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AUTHOR Gustafsson, Jan-Eric
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ABSTRACT

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Jan-Eric Gustafsson

INSTITUTE OF EDUCATION, UNIVERSITY OF GÖTEBORG Fack S-431 20 MÖLNDAL SWEDEN

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INTRODUCTION

The concept of imagery has recently received considerable interest within the psychology of learning. Imagery has, among other things, been studied as a stimulus attribute, primarily in associative learning tasks, and almost invariably items of high imagery have been found to be more easily learned than items of low imagery (e.g. Bower, 1972; Paivio, 1969, 1971; Rohwer, 1970). Imagery has also been studied as an experimentally induced learning set through instructions in which the subjects are told to form mental pictures integrating the presented material, typically in comparison with subjects that either engage in rote rehearsal or in finding verbal mediators. The most prevalent pattern of results is improved learning on the part of the subjects given the imagery instructions (e.g. Bower, 1972; Paivio, 1969, 1971).

To some extent imagery has also been studied as a subject characteristic (see Gustafsson, 1976 a, chapter 2; Paivio, 1971, chapter 14), unfortunately, however, too few such studies have been conducted to allow a stable pattern of results to emerge.

The purpose of the present study is to bring into closer focus imagery as a subject characteristic within an aptitude-treatment interaction (ATI) design (Cronbach & Snow, in press; Gustafsson, 1976 a), with imagery instructions (given or not given) as the treatment variable. Before the study is presented, however, a closer look will be taken at some empirical results and theoretical interpretations.

Researchers trying to account for the existence and effects of imagery have found it necessary to formulate models including (at least) two coding and storage systems in memory - one verbal and one non-verbal (Bower, 1972; Paivio, 1969, 1971). Even though these systems are specialized in that

they deal with different types of information, rich interconnections between them are assumed. Paivio (1969, 1971) accounted in such terms for, among other things, the apparent effects on learning of the rated imagery of the stimulus material. Items of low imagery are assumed to involve primarily the verbal system, while high-imagery items are assumed to have the benefit of the non-verbal system as well. As a consequence, high-imagery items are more easily recalled as a function of the summative effect of the two systems.

The "dual coding model" is highly susceptible to criticism, primarily because it does not involve any modality-free mode of representation (Pylyshyn, 1973). However, even though it does seem necessary to postulate a modality-free or sign-neutral level of information (cf. Marton, 1976), there evidently is great functional importance to be attached to the modality of information and processing.

At the empirical level the most interesting results have been obtained in studies investigating interactions between different types of imagery factors. Several studies have been conducted in which the type of induced strategy (primarily imagery mediation or verbal mediation) and the imagery value of the stiumulus material have been varied orthogonally. Yuille and Paivio (1967) found that the latency for finding an imagery mediator was much longer for low-imagery (or abstract) stimuli than for high-imagery (or concrete) stimuli, but no such differences were found when the task was to find a verbal mediator. It has, however, proven difficult to establish the same type of interaction with respect to the learning of the items (Cunningham, 1972; Mueller & Jablonski, 1970; Paivio, 1969), unless, as was the case in the study by Paivio and Foth (1970), the subjects are overtly producing the mediators. Paivio and Foth found that imagery mediation gave a better result with high-imagery items, while verbal mediation gave a better result with low-imagery items. In this experiment the sub-

jects were evidently forced to adhers to the experimental strategies, while in the other experiments they had to some extent the opportunity of shifting their strategy according to what was found suitable for different items.

The straightforward but still quite basic conclusion to be drawn from the Paivio and Foth (1970) study therefore is that when it is difficult to generate suitable imagery, performance will deteriorate.

Since subjects can be assumed to differ with respect to the facility with which they can generate imagery, the hypothesis of interactions with subject characteristics is not farfetched. As was mentioned above few such studies have been conducted but also studies not designed to test hypotheses about ATIs can sometimes provide evidence concerning the existence of interactions. An example of such a study is the one conducted by Horvitz and Levin (1972). Subjects from the third and sixth gradeswere given a list of paired associates presented in sentences under either an imagery instructions condition or a regular paired-associates learning condition. In the sixth grade a higher mean was found for the subjects having imagery instructions, while in the third grade there was no mean difference. There was, however, in the third grade a significantly higher variance of the learning scores in the group having the imagery instructions. This was interpreted to mean that "the learning of some third-graders was in fact facilitated by imagery instructions, while the learning of others was depressed" (Horvitz & Levin, 1972, p. 16).

There are also studies making a direct appraisal of the imagery ability of the subjects. Following Barratt (1953), performance on spatial tests has been used as an indicator of imagery ability (see Gustafsson, 1976 a, chapter 2). Ernest and Paivio (1971) found that subjects with high spatial ability (or high imagery) more quickly aroused an

image when the stimulus word was abstract, but that there were small or no differences with concrete stimuli. A similar result has been obtained by Klee and Eysenck (1973) with sentences that varied in abstractness.

Di Vesta and Ross (1971) found some interactions of a higher order involving imagery ability in a complex factorial experiment employing a paired-associates task with items differing in imagery arousal potential. The interactions were essentially caused by the high-imagery subjects doing better than the low-imagery subjects on pairs where the stimulus-member was of low-rated imagery. The interpretation propcsed by Di Vesta and Ross was that the high-imagery subjects have an advantage on the low-imagery items because of their better ability to generate imagery, while for the concrete stimuli there is no need for imagery ability because these stimuli are sufficiently imagery evoking in themselves.

Levin, Divine-Hawkins, Kerst and Guttman (1974) used performance on a paired-associates learning taskwith pictures and words as items for identifying learner types. According to their performance on the two item types the subjects were blocked into three combinations of levels (high picture - high word, high picture - low word and low picture - low word; there were only a few subjects with the low picture - high word combination). The subjects were then given a learning task under either imagery instructions or regular reading instructions. No main effect for treatment was found, but there was a disordinal interaction - pupils with the low picture - low word combination did much worse with imagery instructions, while for the other two combinations of levels on the paired-associates task there was a better performance with the imagery instructions.

The Levin et al. (1974) study contrasts with the other studies discussed above in that the learning material in

the experiment was meaningful material. Relatively few studies have been conducted on the effects of imagery instructions with anything other than associative learning tasks. However, Kulhavy and Swenson (1975) as well as Rasco, Tennyson and Boutwell (1975) have conducted studies in which educationally relevant teaching materials have been used. These studies indicate positive effects on learning of imagery instructions, but evidently these effects are much less pronounced than the quite dramatic effects often found in the associative learning tasks. It should also be pointed out that in these studies no attempts have been made to study differential effects of imagery instructions with respect to different outcomes, or with respect to subjects with different aptitudes.

The studies considered above indicate clearly that interactions with imagery ability can be expected. It seems as if high-imagery subjects are especially good at acquiring low-imagery materials; it also appears as if the high-imagery subjects have an advantage when given imagery instructions. There is, however, a need for studying simultaneosly imagery as a treatment variable, stimulus attribute and aptitude variable and for studies using a meaningful learning material.

METHOD

The experiment to be described is one part of what can be regarded as a large ATI experiment, another part of which has already been presented by Gustafsson (1976 a). The same set of aptitude variables was given to all subjects, who also took part in two experimental activities. The aptitude variables were administered on two occasions, and as the first activity on the second occasion the pre-

sent experiment took place with one group of subjects studying a teaching material under imagery instructions, another group of subjects receiving no imagery instructions.

The teaching material

The teaching material deals with the marmoset and the chimpanzee. After some general information about primates, the subjects are told where the marmoset and chimpanzee live, how big they are, what they look like, to what groups they belong, what their hands and feet look like and how they use them, where they prefer to stay, how they move and what they eat. The information is thus to an overwhelming degree factual.

The number of words used is 473 and there are 12 illustrations, all rather simple black and white drawings.

The post-test

A post-test was constructed containing 27 questions, most of these being "sub-questions". All questions are formulated in the verbal mode and require verbal answers.

Out of these questions three subscales have been produced in order to permit study of differential effects with respect to different outcomes. One of the subscales is labeled *Simple*. It consists of 7 items requiring only a term or a figure as the answer. Examples of items classified into this group are some questions, which ask how tall the chimpanzee and the marmoset can become, and a question which asks what the group of animals to which man and apes belong is called. It should also be pointed out that two questions, which ask in what parts of the world the marmoset and the

chimpanzee are found were scored in two ways. These questions were first scored zero or one depending upon whether or not the continent was correctly supplied; they were then scored zero or one a second time depending upon whether or not the more exact localization within continents was correctly stated. For each question the first of the two scores has been classified into the Simple group. The scores resulting from the second way of scoring were, however, classified into a group labeled *Complex*. This group of items is composed of questions asking for more complex information and requiring more elaborate definitions. Another example of the six items classified into this group is a question, which asks in what way the group of animals composed of monkeys and man differs from other groups of animals.

The third group of items is referred to as *Description*. There are 13 items classified into this group and they all refer to picturable descriptions of the two animals. Examples of this group of items are some questions which ask what the ears of the chimpanzee and the marmoset look like. The question which asks what the ears of the chimpanzee look like is a third question that has been scored in two ways. One aspect of the answers that was scored zero or one was whether the answer stated that the ears are naked; the other aspect scored zero or one whether the answer stated that the chimpanzee has protruding ears.

The treatments

One problem encountered when instructing subjects to deal with a material in a special way is that this may imply a generally more intense reading without this necessarily reflecting anything other than the fact that the subjects were given instructions. In order to circumvent this possibility two precautions were taken. First, both treatment

groups were given the same amount of time to study each of the six pages of the material. Second the subjects receiving the imagery instructions (the I group) were given a certain time after the reading of each page for generating imagery. For studying page 1 two minutes were given, for pages 2 and 3 one minute was allowed for each and for the remaining pages two minutes were given for each page.

Before the reading, the subjects in the I group were given brief and informal training in imagery. They were told that: "As you all know, you can think of pictures, such as for example..." Then a short story was told about cycling to the sea and the pupils were at intervals instructed to close their eyes and imagine the scenes.

After the reading of each page was completed, the subjects in the I group were instructed to close their eyes and imagine pictures of what they had read on the page. After about 40 seconds the test administrator told the class to turn to the next page and continue reading. The subjects not having the imagery instructions (the NI group) were simply told to turn to the next page as soon as the time alloted for the preceding one was out.

After the reading the subjects were immediately given the posttest.

Aptitude variables

For a more detailed presentation and analysis of the aptitude variables than can be supplied here the reader is referred to Gustafsson (1976 a).

The test battery included two verbal tests. One of these tests is a vocabulary test called *Opposites* (Svensson, 1964, 1971) in which the task is to find the opposite of a given

word among four choices. The other verbal test, labeled RS 2, is a test of reading speed constructed by Malmquist (1973). In this test the subjects are given a certain time to read a text in which at intervals there are parentheses containing three words. The task is to underline the word that fits into the sentence.

Three tests of spatial ability were also administered. The items in one of these (*Metal folding*) require the subjects to find the three-dimensional object among four choices that can be made of a flat piece of metal with bending lines marked on the drawings. This test was constructed by Svensson (1964, 1971). The second spatial test administered to the subjects was *Figures*. This test was originally constructed by Thurstone, but the Swedish version in the Dureman and Sälde (1959) battery was used. In Figures the task is to decide which figures in groups of seven can be made identical with a given figure through rotation on one plane. As the third spatial test, the *Hands* test was administered. This test, which presents pictures of hands with the task being to decide whether it is a left hand or a right hand, was originally constructed by Thurstone. There is, however, a Swedish version of the test in the Dureman and Sälde (1959) battery.

A reasoning test, *Number series*, was also included. In this test the task is to complete a number series of which six numbers are given with two more numbers. The test was constructed by Svensson (1964, 1971).

On each occasion parallel versions of a paired-associates learning task with pictures and words as items were also administered. This test was modeled after the instrument described by Levin et al. (1974). In the analysis to be presented below this test will, however, not be included since some results obtained with these variables have already been presented by Gustafsson (1976 b). This latter study had a methodological purpose, investigating class

effects (Cronbach and Webb, 1975). It was found that when within-class analyses were conducted in which the subjects scores on the aptitude variables and dependent variables were computed as deviation scores round class means, interactions that had been found in analyses not taking into account class effects disappeared. This result was interpreted to be a consequence of correlated errors at the class level for the aptitude variables and the dependent variables.

Subjects

Subjects in the study were pupils from the fifth grade. Seven classes were allocated to each treatment and the administration of the aptitude variables as well as the experiment proper took place with intact classes.

Since the data collection took place on two occasions separated about three weeks and only subjects with a complete set of data have been used in the analyses, there was attrition of the treatment groups. According to the class lists there were 169 and 173 pupils in the NI and I groups respectively. After attrition the groups were comprised of 141 and 130 subjects respectively.

RESULTS

In statistical analyses of ATI studies Cronbach and Snow (in press) have recommended linear multiple regression followed by the establishing of confidence intervals for the regressions according to the procedure described by Potthoff (1964). Gustafsson (1976 a), investigating different methods of analysis and starting from the point of view that as good a description as possible should be sought

for concluded that simultaneous blocking on two (or more) aptitude variables may sometimes be a preferable strategy. Another reason for advocating blocking was that with this method of analysis it is sometimes possible to evaluate the effects on the patterns of results of differences between treatment groups with respect to the aptitude variables. The quite simple method employed by Gustafsson (1976 a), to achieve this aim was to compare the pattern of differences for the corresponding combinations of levels, within the treatment groups with respect to the dependent variables with the pattern of differences with respect to aptitude variables highly related to achievement. Such analyses will be those on which interpretations are to be based. However, before the results from analyses based on blocking are presented some regression analyses will be presented.

Regression analyses

In the regression analyses only one aptitude variable at a time has been studied, but analyses allowing for curvilinear regressions have been conducted. That is, within each treatment the dependent variable (Y) has been regressed on the aptitude variable (X) under a model of the kind:

$$\hat{Y} = a + b_1X + b_2X^2$$

The X^2 term is a quadratic term representing curvilinearity. The estimation of the coefficients of regression and the testing of the homogeneity of within-treatment has been carried out under a "general linear hypothesis" model (see Gustafsson, 1976 a, chapter 3).

Results will be presented separately for boys and girls. When the treatment groups are divided according to sex, another variable is introduced into the design, the effects of which could be studied together with treatment and aptitude in a three-factor design. However, the disproportio-

nate cell sizes make such analyses difficult to conduct and interpret and in addition such an analysis has to be complemented with several pair-wise comparisons. In order to keep presentation brief, the simple approach of only comparing the within-treatment regressions separately for the sexes has been chosen.

Coefficients of regression and F-ratios for interaction (i.e. the overall interaction, with two degrees of freedom for the numerator as well as for each term and with one degree of freedom for the numerator) are presented for boys in Table 1 (p. 13) and for girls in Table 2 (p. 14).

Several significant interactions are found, but variables that tend to interact for boys are different from those that tend to interact for girls. For the boys there is a significantly higher coefficient in the I treatment for the linear regression of the Simple criterion on Opposites; for the girls there are higher coefficients for the spatial tests in the I treatment. For the boys there are also in some cases differences between the within-treatment regressions on the spatial tests. However, these differences pertain to the curvilinearity of the regressions.

It can be noted that with respect to the Simple criterion there are tendencies in the same direction for both sexes, even though they are of different strenghts. With respect to the other dependent variables, however, the differences between the treatments for the coefficients of regression for the linear terms generally are of different signs for boys and girls. For the Complex criterion, for example, there is for the girls for Metal folding and Figures a significantly higher coefficient in the I treatment; for the boys there is a higher coefficient in the NI treatment. The same pattern of results is found for the Description criterion, even though no significant interaction is found with respect to this outcome.

Table 1. Coefficients of regression and F-ratios for interaction for curvilinear regressions for boys

		Simple			Complex			Description		
		NI	I	F	NI	I	F	NI	I	F
Opposites	x	.065	.230	4.83*	.200	.142	1.29	.277	.144	2.14
	x^2	-.013	-.012	.00	.005	.002	.12	-.009	.002	.64
	F for overall interaction			2.45			.66			1.60
RS 2	x	.081	.141	.96	.080	.108	.43	.113	.079	.19
	x^2	.005	-.006	2.45	.001	.000	.08	.002	.000	.06
	F for overall interaction			1.60			.24			.13
Number series	x	.093	.098	.01	.093	.064	.71	.162	.056	3.30
	x^2	-.002	-.002	.00	-.002	.000	.20	-.009	-.002	1.34
	F for overall interaction			.01			.43			2.19
Metal folding	x	.067	.086	.16	.073	.036	1.14	.127	.074	.83
	x^2	.012	-.003	5.75*	.005	-.005	4.85*	.004	-.006	1.58
	F for overall interaction			3.30*			2.61			1.01
Figures	x	.013	.043	1.04	.030	.004	1.56	.064	.046	.27
	x^2	.000	.000	.02	.001	-.002	5.23*	.003	.001	1.15
	F for overall interaction			.58			2.93			.62
Hands	x	.005	.016	.20	-.004	.012	.77	.028	.015	.18
	x^2	.001	.002	.08	.002	.001	.60	.003	.000	1.09
	F for overall interaction			.14			.70			.63

Critical values: F.95 (1,126) = 3.92
F.95 (2,126) = 3,07

Table 2. Coefficients of regression and F-ratios for interaction for curvilinear regressions for girls

		Simple			Complex			Description		
		NI	I	F	NI	I	F	NI	I	F
Opposites	x	.215	.289	1.32	.125	.140	.13	.330	.312	.04
	x^2	-.011	-.008	.12	.003	-.004	1.27	-.006	-.012	.29
	F for overall interaction			1.03			.64			
RS 2	x	.140	.265	3.50	.113	.115	.00	.158	.284	1.91
	x^2	-.010	-.007	.14	-.002	-.004	.07	-.010	-.009	.01
	F for overall interaction			2.13			.04			1.06
Number series	x	.131	.223	3.47	.040	.097	2.75	.184	.241	.76
	x^2	.001	-.006	1.53	.003	-.003	2.28	-.002	-.016	3.33
	F for overall interaction			2.20			2.27			1.90
Metal folding	x	.080	.210	5.25*	.027	.115	5.83*	.196	.241	.38
	x^2	.005	.001	.38	-.001	.000	.07	-.005	.000	.34
	F for overall interaction			3.10			2.92			.31
Figures	x	.016	.078	4.26*	.001	.060	10.21*	.039	.101	2.61
	x^2	.001	-.002	3.28	.001	.000	.97	-.001	-.004	.99
	F for overall interaction			4.28*			6.05*			2.02
Hands	x	-.002	.061	3.97*	-.004	.025	2.20	-.024	.057	3.84
	x^2	.000	-.003	1.51	-.001	-.002	.21	-.002	-.001	.11
	F for overall interaction			2.02			1.15			3.01

Critical values: F.95 (1,133) = 3.92
F.95 (2,133) = 3.07

In earlier ATI studies (Gustafsson, 1976 a) it has as a general rule been found that the treatment groups lack perfect comparability with respect to the aptitude variables. It has also been found that it may sometimes be possible to account for even significant interactions in terms of such differences between the treatment groups. When the group sizes are reduced through division according to sex, the chances of course increase of finding differences between the treatment groups with respect to the aptitude variables.

Means and standard deviations on the variables for the four groups are presented in Table 3 in the Appendix. Results from two-way analyses of variance with treatment and sex as factors are also presented. With respect to the aptitude variables, no significant effect for treatment or the interaction between sex and treatment is found even though the means certainly cannot be regarded as being identical. It can also be noted that there are in several cases important differences between the standard deviations of the four groups.

The intercorrelations among the variables within the four groups are presented in table 4 in the Appendix. There is very little reason to describe the differences between the groups; suffice it to point out that there are in several cases very large differences between correlations that "should" be identical.

Analyses based on blocking

In order better to describe the pattern of results and also to be in a better position to evaluate the effects on the pattern of results of the differences between the groups with respect to the aptitude variables, analyses based on blocking will be described next.

The analysis based on blocking will be restricted to the tests Opposites and Figures. The reason for choosing Opposites rather than the other verbal test RS 2 is that Opposites is a better test of verbal ability. The reason for choosing Figures rather than Metal folding is that Figures has a lower correlation with Opposites, while at the same time giving roughly equivalent results as Metal folding in the regression analyses. It is virtually a necessity using lowly intercorrelated tests in the blocking since simultaneous blocking on two variables requires a large number of subjects as soon there is a correlation between the aptitude variables. Since in this case the blocking evidently has to be done within sexes, the effective sample sizes are considerably reduced.

It would have been desirable to block each aptitude variable into three levels. The modest sample sizes do not, however, permit this. Nevertheless there is a need to be able to study the curvilinearity found for Figures in some analyses, and Figures has thus been blocked into three equal-sized levels (with the same cutting scores for both sexes). Opposites has been blocked into two levels. In spite of this the group sizes are in some cases as small as 5 subjects.

Opposites will not only be used as a blocking variable but the means on Opposites for the groups will also be compared with the means on the dependent variables. It would of course have been preferable to use as a control variable an aptitude variable not used in blocking. Opposites, however, is the only aptitude variable that is highly related to the kind of learning studied here and, since Opposites is only blocked into two levels, the means on the variable are not too severly constrained.

The results will be presented graphically, but the figures upon which the graphical presentation is based are presented in Table 5 in the Appendix. The results for the Simple and Complex criteria as well as for Opposites are presented in Figures 1 (p. 17) and 2 (p. 18).

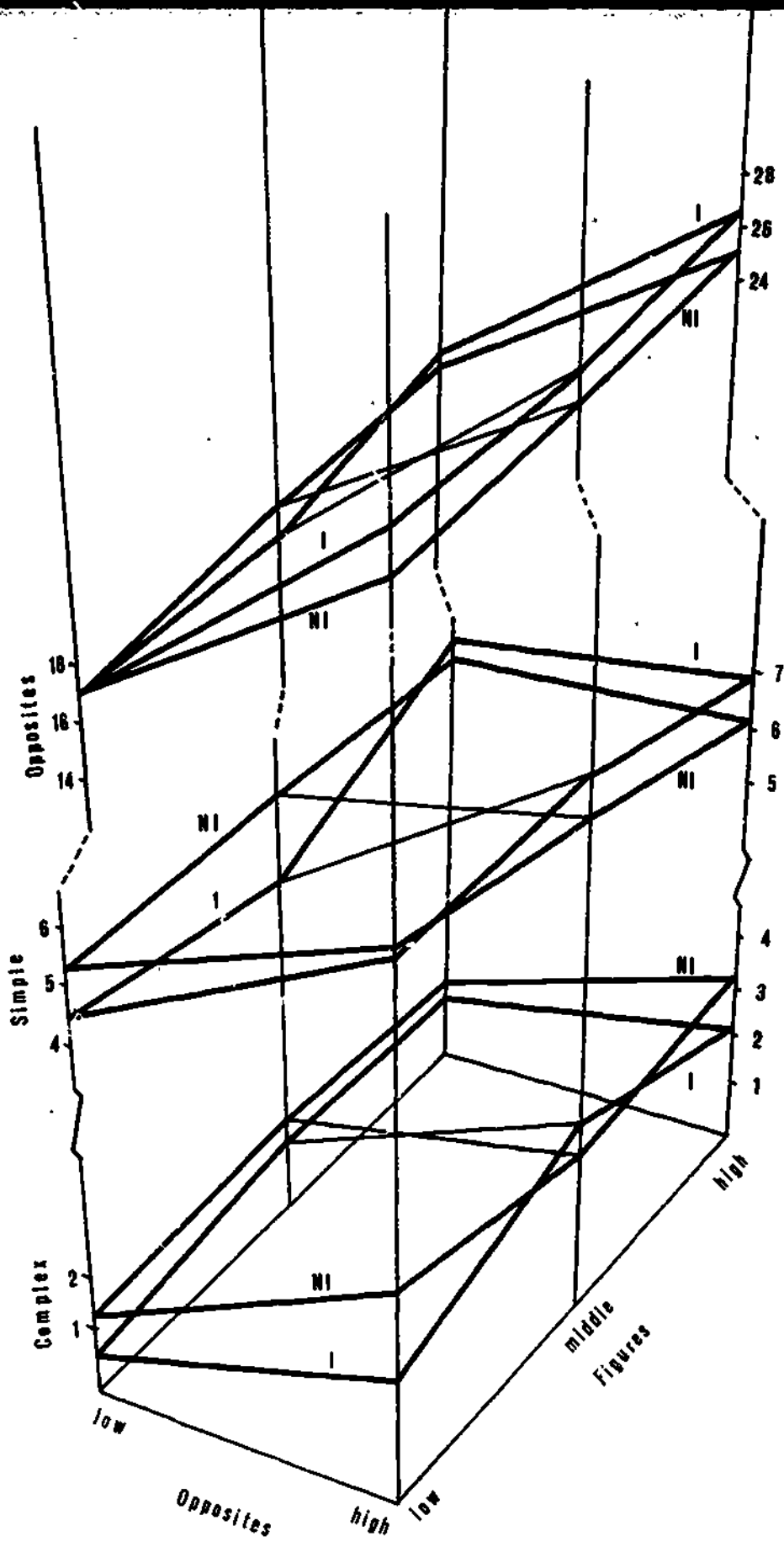

Figure 1. Graphs of cell means for the Complex and Simple criteria and for Opposites in the blocking and crossing of Opposites and Figures. Results for boys.

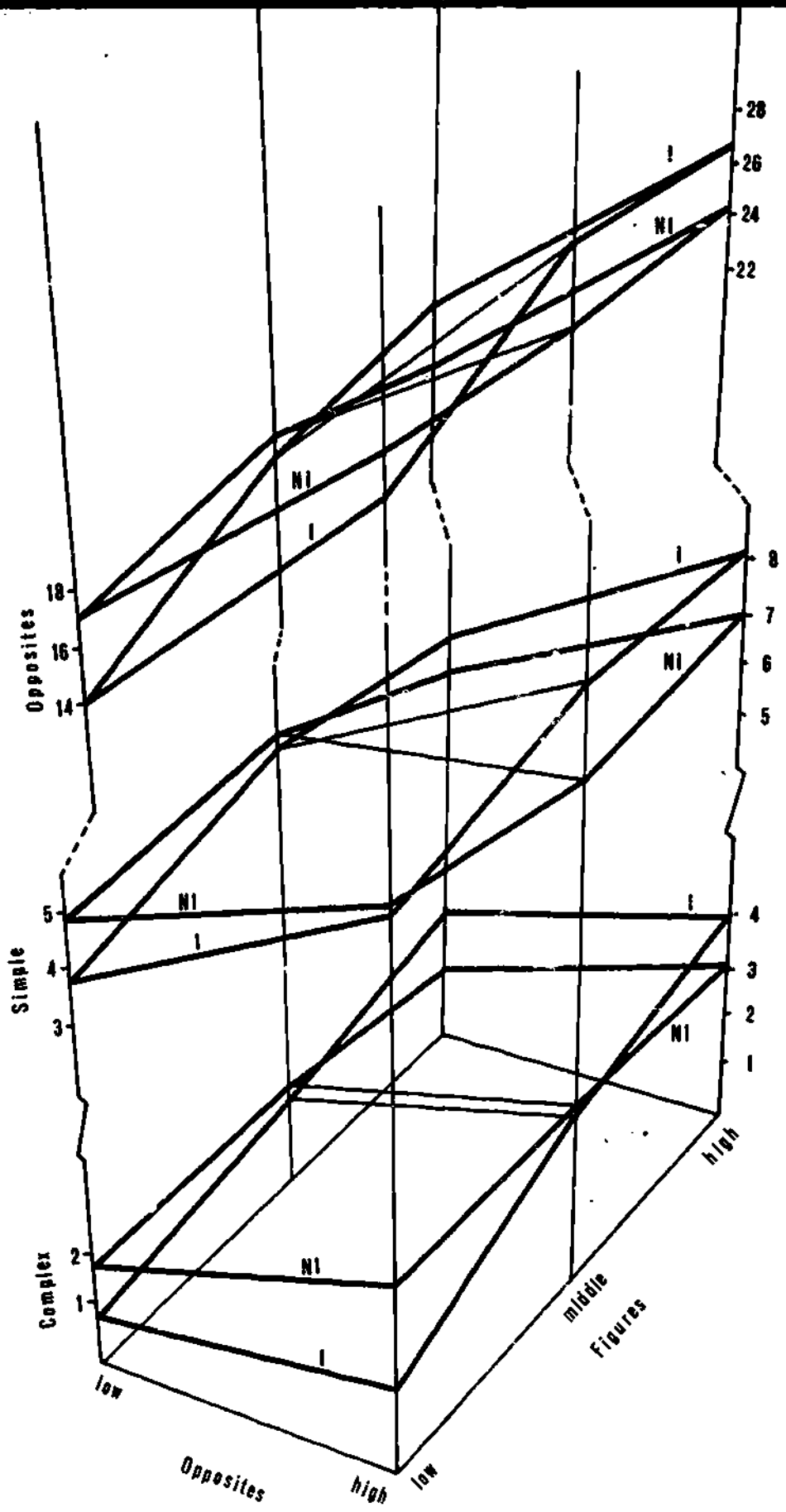

Figure 2. Graphs of cell means for the Complex and Simple criteria and for Opposites in the blocking and crossing of Opposites and Figures. Results for girls.

If the results on the Simple criterion for the boys (Figure 1) are looked at first, it is found that there is a better performance with the NI treatment than with the I treatment for subjects with a low score on Opposites and a low or middle score on Figures; but there is a better result under the I treatment than under the NI treatment for subjects with a high score on Opposites and a middle or high score on Figures. If the pattern of differences for Opposites is investigated, only rather small differences are found for the corresponding combinations of levels within the treatment. There are some systematic differences, however, in that there is a somewhat higher mean on Opposites for the I treatment for all the combinations of levels involving a high score on Opposites.

The results for the girls (Figure 2) with respect to the Simple criterion are roughly the same as those found for the boys. But if the "results" for the girls on Opposites are investigated, important differences between supposedly similar groups are found, and more important still is the fact that the pattern of differences with respect to Opposites almost perfectly coincides with the pattern of differences with respect to the Simple criterion.

For the Complex criterion there is for the boys for all combinations of levels except one a higher mean with the NI treatment (there is a significant main effect for treatment with respect to this outcome, see table 4 in the Appendix). Even though the higher mean with the I treatment for the combination involving high Opposites and middle Figures is not accompanied by a difference in the same direction for Opposites, the explanation that chance accounts for the tendency towards a disordinal interaction is the most reasonable one.

For the girls the pattern of differences with respect to the Complex criterion gives evidence of a disordinal inter-

action - there being a better performance with NI for subjects low on Figures and a better performance with the I treatment for subjects high on Figures. Again, however, the pattern of differences with respect to the dependent variable closely follows the pattern of differences with respect to Opposites. The hypothesis that the interactions found can be accounted for by differences between the treatment groups with respect to the aptitude variables must therefore be seriously entertained.

The results for the Description criterion, are shown in Figures 3 and 4. What is notable about the results for the boys is the poor performance with imagery instructions on the part of the subjects high in verbal and low spatial ability. For the girls, too, there is a difference in favor of the NI treatment for the subjects low on Figures and high on Opposites, but what is most notable about the pattern of results for the girls is the extremely poor performance in the NI treatment for subjects high on Figures and low on Opposites. Even though this difference is larger than what could be expected from the difference in the same direction of 2.4 units on Opposites, it does not seem to be interpretable.

It appears as if it can be concluded from these analyses that the very important differences in the patterns of results between boys and girls can be accounted for by there being differences with respect to the aptitude variables for the girls in the two treatments. There is of course the possibility that there are genuine higher-order interactions involving sex as a factor, but only further studies can provide the necessary information for answering this question.

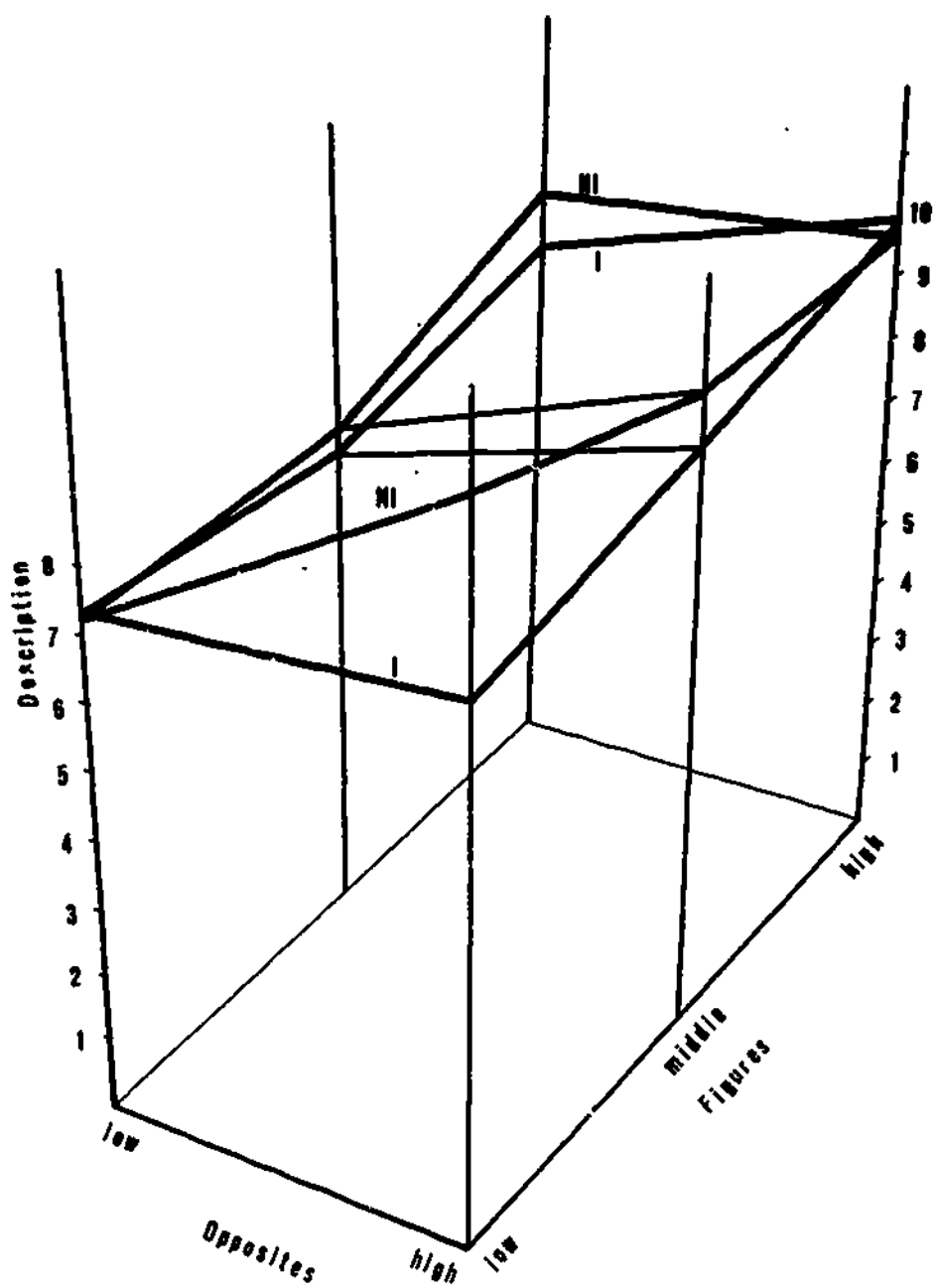

Figure 3. Graphs of cell means for the Description criterion in the blocking and crossing of Opposites and Figures. Results for boys.

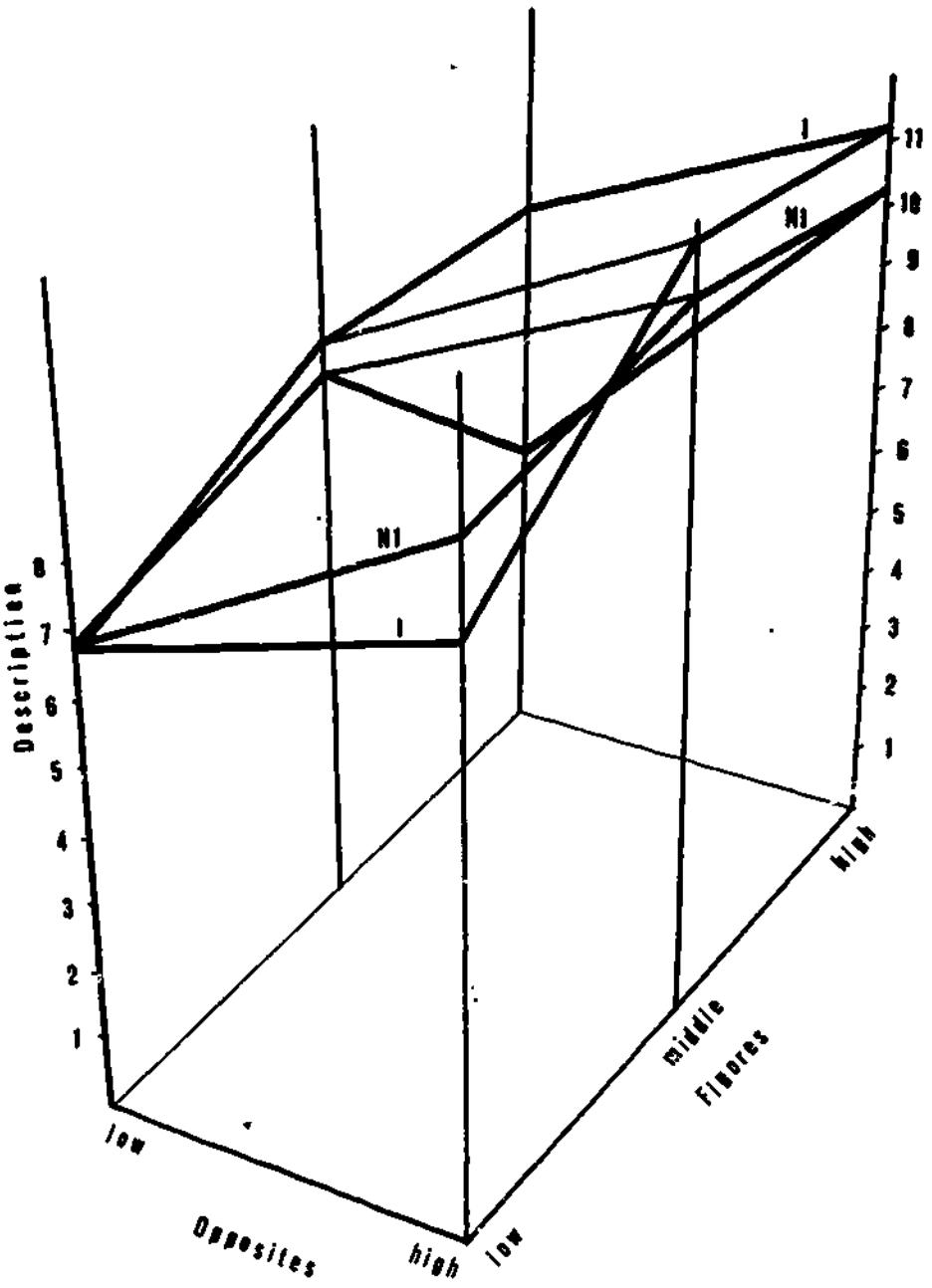

Figure 4. Graphs of cell means for the Description criterion in the blocking and crossing of Opposites and Figures. Results for girls.

DISCUSSION

In an earlier study (Gustafsson, 1976, ch. 7) it was found necessary to rule out an apparent interaction as being only a consequence of incomparable treatment groups. In that study too, the pattern of differences for the dependent variables was compared with the pattern of diffenrences for aptitude variables highly related to achievement in both groups. Admittedly this technique is crude and lacks in statistical sophistication. In spite of this, however, it appears quite impossible to accept for interpretation an interaction when a coinciding pattern of differences for aptitude variables and dependent variables is found. It has thus been judged necessary to restrict the discussion in substantive terms to the results obtained for the boys.

With respect to the Complex criterion a very poor performance was found for all the boys having imagery instructions, irrespective of their combinations of levels on the aptitude variables. This result can be related to the result in the Paivio and Foth (1971) study where it was found that imagery instructions are negative with abstract material. It is of course quite natural that attempts to produce in images information that is not easily represented in that way should have detrimental effects on learning.

The information covered by the Simple criterion can on the other hand be assumed to be more easily imagined. With respect to this outcome a disordinal interaction was found in that the subjects with a higher score on Opposites and a middle or high score on Figures did better with imagery instructions while subjects with a low score on Opposites and middle or low score on Figures did better without any imagery instructions. Thus even with respect to this kind of information only subjects high in both verbal ability and imagery ability were able to profit from the imagery instructions.

The results for the Description outcome are quite puzzling. It would for this outcome have been very reasonable to expect a better result with the I treatment for subjects high on spatial ability. This positive effect was not found, the only difference being a very poor performance under the I treatment for subjects high in verbal and low in spatial ability. Although this negative effect certainly is reasonable, the lack of positive effects of imagery instructions for the subjects high in spatial ability requires an explanation.

One hypothesis, of course, is that the items making up the Description criterion do not, in fact, possess the hypothesized quality of referring to information that is easily represented with visual means. This hypothesis is, however, strongly contradicted by the fact that there is in both treatments a rather strong relation between spatial ability and performance on the Description outcome, which is not the case for the other two dependent variables.

Another, and more reasonable hypothesis centers on problems with decoding the visually represented information into verbal answers. With respect to most of the items in the Simple criterion it seems as if a correct answer could easily be tagged to an imagery representation. The items in the Description subscale, however, to a larger degree require the "reading off" of visual representations, a task that has proven difficult especially for younger children (Dilley & Paivio, 1968; Ducharme & Fraisse, 1965). There is thus a possibility that the subjects high in spatial ability having the I treatment could easily find suitable mental imagery for the information covered by the Description subscale but that they were not able to express this knowledge on the verbal post-test. The tendency towards a better performance with the NI than with the I treatment for the boys high in spatial but low in verbal ability speaks in favor of this interpretation.

In conclusion the present study gives evidence that imagery instructions can be negative as well as positive. Positive effects are only obtained for those subjects that can easily generate visual imagery and even for them only in connection with a concrete and simple kind of material.

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Appendix

Table 3. Means and standard deviation on the variables for the sexes within treatments

		NI			I			F-ratios for:		
		$\bar{X}$	s	N	$\bar{X}$	s	N	Sex	treat-ment	sex x treatment
Opposites	Boys	21.23	4.60	66	22.10	5.64	66			
	Girls	20.33	5.25	75	19.59	6.46	64	6.21[x]	.03	1.44
RS 2	Boys	14.42	5.21		14.88	7.27				
	Girls	14.57	4.92		14.66	6.40		.00	.13	.07
Number series	Boys	19.27	7.15		20.12	8.78				
	Girls	19.39	7.31		17.22	7.08		2.11	.49	2.68
Metal folding	Boys	19.91	7.56		21.53	8.19				
	Girls	21.12	6.75		19142	7.20		.18	.00	3.37
Figures	Boys	31.85	12.48		30.02	14.74				
	Girls	24.24	13.39		24.81	13.11		16.02[x]	.07	.45
Hands	Boys	23.08	14.04		23.50	16.93				
	Girls	15.32	14.14		18.19	15.40		12.78[x]	1.10	.44
Simple	Boys	6.21	2.15		6.33	2.24				
	Girls	5.80	2.24		5.69	2.60		3.49	.00	.17
Complex	Boys	2.29	1.65		1.86	1.53				
	Girls	2.35	1.48		1.94	1.53		.12	4.97[x]	.00
Descrip-tion	Boys	8.92	2.83		8.38	2.49				
	Girls	8.39	3.17		8.81	3.10		.04	.02	1.88

x significant at the .05 level

Table 4. Intercorrelations among the variables with the treatment groups divided according to sex. (Values for the NI treatment above the diagonal and values for the I treatment below the diagonal)

Boys	1	2	3	4	5	6	7	8	9
1 Opposites	-	.33	.52	.40	.28	.11	.20	.53	.48
2 RS 2	.66	-	.30	.06	.19	-.06	.20	.25	.21
3 Number series	.51	.48	-	.09	.21	.06	.32	.41	.43
4 Metal folding	.33	.20	.27	-	.46	.22	.16	.29	.32
5 Figures	.18	.24	.41	.43	-	.37	.07	.21	.26
6 Hands	.10	.14	.29	.17	.45	-	.03	-.04	.13
7 Simple	.51	.41	.36	.33	.28	.13	-	.48	.38
8 Complex	.54	.52	.37	.22	.15	.14	.51	-	.45
9 Description	.34	.23	.19	.27	.24	.10	.45	.43	-

Girls	1	2	3	4	5	6	7	8	9
1 Opposites	-	.37	.49	.38	.22	.04	.41	.47	.50
2 RS 2	.52	-	.02	.01	-.06	.04	.25	.36	.21
3 Number series	.56	.55	-	.61	.44	.14	.43	.23	.42
4 Metal folding	.67	.53	.46	-	.45	.30	.26	.12	.40
5 Figures	.36	.44	.36	.56	-	.29	.09	.01	.17
6 Hands	.07	.18	.15	.10	.30	-	-.01	-.10	-.15
7 Simple	.68	.61	.61	.58	.43	.24	-	.54	.45
8 Complex	.56	.44	.45	.53	.52	.13	.63	-	.52
9 Description	.60	.55	.56	.56	.48	.26	.62	.57	-

Table 5. Means and standard deviations on opposites and the dependent variables for groups obtained in the blocking and crossing of opposites (two levels) and Figures (three levels)

			Opposites				Simple				Complex				Description			
			NI		I		NI		I		NI		I		NI		I	
	NI	I	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
BOYS																		
1 Low Op. - Low Fig.	11	13	17.0	2.8	17.1	2.8	5.4	1.7	4.5	1.9	1.3	1.1	.6	.9	7.3	2.7	7.4	2.5
2 Low Op. - Middle Fig.	10	6	17.5	2.7	16.5	3.9	5.3	2.9	4.2	1.9	1.6	1.1	1.2	.8	7.5	3.7	7.2	2.8
3 Low Op. - High Fig.	12	12	17.7	3.2	18.1	2.4	6.3	2.4	6.7	2.1	1.6	1.5	1.3	1.6	9.2	2.1	8.3	1.8
4 High Op. - Low Fig.	5	8	24.8	1.9	26.3	3.7	7.2	1.5	7.1	2.1	3.6	.9	2.1	1.1	10.6	1.5	7.9	2.8
5 High Op. - Middle Fig.	11	14	25.0	2.2	25.9	4.2	6.9	1.6	7.6	2.1	2.8	1.9	3.3	1.4	9.6	2.7	8.8	2.9
6 High Op. - High Fig.	17	13	25.2	2.2	26.7	3.9	6.2	2.1	6.9	1.4	3.1	1.7	2.2	1.3	9.7	2.6	9.9	1.7
GIRLS																		
1 Low Op. - Low Fig.	24	20	17.2	2.7	14.2	3.5	4.8	2.1	3.8	1.9	1.8	1.2	.9	.8	6.9	2.6	6.8	3.2
2 Low Op. - Middle Fig.	16	15	17.5	2.9	17.1	3.1	5.6	2.4	5.5	2.2	1.8	1.3	1.6	.9	8.4	2.8	8.8	3.0
3 Low Op. - High Fig.	6	7	15.3	2.0	17.7	2.9	4.7	2.0	5.4	2.3	1.5	1.5	2.7	1.5	4.5	2.9	8.9	2.7
4 High Op. - Low Fig.	9	6	26.3	3.1	24.8	2.9	6.7	2.3	6.5	2.4	3.3	1.7	1.5	.5	10.1	2.1	8.5	1.9
5 High Op. - Middle Fig.	9	11	24.9	2.9	28.0	4.5	7.2	1.8	8.0	1.9	3.2	1.2	3.2	1.7	10.9	2.1	11.6	1.3
6 High Op. - High Fig.	11	5	25.5	4.3	26.8	4.3	7.0	1.3	8.2	2.4	3.1	1.4	4.0	1.7	10.4	2.8	11.2	1.3

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