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ABSTRACT

Results pertaining to methodological aspects of an aptitude-treatment interaction study are presented. One treatment group in the study was given imagery instructions, the other had no imagery instructions. Each treatment group consisted of seven fifth-grade classes. Among the aptitude variables there were two versions of a paired-associates learning task. Within-class analyses and analyses where class effects were allowed to have influence were conducted. In the latter analyses there were several significant aptitude-treatment interactions with subscores derived from the paired-associates tasks, but this was not the case in the within-class analyses. The interactions found are interpreted as being consequences of class effects with respect to the errors of measurement. (Author)

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Abstract

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Introduction

Cronbach and Snow (1976) made a "radical reappraisal of the ATI model," asserting the necessity of separating between-class and within-class components of aptitude-treatment interaction (ATI) effects. The rationale behind this suggestion was that ATIs may arise not just through individuals' differential responses to treatments. Some processes may affect the class as a unit, and the pupil's relative standing in his class may sometimes be of functional importance.

Cronbach and Webb (1975) presented a reanalysis of a study by Anderson (1941). In the reanalysis, between-class and within-class components of the within-treatment regressions were determined. The original analysis had yielded strong and seemingly interpretable ATIs; but in the reanalysis there was no sign of an interaction in analyses based on pooled within-class regressions, and an apparent interaction at the class level was pinned down as being due to an accident of sampling.

The results of the reanalysis of the Anderson study indicate that separation of between-class and within-class effects may be profitable not only in the study of substantive hypotheses related to processes at the group level and at the individual level. It also seems as if such techniques can be of further use in keeping track of anomalies in the data. It will be shown below that this sometimes warrants the separation of individual effects and group effects also in studies where the latter kind of effect cannot be assumed to be interpretable in substantive terms.

METHOD

An experiment was conducted to study differential effects of imagery instructions on pupils with different abilities (for a full presentation see Gustafsson, 1976 b). Two treatment groups, each consisting of seven fifth-grade classes, studied a teaching material dealing with two monkeys. One of the treatment groups (called the I treatment) was told to generate visual imagery, the other group (the NI treatment) studied the material in a regular fashion. Immediately after studying the material the subjects were given a post-test, consisting of three types of scrambled items, which yielded three dependent variables for the analysis. One item type, called Simple, asked for terms or figures. Another type, labeled Complex, asked for more elaborate definitions. The third, called Description, asked for information concerning pictureable descriptions of the two monkeys.

The subjects were also given a series of aptitude tests. The test battery included two verbal, one reasoning and three spatial tests. Also included in the test-battery were two parallel forms of a paired-associates (PA) learning task with pictures and words as scrambled items. In the presentation of results the main interest will be concentrated on this test; hence only the PA test will be given a more detailed description. However, for purposes of comparisons results will also be presented for one verbal test (Opposites) and one spatial test (Metal folding). For descriptions of these tests the reader is referred to Gustafsson (1976 a and b).

The PA test was modelled after an instrument described by Levin, Divine-Hawkins, Kerst and Guttman (1974). For each form 11 word-pairs and 11 picture-pairs were chosen. These were photographed and the transparencies were mounted on slides to be projected on a screen. The administration of the PA test took place, as did all the other learning and testing, with intact classes. The subjects were first given information about the task and some sample practice items. Then the 22-item list was presented. Each item in the test was shown for four seconds, and the list was presented twice, in two random orders. After the second presentation the subjects were given a list of the stimulus terms and were to supply the response terms. In the scoring, the number of word-pairs (Words) recalled and the number of picture-pairs (Pictures) recalled were computed separately.

The two parallel forms of the PA test were presented on two occasions, separated by about three weeks. The subscores resulting from the first PA test are referred to as Pictures 1 and Words 1; those from the second PA test as Pictures 2 and Words

2. The totals are referred to as Pictures T and Words T. On each occasion half the number of the other aptitude variables were also administered. On the second occasion the experiment proper was the first activity of the session. On both occasion the PA test was administered as the last test.

Since the data collection took place on two occasions there was an attrition of the treatment groups. According to the class lists there were 169 and 173 pupils in the NI and I groups respectively. Since only subjects with a complete set of data were included, there were 141 and 130 subjects respectively in the treatments that were available for analysis.

Procedures in the analysis

Analyses were conducted allowing for curvilinear regressions of the dependent variables on each aptitude variable within treatments. This was effected through the addition of a quadratic term. One set of analyses (labeled Pooled) were made in which within-class and between-class effects were not separated. In these analyses the raw scores on the dependent variables were used, and for the aptitude variables deviation scores round the total mean were used. The rationale for using deviation scores rather than raw scores was to avoid multicollinearity with the quadratic variable.

In their reanalysis of the Anderson study Cronbach and Webb (1975) used for the within-class analysis deviation scores round class means for the dependent variables as well as for the aptitude variables. Classes were pooled, thereby allowing each class to influence the analysis according to its size. Here the same procedure has been followed in a set of analyses called Within.

No estimates of any further effects have been made. Even though between-class regression could have easily been determined, comparisons between the Pooled and the Within analyses suffice for the present purposes.

Significance testing presents great problems in the analysis of within-class and between-class effects. For one thing a large number of classes is needed if a significant heterogeneity of between-class within-treatment regressions is ever to be found. For another thing the construction of proper error terms presents problems. The recognition that the class is a unit, both in sampling and in treatment, of course reveals as illegitimate the usual procedure in what is here called the Pooled analyses, of acting as if the individual was the sampling unit. Despite this, however, the number of pupils in the classes was used for determining the degrees of freedom for the error mean square in the Pooled analyses. The main reason for this was that no alternative was available. The same degrees of freedom have been used for the Within analyses in spite of the fact that each class evidently consumes one degree of freedom. However, correcting for this would here have only little bearing on the pattern of results.

The statistical tests and the estimation of coefficients of regression were made under a "general linear hypothesis" model, with treatment coded as a dummy variable and aptitude-treatment interaction effects represented with cross-product terms in the regression equations. The computations were performed with program BMD10V (Dixon, 1973).

RESULTS

Results from the Pooled analyses are presented in Table 1. Several significant interaction effects are found. The verbal test Opposites shows a significant difference in slope between treatments with respect to the Simple criterion; and with respect to the same criterion there are for Metal folding significant differences between the treatments with respect to both the linear and the quadratic terms. For the PA variables there are in several cases differences between the treatments for the quadratic terms. But it is quite embarrasing to find that the parallel versions of the same test give very different patterns of results. For the Words 1 variable there is for example with respect to the Complex criterion a highly significant interaction; but for the Words 2 variable there is not only a lack of significant interaction but there are also for both the linear and the quadratic terms weak tendencies in the opposite direction to what was found with Words 1.

Table 1 Coefficients of regression and F-ratios for aptitude-treatment interactions in the Pooled analyses.

		Simple			Complex			Description		
		NI	I	F	NI	I	F	NI	I	F
Opposites										
	x	.154	.260	5.46^x	.152	.132	.44	.312	.220	2.51
	x^2	-.010	-.010	.00	.003	.000	.41	-.007	-.006	.02
	F for overall interaction			2.82			.52			1.27
Metal folding	x	.065	.139	4.34^x	.046	.063	.52	.148	.131	.13
	x^2	.003	-.003	5.91^x	.001	-.004	2.70	.000	-.006	1.21
	F for overall interaction			5.90^x			1.80			.63
Words 1										
	x	.186	.286	.45	.152	.302	2.46	.109	.377	1.98
	x^2	.038	-.029	2.17	.049	-.055	12.93^x	.047	-.033	2.00
	F for overall interaction			1.09			6.52^x			1.32
Pictures 1										
	x	.166	.206	.07	.064	.230	2.98	.018	.366	3.65
	x^2	.034	-.011	.68	.013	.006	.03	-.025	-.051	.15
	F for overall interaction			.55			1.93			2.59
Words 2										
	x	.258	.059	2.38	.234	.159	.80	.250	.237	.01
	x^2	-.002	.027	.60	-.002	.002	.02	.007	.015	.03
	F for overall interaction			1.19			.46			.02
Pictures 2										
	x	.227	.096	1.21	.201	.101	1.66	.343	.265	.28
	x^2	.014	.026	.09	.050	-.009	4.67^x	.085	-.025	4.65^x
	F for overall interaction			.80			2.59			2.33
Words T										
	x	.167	.120	.34	.138	.149	.05	.136	.227	.81
	x^2	.005	-.003	.40	.010	-.008	5.69^x	.010	-.010	1.65
	F for overall interaction			.73			3.46^x			.87
Pictures T										
	x	.136	.088	.42	.107	.099	.03	.166	.202	.16
	x^2	.007	-.002	.28	.020	-.009	6.55^x	.030	-.029	7.50^x
	F for overall interaction			.28			3.40^x			4.39^x

Critical values: $F_{.95}(1,265)=3.88$ $F_{.95}(2,265)=3.03$

Table 2 Coefficients of regression and F-ratios for aptitude-treatment interactions in the Within analyses.

		Simple			Complex			Description		
		NI	I	F	NI	I	F	NI	I	F
Opposites										
	x	.116	.248	7.87^x	.122	.133	.12	.266	.232	.35
	x^2	-.005	-.006	.05	.004	-.001	1.37	-.006	-.011	.30
	F for overall interaction			4.02^x			.69			.42
Metal folding	x	.055	.143	6.23^x	.039	.067	1.40	.115	.158	1.00
	x^2	.008	-.002	4.59^x	.001	-.004	1.93	.000	-.009	2.37
	F for overall interaction			5.69^x			1.75			1.77
Words 1										
	x	.276	.286	.00	.192	.268	.67	.150	.383	1.69
	x^2	-.004	-.015	.08	.019	-.047	5.89^x	.011	-.016	.28
	F for overall interaction			.04			3.05^x			.86
Pictures 1										
	x	.222	.203	.02	.117	.227	1.56	.098	.381	2.89
	x^2	.032	-.019	.93	.019	.002	.27	-.025	-.059	.29
	F for overall interaction			.49			1.30			2.18
Words 2										
	x	.205	.147	.23	.190	.189	.00	.177	.283	.53
	x^2	-.001	.020	.30	-.011	.001	.23	-.008	.020	.35
	F for overall interaction			.19			.14			.75
Pictures 2										
	x	.186	.157	.06	.171	.147	.10	.305	.376	.25
	x^2	-.013	.015	.48	.026	.001	.85	.049	-.014	1.60
	F for overall interaction			.37			.42			1.28
Words T										
	x	.166	.136	.17	.131	.147	.11	.118	.233	1.58
	x^2	-.001	.002	.07	.004	-.007	1.92	-.001	-.005	.12
	F for overall interaction			.09			1.00			.81
Pictures T										
	x	.130	.120	.02	.100	.123	.27	.151	.257	1.53
	x^2	-.007	.001	.21	.010	.001	.70	.009	-.014	1.78
	F for overall interaction			.10			.63			2.21

Critical values: $F_{.95}(1,265)=3.88$, $F_{.95}(2,265)=3.03$

Results from the Within analyses are presented in Table 2. The interactions found for both Opposites and Metal folding reappear essentially unaltered in these analyses. But almost all the interactions with the PA variables fail to reappear in the Within analyses. The only exception is formed by the Words 1 variable with respect to the Complex criterion, but it can be noted that this interaction is considerably weaker in the Within analysis.

DISCUSSION AND CONCLUSIONS

Here will only be discussed methodological aspects of the pattern of results; the reader interested in a full presentation of the results and interpretations in substantive terms for the verbal and spatial aptitude variables is referred to Gustafsson (1976 b).

The fact that for the PA variables there were no interactions in the Within analyses, and the fact that there were great differences between the patterns of results of the two forms, indicate that the results obtained in the Pooled analyses are nothing else than artefacts arising from the circumstance that the administration of the PA test as well as the experiment proper took place with intact classes.

It is reasonable to assume that a learning task is highly sensitive to the instructions given, to the mental alertness of the subjects, to events happening during the administration of the task and so on. When the task is given class-wise this implies that many of these factors will influence all pupils more or less in the same way. The effect of this, of course, is that there will be a large intraclass correlation for the errors of measurement. But when this occurs for both aptitude variables and dependent variables in an ATI study where classes are nested within treatments this may imply correlated errors for aptitude variables and dependent variables. Since these correlated errors may be of different kinds within the treatments this may in turn have as a consequence what is judged to be significant aptitude-treatment interactions.

In the Within analyses, in contrast, each subject's scores on the variables are computed as deviations from the class means; any positive or negative fortuitious effect on the scores that is common to the class will consequently not affect the analysis.

In this case the class effects with respect to the errors of measurement resulted in quite complex aptitude-treatment interactions which pertained to the quadratic component of the regression. From this it cannot be assumed, however, that the linear regressions on the aptitude variables remain free from such effects. Whenever there is a small number of classes that are nested within treatments, class effects at the administration of the aptitude variables and experimental tasks can have as a consequence interactions of any kind.

The present analysis thus strongly indicates the need for keeping track of class-mediated effects also with respect to the aptitude variables. Aptitude variables (and classes) of course are sensitive in differing degrees to such effects, but whenever the presence of class-mediated errors of measurement are suspected, within-class analyses should be conducted.

Obviously attempts should also be made to avoid the problem altogether. One possibility is, of course, to administer "sensitive" tests individually. This, however, may not be possible due to the large number of subjects needed for aptitude-treatment interaction studies. If for this, or any other reason, strictly individual testing is not possible, (small) groups of subjects having different treatments should be tested together.

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