by Williams (1975) overcomes the difficulties caused by ipsative data, in our judgment, it does not conform to the original aim of Heath, namely to identify preferences. In real lifesituations people reveal preferences by choosing, by identifying something that they like better than something else. Preference is ipsative by definition. Moreover, the use of normative procedure may obscure the differences among relative levels of preference towards each of the four areas and, instead, express a generalized preferred level of response. Examination of Williams data reveal high positive correlations among the three areas which were included in his study, namely: Recall, Principles and Application, in all subject matter areas (Table 1). Such intercorrelations do not give much hope for obtaining highly discrete contrasting preference patterns. Indeed, most variables cluster together, as may be seen in the results of the factor analysis (Table 2). The existence of the two factors presented in Table 2 may be attributed to the effect of the subject matter rather than to different cognitive preference areas. Two recent studies (Tamir and Kempa 1976, Tamir and Kempa 1977) showed that non-ipsative data behaved in a manner considerably similar to ipsative data. For example, in Table 3 taken from Tamir and Kempa (1977) the relationship of R biology, either to Q chemistry or to Q medicine, is hardly different from its relationship to Q biology.

Yet, the former are based on different tests and therefore are non-ipsative, while the latter, namely R, Q, biology are results of the same test and therefore are clearly ipsative. Our belief that ipsative procedures are more appropriate for the study of preferences and the similarity in some previous findings between ipsative and normative data, prompted the present study. The purpose is to find out empirically, to what extent are the results obtained by ipsative procedures different from those obtained by normative procedures.

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 weeks 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, factor 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: Northeast, 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).

Findings

The mean scores obtained by the normative and ipsative procedures, their reliability and their intercorrelations are presented in Table 4.

Insert Table 4 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 reported in Table 4 pertain to tests consisting of 20 items and that the whole BCPT has 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. Table 5 presents a matrix of the intercorrelations among the various cognitive preference scores.

Insert Table 5 here

An examination of Table 5 reveals considerable similarity in the directions of the correlations between ipsative and normative scores. The most conspicuous similarity concerns the relationships among Q and R scores. The correlations of Q and R have similar directions in all possible correlations of ipsative and normative scores (including Q-R and P-A). However, the values of the correlation coefficients among ipsative scores is substantially higher. Since the normative and the ipsative scores are independent of each other, the similarity in their inter-relationships, for example the correlations between R_n and Q_i (-.36) or between R_i and Q_n (-.25), is of special interest. The general pattern of relationships is best observed in the results of factor analysis (Table 6).

Insert Table 6 here

As shown in Table 6 three factors emerged when ipsative and normative scores were submitted to an R factor analysis with varimax rotation. Factor 1 may be called "Normative" and is very similar to Factor 1 obtained with Williams (1975) data (see Table 2). Factor 2 clearly represents the Curiosity (Q <-----> R) Scale which was first identified by Kempa and Dube (1973) and later replicated by others (see Introduction). Factor 3 represents the Utility (P <------> A) Scale as identified by Kempa and Dube (1973), as far as its ipsative scores are concerned. Although the loadings of P_n and A_n

are in the expected directions they are too low to be considered a significant component of this factor.

When the combined (ipsative and normative) scores were intercorrelated and factor analyzed the results presented in Tables 7 and 8 were obtained.

Insert Tables 7 and 8 here

The Curiosity (O <-----> R) Scale is again demonstrated by these data.

It is beyond the scope of the present paper to present the results obtained by relating cognitive preferences to all the background variables on which data was available. These results are reported elsewhere (Lunetta and Tamir, 1977). Yet a few comparisons are presented in order to show the similarity and differences between the normative and the ipsative procedures. Tables 9, 10, and 11 present the relationships between cognitive preferences and three independent variables, namely achievement, high school biology curriculum and propsective major field of study in college, respectively.

Insert Tables 9, 10, and 11 here

Achievement. The sample being highly selected, included only high achieving students. Therefore it was possible to compare only "A" and "B" students (see Table 9). 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. Although the same trend is evident in both normative and ipsative scores, only the latter showed statistically significant differences.

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 (Cohen, 1969). 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. The important finding in Table 10 is the highest Q and lowest R score of BSCS Yellow and Blue compared with students who had studied the traditional course 'Modern Biology'. Again, while both normative and ipsative scores revealed the same trend, statistically significant differences were obtained only with the ipsative and combined scores.

Prospective major field of study in college. Table 11 presents the distribution of cognitive preference scores according to the prospective desired field of study in college. Table 11 reveals only few statistically significant differences, mainly in the normative scores. Non-science majors have the lowest preferences for recall. Pre-medical 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. Again, the normative P scores follow the same trend but the differences are statistically non-significant.

Discussion

Generally the findings obtained with normative scores were quite similar to those obtained with ipsative scores. The ipsative scores appear to have a higher discriminability among groups with different cognitive preference patterns as demonstrated by the results reported in Tables 9, 10, and 11. In Table 11, 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.

This recommendation takes into consideration the fact that normative procedures yield somewhat higher levels of internal consistency. We argue that when cognitive preference tests are properly designed, and when no less than 20 items are included, the ipsative procedure yields satisfactory internal consistency coefficients. Since the ranking procedure is so much more congruent with the construct of preference it is more adequate than the normative procedure in spite of its limitations. The most important finding of the present study is the similarity in the inter-relationships among the four cognitive preference areas which was demonstrated by the factor analysis, especially with regard to the Curiosity (Q <-----> R) Scale. On the basis of the present findings as well as others mentioned in the introduction (Tamir and Kempa, 1976; Tamir and Kempa, 1977), it is concluded that, as far as cognitive preferences are concerned, the ipsative procedure does not yield distorted results even with regard to relationships. Many studies involving cognitive preference tests using ipsative procedures have reported findings of substantial educational significance. The ipsative nature of the data has raised some doubts regarding the validity of these findings. Complex statistical analysis, like unfolding, have failed to offer any additional useful information compared with simpler statistical analyses (Brown, 1975). The present study provides empirical evidence to support past and future studies using ipsative procedures in the study of cognitive preferences.

Summary and Conclusions

Scores of high school students responding to the same biology cognitive preference test utilizing both normative and ipsative procedures were compared. All subtests whether ipsative or normative had high alpha Cronbach internal consistency, coeffients. A number of similarities were found in the mean scores obtained by the two procedures, as well as moderate positive correlations in each of the cognitive preference areas. R factor analysis of the normative and ipsative scores in the four areas yielded three factors. The first factor clustered only normative scores which, with the exception of Q, had loadings greater than 0.60. The second factor had positive loadings of R and negative loadings of Q, both ipsative and normative. This result shows that the Curiosity (Q <-----> R) Scale which was found in a number of previous studies utilizing ipsative scores, exists also when both ipsative and normative procedures are employed. The third factor corresponding to the Utility (P <----> A) Scale was less conspicuous: only the ipsative scores had loadings above 0.29.

In a variety of comparisons of different groups which differed in several background variables, similar results were obtained with both ipsative and normative scores. In most cases, however, the ipsative procedures discriminated more clearly between different cognitive patterns. It may be concluded that when ipsative procedures are preferred on the ground of construct validity, a position favored by the present authors, the danger of distorted relationships is not as severe as might have been expected. This conclusion is limited to the use of cognitive preference tests such as the one used in the present study.

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NOTE: The authors acknowledge the help of Yuval Tamir who designed the cognitive preference computer program and performed all the computer analyses.

TABLE 1

Intercorrelations among cognitive preference scores (taken from Williams, 1971)

	R Sci	P Sci	A Sci	R Math	P Math	A Math	R Soc	P Soc
P sci	.82							
A sci	.62	.78						
R math	.57	.54	.52					
P math	.44	.54	.63	.71				
A math	.22	.35	.68	.52	.73			
R soc	.56	.45	.47	.54	.42	.35		
P soc	.39	.55	.66	.44	.61	.57	.68	
A soc	.41	.52	.69	.46	.61	.65	.72	.87

Sci = science; soc = social sciences

TABLE 2

Results of factor analysis with varimax rotation of the data in Table 1[a]

Cognitive preference area	Factor Loadings	
	Factor 1	Factor 2
R sci	.16	.94
P sci	.35	.82
A sci	.64	.55
R math	.50	.49
P math	.71	.35
A math	.79	.12
R soc	.54	.42
P soc	.79	.30
A soc	.85	.30
% of variance	84.7	15.3

a) This analysis was performed by the present author

TABLE 3

Results of Varimax Rotation of 12 Cognitive Preference Scores in Biology, Chemistry, and Medicine (N=150)

Cognitive preference area		Rotated factor loadings[a]			
		Factor 1	Factor 2	Factor 3	Factor 4
Biology	R	0.64	-0.54		
	P			0.32	
	Q	-0.84			
	A		0.90		
Chemistry	R	0.74			
	P				0.78
	Q	-0.67			
	A	-0.33	0.41	-0.34	
Medicine	R	0.57			0.31
	P			0.84	
	Q	-0.78			
	A			-0.57	
% of variance		49.2	25.4	15.6	9.7

a) only loadings greater than 0.30 are included.

TABLE 4

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

		Form A + B		α Cronbach reliability		Intercorrelation	t
		x̄	S.D.	Form A (N=104)	Form B[a] (N=73)		
R	normative	2.44	0.52	.84	.83	0.34**	3.11**
	ipsative	[illegible]	[illegible]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 5

Intercorrelations among ipsative and normative cognitive preference scores
(N=177)

	R_n	R_i	P_n	P_i	Q_n	Q_i	A_n	A_i	$Q\text{-}R_n$	$Q\text{-}R_i$	$P\text{-}A_n$
R_i	.34										
P_n	.60	.25									
P_i	.21	.18	.34								
Q_n	.00	-.25	.21	-.03							
Q_i	-.36	-.67	-.30	-.46	.35						
A_n	.56	.09	.53	-.03	.35	-.09					
A_i	.05	-.25	-.09	-.27	-.19	-.22	.10				
$Q\text{-}R_n$	-.71	-.42	-.28	-.16	.70	.51	-.15	-.17			
$Q\text{-}R_i$	-.39	-.90	-.31	-.36	.36	.93	-.10	.00	.51		
$P\text{-}A_n$	.02	.17	.46	.38	-.16	-.21	-.51	-.20	-.12	-.21	
$P\text{-}A_i$	.08	.27	.25	.75	.12	-.11	-.09	-.84	.02	-.20	.35

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

i = ipsative; n = normative

TABLE 6

Results of factor analysis with varimax rotation of ipsative and normative cognitive preference scores (N=177)

Cognitive preference area	Rotated Factor Loadings		
	Factor 1	Factor 2	Factor 3
R_i	0.15	0.66	0.19
P_i	0.14	0.40	0.29
Q_i	-0.18	-0.97	0.18
A_i	0.04	0.00	-0.90
R_n	0.69	0.31	-0.03
P_n	0.74	0.22	0.17
Q_n	0.33	-0.44	0.22
A_n	0.82	-0.10	-0.09
% of variance	49.1	29.4	21.5

i = ipsative; n = normative

TABLE 7

Intercorrelations among combined (ipsative + normative) cognitive preference scores
(N=177)

	R	P	Q
P	.50		
Q	-.46	-.20	
A	.24	.13	-.04

TABLE 8

Results of factor analysis of combined cognitive preference scores
(N=177)

	Factor 1[a]
R_c	.99
P_c	.49
Q_c	-.44
A_c	.22
% of variance	100

a) since only one factor appeared in the principal component analysis no varimax rotation was performed.

TABLE 9

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.	Grade Point Average A (N=128) $\bar{x}$	S.D.	t	Biology Grade B (N=28) $\bar{x}$	S.D.	Biology Grade 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 10

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 11

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	1.58			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