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A Method of Analysis and Triadic Performance on a Complementary Task

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Abstract

An exploratory investigation into a complementary task situation in which the members partly shared the relevant information showed that (a) triads improved more on a retest than did individuals, (b) over all levels of initial ability, subjects working with at least one partner of greater ability improved more than did comparable subjects working with partners of only comparable and/or less ability or working alone, (c) for the high level, subjects working with one partner of comparable ability improved more than did high subjects working with partners of less ability or working alone, (d) for the medium level, subjects working with only one partner of comparable ability and the other of less ability did not improve more than medium subjects working with partners of less ability or working alone, and (e) over all levels, subjects working with partners of less ability did not improve more than comparable subjects working alone. The comparison of improvement based on the traditional absolute-gain scores and improvement based on the percent-gain scores indicated that the two improvement measures are equally sensitive for a test without a ceiling confound but with a specifiable maximum.

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Although the history of the experimental study of group performance is undeniably prodigious, a unified literature review is a rarity. The lack of an adequate taxonomy to classify the different types of tasks, the inadequate methods of assessing the quality of solutions to complex problems, and the deficient techniques for analyzing the problem solving process have influenced the accumulation of isolated research (Hoffman, 1965). Hoffman contended that suitable taxonomies, methods, and techniques must be developed antecedent to systematic manipulations and analyses of the factors which influence group performance. Furthermore, the effectiveness of the research on group performance has remained limited because of restraints on its external validity due to the lack of comparability between studies.

Steiner (1966) has suggested that group productivity is a function of four factors: (a) the nature of the task demands, (b) the relevant resources of the group members, (c) the motivational levels of each member regarding the task solution, and (d) the coordination patterns developed as the group proceeds with its work. Steiner then presented five models for inferring potential group productivity as a function of task demands and group size. The five models were: (a) the additive-task model, (b) the disjunctive-task model, (c) the conjunctive-task model, (d) the compensatory-task model, and (e) the complementary-task model (with either unshared or partly shared resources).

The potential utility of Steiner's taxonomy is considerable in light of Hoffman's declaration that the term "problem solving" itself "has been used with reference to tasks as varied as judging the number of dots briefly displayed on a large card, to providing answers to arithmetic reasoning problems, to solving complex problems faced by managements of large business organizations (p. 122-123)."

Steiner described the utility of the complementary task model as "designed to deal with cases in which the single individual performs only a part of a total task, while other persons, possessing different kinds of resources, perform the remaining parts (p. 280)." Stated another way, the complementary task situation allows for types of divisions of labor among the group members. Steiner's complementary model, which can be related to Model B of Lorge and Solomon (1955), predicts that the members of the group pool unshared information and thereby the group surpasses the performance of its best individual.

Steiner proceeded to formulate specific predictions for one type of complementary task situation in which the members partly share the relevant resources and the items "relevant to the solution of a problem ... are uncorrelated across the members of a large population (p. 281)." The model is useful, however, when studying all types of complementary task situations because Steiner indicated that the specific factor influencing the group scores is the degree of overlap of the partly shared information each brings into the problem-solving situation. Steiner has contended that totally unique information is probably rare and that partly shared information is likely to be the rule. A member's relevant resources are likely to be greatly shared and minimally unique when compared to the resources of members of comparable or greater levels, but a member's resources are likely to be a little less

shared and a little more unique when compared to the resources of members of a lesser level. Figure 1 depicts the theoretical degrees of shared and unique information for three levels of resources by means of Venn Diagrams.

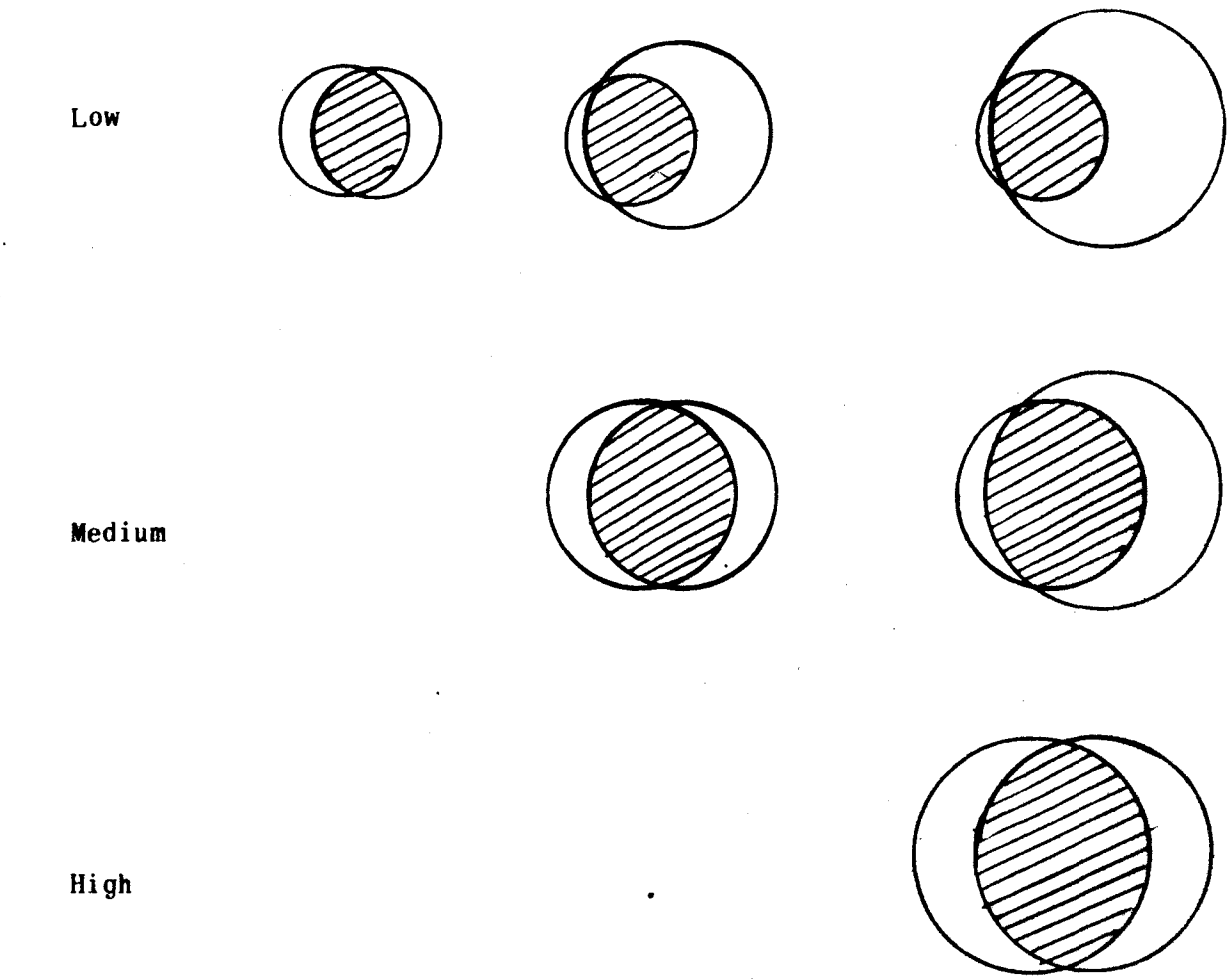
Goldman (1965) analyzed the absolute-gain improvement scores between individuals and dyads and between the six possible dyads formed from initially high, medium, and low scoring subjects on two administrations of equivalent forms of the Wonderlic Intelligence Test. Goldman's data showed that dyads performed better than individuals and also indicated that improvement in terms of absolute-gain is greatest for initially low scoring subjects.

Laughlin and Johnson (1966) suggested that the Goldman study was not an adequate exploration of a complementary task because the task utilized by Goldman (the Wonderlic Intelligence Test administered to college students under power conditions) had an inherent ceiling confound operating on the higher scoring subjects. Laughlin and Johnson essentially replicated the Goldman study with the Terman Concept Mastery Test (1956) to obviate the ceiling confound. The Laughlin and Johnson study provided considerable experimental evidence for a complementary task by showing that for all levels of resources, subjects working with partners of comparable or greater levels of ability improved more than subjects of the same level working alone, and subjects working with partners of lower levels did not improve relative to subjects of the same levels working alone. In the Laughlin and Johnson study, as was the case with the Goldman study, dyads improved more than individuals and improvement was inversely related to initial levels of resources when improvement was analyzed by means of the absolute-gain scores.

The present study sought to provide experimental data for a complementary task situation, but not specifically Steiner's complementary model because it

Figure 1

Venn Diagrams Depicting the Theoretical Degrees of Unique and Shared Information When Three Levels of Ability Pool Their Relevant Resources



Note. - The crosshatched areas represent shared information; the areas not crosshatched within the circles represent unique information.

contains an assumption which is unwarranted when employing a verbal task such as the Terman Concept Mastery Test. A second purpose was to compare the typical absolute-gain improvement measure and a percent-of-possible-gain improvement measure in a task with a specifiable maximum score but without a ceiling confound by means of performing the statistical analyses on all the predictions with both measures of improvement and thereby contrast the results. The basic hypotheses of the investigation, which had their conception in the concepts used by Steiner in the explanation of his complementary task model and which should be supported by both the absolute-gain analyses and the percent-gain analyses, were: (a) Over all levels of initial ability, triads will improve more on a retest than will individuals. (b) Triadic improvement will be inversely related to initial ability. (c) Over all levels of initial ability, subjects working with at least one partner of greater ability will improve more than will subjects of the same initial ability working with partners of only comparable and/or less ability or working alone. (d) Over all levels, subjects working with partners of comparable resources will improve more than will subjects of the same initial ability working with only one partner of comparable ability and the other of less ability, or working with two partners of less ability, or working alone. (e) Over the high level of resources, subjects working with one partner of comparable ability and the other of less ability will improve more than will subjects of the same initial ability working with partners of less ability or working alone. (f) Subjects in the middle level of initial resources working with only one partner of comparable ability and the other of less ability will not improve more than will subjects of the same initial ability working with partners of less ability or working alone. (g) Over all levels of resources, subjects working with partners of

less ability will not improve more than subjects of the same initial ability working alone.

Method

The method was similar to that of Laughlin and Johnson (1966). The subjects were 528 undergraduate students enrolled in various day and evening psychology and philosophy courses at Loyola University and Mundelein College. By means of adhering to the prepared instructions on the Terman Concept Mastery Test (Terman, 1956), 680 Ss were administered the first part of Form T of the test during regularly scheduled class periods with class sizes ranging from 12 to 81. The items of the first part of the Terman test require the identification of synonyms and antonyms. The items were originally selected to draw on a wide variety of concepts.

No time limits were imposed on the Ss, but everyone completed the part in 20 min. to 25 min. and turned in the answer sheets. Like-sexed groups of three were then formed at random. The triads were directed to complete the first part of Form T together, discuss each item, and reach a mutual solution to each item. Each triad recorded the answers on a single answer sheet. Again no time limit was imposed, but most groups were able to finish in 25 min. to 30 min. Control Ss in each class retook the first part of the test again as individuals.

On the basis of the initial scores, the Ss were divided into three categories. Those Ss who scored 27 or below were designated as low (L); those Ss who scored between 27 and 46 were designated as middle (M); those Ss who scored 46 or above were designated as high (H). The means for the Ss designated as L, M, and H were 17.1, 37.7, and 60.4, respectively. The total range for the Ss was 0 to 113 out of a maximum of 115 scored on a right minus wrong correction basis. The 13 conditions required in the study were: H, M, and L

Ss retaking the test on an individual basis, and triads representing all the possible combinations of resources (HHH, HHM, HHL, HMM, HML, HLL, MMM, MML, MLL, and LLL). The first 16 individuals were admitted into each of the three individual treatments and the first 16 triads were admitted into each of the triadic treatments.

An absolute-gain improvement score was obtained by subtracting each S's initial score from the final score of his group or his second score for those Ss who retook the test as individuals. The relative-gain improvement score, obtained by dividing the absolute-gain score by the difference between the maximum possible score (115) and the S's initial score and converting the decimal into a percentage, was called the percent-of-possible-gain improvement score. If, however, the absolute-gain was negative, then the percent-gain was considered logically to be zero.

Results

The improvement scores were analyzed in order to answer the following questions: (a) Do subjects working in triads improve their scores more than subjects working as individuals? (b) Is improvement a function of the subject's initial ability? (c) Is improvement a function of the partners' initial ability levels? (d) What are the relationships for improvement between a subject's initial ability and the partners' ability levels?

Analysis by means of absolute-gain improvement scores. The mean improvement scores for individuals and triads of H, M, and L initial performance levels are given in Table 1. Triads improved more than individuals beyond the .001 level of confidence, F (1, 522) = 26.81. The three levels of performance differed well beyond the .001 level of confidence, F (2, 522) = 35.63. The results of the Duncan Multiple-range Tests for unequal numbers of replications with Kramer's adaptation (Kramer, 1956) showed that initially low scoring subjects improved more than either M or H subjects beyond the .001 confidence level, and initially medium scoring subjects improved more than H subjects beyond the .001 level. The interaction between initial ability levels and condition (individuals or triads) was not significant. Stated differently, subjects working in triads improved significantly more than did subjects working as individuals; and improvement in triads was inversely related to initial ability levels, but improvement for individuals was curvilinearly related to initial ability levels.

The mean improvement scores for H, M, and L subjects when working with either HH, HM, HL, MM, ML, or LL partners, or when working alone are presented in Table 2. Row 1 of Table 2 gives the mean improvement scores for H subjects

Table 1

Mean Improvement Scores for H, M, and L Subjects Working as Individuals and in Triads

Subjects	High	Medium	Low
Working as Individuals	-0.44	7.38	5.75
	(N = 16)	(N = 16)	(N = 16)
Working in Triads	9.76	15.95	25.18
	(N = 160)	(N = 160)	(N = 160)

Table 2

Mean Improvement Scores for H, M, and L Subjects Working with Two Partners or as Individuals

Ss	Working with:						Working as
	HH	HM	HL	MM	ML	LL	Individuals
H	18.27	12.88	8.28	2.62	-1.31	-0.81	-0.44
	(N = 48)	(N = 32)	(N = 32)	(N = 16)	(N = 16)	(N = 16)	(N = 16)
M	37.75	24.75	27.06	11.58	4.28	1.88	7.38
	(N = 16)	(N = 32)	(N = 16)	(N = 48)	(N = 32)	(N = 16)	(N = 16)
L	51.88	43.94	38.28	22.19	19.53	6.06	5.75
	(N = 16)	(N = 16)	(N = 32)	(N = 16)	(N = 32)	(N = 48)	(N = 16)

retaking the test in all the possible conditions. The overall difference in row 1 was significant beyond the .001 confidence level, $\underline{F}$ (6, 169) = 12.00. Likewise, the overall differences in row 2 (for M subjects) and in row 3 (for L subjects) were significant beyond the .001 level of confidence, $\underline{F}$ (6, 169) = 30.21 and $\underline{F}$ (6, 169) = 54.45, respectively. Therefore, improvement was demonstrated to be a function of the partners' ability levels. The results of the Duncan tests between the 21 possible comparisons in row 1 (of H subjects working in the seven different conditions) are presented in Table 3. The results of the Duncan tests for row 2 and for row 3 are presented in Table 4 and Table 5, respectively. Tables 3, 4, and 5 aid in ascertaining the specific relationships for improvement in terms of the subject's initial ability and the partners' ability levels.

Table 3 shows that initially high scoring subjects working with partners of comparable ability improved more than subjects of the same initial ability working with only one partner of comparable ability and the other of less ability, or working with a dyad of less ability, or working alone; that initially high scoring subjects working with at least one partner of comparable ability improved more than H subjects working with partners of less ability or working alone (except for the H subjects working with a high partner and a low partner, who did not improve significantly more than the H subjects working with a dyad of mediums); that H subjects working with partners of less ability did not improve more than H subjects working alone.

Table 4 shows that initially medium scoring subjects working with at least one partner of greater ability improved more than did comparable subjects working with partners of comparable and/or less ability or working alone; that M subjects working with partners of comparable ability improved

Table 3

Levels of Significance of Comparisons by Duncan Multiple-range Tests for H Subjects in Seven Conditions

	H·HM	H·HL	H·MM	H-Ind.	H·LL	H·ML
H·HH	.05	.001	.001	.001	.001	.001
H·HM		NS	.01	.001	.001	.001
H·HL			NS	.05	.05	.05
H·MM				NS	NS	NS
H-Ind.					NS	NS
H·LL						NS

Note. - A cell heading like "H·HM" should be read as "a high person working with a high and a medium partner."

Table 4

Levels of Significance of Comparisons by Duncan Multiple-range Tests for M Subjects in Seven Conditions

	M·HL	M·HM	M·MM	M-Ind.	M·ML	M·LL
M·HH	.01	.001	.001	.001	.001	.001
M·HL		NS	.001	.001	.001	.001
M·HM			.001	.001	.001	.001
M·MM				NS	.01	.01
M-Ind.					NS	NS
M·ML						NS

Table 5

Levels of Significance of Comparisons by Duncan Multiple-range Tests for L Subjects in Seven Conditions

	L·HM	L·HL	L·MM	L·ML	L·LL	L-Ind.
L·HH	NS	.001	.001	.001	.001	.001
L·HM		NS	.001	.001	.001	.001
L·HL			.001	.001	.001	.001
L·MM				NS	.001	.001
L·ML					.001	.001
L·LL						NS

more than subjects of the same ability working with only one partner of comparable ability and the other of less ability, or working with partners of less ability, but did not improve more than M subjects working alone; that M subjects working with one partner of comparable ability and the other of less ability or working with both partners of less ability did not improve more than M subjects working alone.

Table 5 shows that initially low scoring subjects working with at least one partner of greater ability improved more than subjects of the same ability working with partners of only comparable ability or working alone. Furthermore, L subjects working with at least one partner of H ability improved more than L subjects working with partners of MM or ML abilities.

Analyses by means of percent-gain improvement scores. The means of the percent-gain improvement scores for individuals and for triads of H, M, and L initial performance levels are presented in Table 6. Triads improved more than individuals beyond the .001 level of confidence, F (1, 522) = 28.61. The three levels of performance differed just beyond the .01 confidence level, F (2, 522) = 5.55. The results of the Duncan tests showed that L subjects improved more than M subjects at the .05 level of confidence, that L subjects improved more than H subjects at the .01 confidence level, and that M subjects did not improve significantly more than H subjects. The interaction between initial ability and condition (individuals or triads) was not significant.

The percent-gain improvement means for H, M, and L subjects when working with all possible pairs or as individuals are presented in Table 7. The overall difference for H subjects (row 1) was significant well beyond the .001 level, F (6, 169) = 13.96. The overall difference for M subjects was also significant well beyond the .001 level, F (6, 169) = 34.27. Likewise, the

Table 6

Mean Percent-gain Improvement Scores for H, M, and L Subjects Working as Individuals and in Triads

Subjects	High	Medium	Low
Working as Individuals	0.0602	0.0941	0.0646
	(N = 16)	(N = 16)	(N = 16)
Working in Triads	0.1908	0.2108	0.2604
	(N = 160)	(N = 160)	(N = 160)

Table 7

Mean Percent-gain Improvement Scores for H, M, and L Subjects Working with Two Partners or as Individuals

Ss	Working with:						Working as
	HH	HM	HL	MM	ML	LL	Individuals
H	0.3168	0.2304	0.1781	0.0725	0.0410	0.0274	0.0602
	(N = 48)	(N = 32)	(N = 32)	(N = 16)	(N = 16)	(N = 16)	(N = 16)
M	0.4752	0.3126	0.3428	0.1562	0.0688	0.0582	0.0941
	(N = 16)	(N = 32)	(N = 16)	(N = 48)	(N = 32)	(N = 16)	(N = 16)
L	0.5149	0.4635	0.3893	0.2218	0.1970	0.0769	0.0646
	(N = 16)	(N = 16)	(N = 32)	(N = 16)	(N = 32)	(N = 48)	(N = 16)

overall difference for L subjects was significant well beyond the .001 level, F (6, 169) = 66.27. Again, improvement was demonstrated to be a function of the partners' ability levels. The results of the Duncan Multiple-range Tests between the 21 possible comparisons of H scoring subjects' improvement in the seven conditions are given in Table 8. The results of the Duncan comparisons for M subjects and for L subjects are presented in Table 9 and Table 10, respectively.

The only suggestive evidence that Table 8 indicates that Table 3 did not show is that H·HL had more improvement than H·MM. Hence, H subjects working with at least one partner of comparable ability did improve significantly more than H subjects working with partners of less ability, without exception, as measured by percent-gain scores.

The levels of significance in Table 9 did not differ at all from the levels of significance reported in Table 4.

The significance levels reported in Table 10 indicated the same relationships as the levels of significance in Table 5. The only difference in the two tables is that the percent-gain analyses showed the difference between the L·HM and the L·HL significant at the .05 level, whereas the absolute-gain analysis did not show this significant difference.

Comparison of absolute-gain and percent-gain analyses. A comparison of the significance levels obtained by the Duncan Multiple-range Tests which differed as a function of the type of gain score used is presented in Table 11. In four out of the eight instances, the percent-gain score yielded a more confident level of significant difference. In two instances (comparing the improvement of L·HM with the improvement of L·HL, and comparing the H·HL with the H·MM), the percent-gain analysis showed the expected significant differ-

Table 8

Levels of Significance of Percent-gain Comparisons by Duncan Multiple-range Tests for H Subjects in Seven Conditions

	H·HM	H·HL	H·MM	H-Ind.	H·LL	H·ML
H·HH	.05	.001	.001	.001	.001	.001
H·HM		NS	.01	.01	.001	.001
H·HL			.05	.05	.01	.01
H·MM				NS	NS	NS
H-Ind.					NS	NS
H·LL						NS

Table 9

Levels of Significance of Percent-gain Comparisons by Duncan Multiple-range Tests for M Subjects in Seven Conditions

	M·HL	M·HM	M·MM	M-Ind.	M·ML	M·LL
M·HH	.01	.001	.001	.001	.001	.001
M·HL		NS	.001	.001	.001	.001
M·HM			.001	.001	.001	.001
M·MM				NS	.01	.01
M-Ind.					NS	NS
M·ML						NS

Table 10

Levels of Significance of Percent-gain Comparisons by Duncan Multiple-range Tests for L Subjects in Seven Conditions

	L·HM	L·HL	L·MM	L·ML	L·LL	L-Ind.
L·HH	NS	.001	.001	.001	.001	.001
L·HM		.05	.001	.001	.001	.001
L·HL			.001	.001	.001	.001
L·MM				NS	.001	.001
L·ML					.001	.001
L·LL						NS

Table 11

Comparisons of Significance Levels

of the Duncan Tests When Different

Comparison	Based on absolute-gain scores	Based on percent-gain scores
H : M	.001	NS
H : L	.001	.01
M : L	.001	.05
H·HM : H-Ind.	.001	.01
H·HL : H·MM	NS	.05
H·HL : H·ML	.05	.01
H·HL : H·LL	.05	.01
L·HM : L·HL	NS	.05

ence while the absolute-gain analyses showed no difference in improvement. In the three comparisons attempting to ascertain whether improvement is inversely related to initial ability in triads, the percent-gain analyses diminished the confidence of this assertion, and in one instance (the comparison of the H subjects with the M subjects) the percent-gain analysis showed no significant difference in improvement.

Analyses of second-test performance. The means for each of the 13 conditions on the second administration of the test are given in Table 12 in their rank order. The overall difference between the 13 conditions was significant well beyond the .001 level of confidence, F (12, 515) = 113.47. The results of the Duncan tests between the 78 possible comparisons are presented in Table 13.

Table 12

Mean Scores on Second Administration of Terman Concept Mastery Test for H, M, and L Individuals and Triads

HHH	HHM	HHL	HML	HMM	H	HLL	MMM	M	MML	MLL	L	LLL
79.94	73.88	66.94	63.75	61.06	59.81	55.50	47.94	42.06	39.44	37.38	25.12	21.62

Table 13

Levels of Significance of Comparisons by Duncan Multiple-range Tests for the 13 Ability Conditions

	HHM	HHL	HML	HMM	H	HLL	MMM	M	MML	MLL	L	LLL
HHH	.01	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
HHM		.01	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
HHL			NS	.05	.05	.001	.001	.001	.001	.001	.001	.001
HML				NS	NS	.001	.001	.001	.001	.001	.001	.001
HMM					NS	.05	.001	.001	.001	.001	.001	.001
H						NS	.001	.001	.001	.001	.001	.001
HLL							.001	.001	.001	.001	.001	.001
MMM								NS	.001	.001	.001	.001
M									NS	NS	.001	.001
MML										NS	,001	.001
MLL											.001	.001
L												NS

Discussion

Absolute-gain versus percent-gain improvement measures. As the Laughlin and Johnson study (1966) demonstrated, when an experimental design contains a ceiling confound hindering the adequate exploration of a group problem solving situation, then the adequate exploration necessitates the utilization of a task which produces (a) more normally distributed first test scores and (b) allows sufficient opportunity for the initially high scoring subjects to improve. The present study, while permitting the adequate exploration of triadic performance according to the two criteria above, was designed to ascertain if a differential sensitivity between the two measures of improvement is evidenced.

The question of a possible differential sensitivity is as much a logical question as it is an empirical problem. The most cogent logical defense of the percent-gain improvement score is that it is difficult to concede that in a test with a maximum score of 115, a gain from 90 to 95 is only as significant as a gain from 15 to 20 (as the absolute-gain improvement score indicates). However, a gain from 90 to 95 (a 20% gain: 95 - 90 ÷ 115 - 90 = 0.20 or 20%) appears definitely superior to a gain from 15 to 20 (a 5% gain: 20 - 15 ÷ 115 - 15 = 0.05 or 5%), but a gain from 15 to 35 (a 20% gain) appears equal to the 90 to 95 gain. Empirical support on behalf of the percent-gain score is that the results of the present study offered more unequivocal confirmations of the theoretical predictions when the empirical data are based on the percent-gain measures than when based on the absolute-gain scores, as Table 11 indicated.

However, the empirical results indicated a high degree of correspondence between the two measures. In fact, the levels of significance were discrepant

in only eight instances when contrasting the two measures in 126 comparisons, and only three of these eight discrepancies were questions of a significant difference versus a difference which was not significant.

Upon examination of three of these discrepancies, the results indicated that the absolute-gain improvement measures yielded an inverse relationship for improvement as a function of the subject's initial ability, with the improvement of H subjects significantly different from the improvement of M or L subjects and M subjects significantly differing from L subjects, all at the .001 level of confidence. This finding, collaborated by the Laughlin and Johnson study, is in accordance with the theoretical prediction because (a) a low ability person has more likelihood of working with at least one partner of greater ability than does a medium ability person, who in turn has more likelihood of working with a partner of greater ability than does a high ability person; and because (b) the L subjects have a greater absolute number of items on which to improve than do M and H subjects, and M subjects in turn have a greater absolute number of items on which to improve than do H subjects. On the other hand, the percent-gain improvement analyses yielded less support for improvement as an inverse function of the subject's initial ability, with the improvement of H subjects not significantly different from the improvement of M subjects, but significantly different from L subjects at the .01 level, while the M subjects improved more than L subjects at the .05 level. Although these findings with the percent-gain measure are somewhat adverse to the findings with the absolute-gain measure and with the theoretical prediction, the data are extremely logical because, while the first reason above dealing with the likelihood of working with a partner of greater ability is still valid, the second reason is invalidated by the mathematical manipulations performed

in obtaining the percent-gain scores, which are the measures of relative improvement. Improvement as an inverse function of the subject's initial ability can analogously be considered as an interaction between the differential probability of working with at least one partner of greater ability and the absolute number of items a subject can improve on. Therefore, the examination of two of the minor discrepancies (differences in the level of significance obtained) and one of the major discrepancies (differences between a significant difference and one that is not) between the two measures of improvement has expanded the understanding of improvement as a function of the subject's initial ability and the partners' abilities, but it has not indicated that either of the two measures is more sensitive than the other. The examination has merely indicated that in this area, the absolute-gain measure reflects a factor that by definition the percent-gain measure does not reflect.

Therefore, an examination of the other five discrepancies between the two measures is essential. In two instances (comparing the improvement of L·HM with the improvement of L·HL and H·HL with H·MM), the percent-gain measures yielded a significant difference in accordance with the theoretical predictions while the absolute-gain measures did not. In two other instances (comparing the improvement of H·HL with H·ML and H·HL with H·LL), the percent-gain scores yielded a more confident level of significant difference in accordance with the predictions; but in the last instance (comparing H·HM with H-Ind.), the percent-gain scores produced a less confident level of significant difference. Accordingly, in only two out of 126 comparisons did the percent-gain measure show itself as a more sensitive index of improvement.

Hence, it is logical to conclude that a differential sensitivity between the two measures was not evidenced. The researcher's dilemma then is to decide

which measure is more appropriate for his purposes. If the experimental manipulations are to be aptly generalized to an educational setting where the criterion of improvement would be relative, then the experimenter would use the percent-gain index. If the question is concerned with absolute improvement, as in industrial situations, then the absolute-gain analyses are in order.

Triadic performance. The two unequivocal findingsof this study are that triads improve more on a retest than do individuals, and that a person's improvement is a function of the partners' abilities. Although these findings are not unexpected, this study has lent itself to the task of specifying the conditions for an individual's improvement when working in a triad on a complementary task when both the subject's and the partners' abilities can be specified. These specific conditions can be summarized as follows: (a) H subjects working with at least one partner of comparable ability improve more than H subjects working with partners of less ability or working alone, but H subjects working with partners of less ability do not improve more than H subjects working alone. (The absolute-gain data would have to make an "exception" to the above statement, based on the difference between the H·HL improvement and the H·MM improvement which was not significant.) (b) M subjects working with at least one partner of greater ability improve more than M subjects working with partners of comparable and/or less ability or working alone; M subjects working with two partners of comparable ability improve more than M subjects working with at least one partner of less ability (and the other of comparable ability), but not more than M subjects working alone; and M subjects working with at least one partner of less ability (and the other of comparable ability) do not improve more than M subjects working alone. (c) L subjects working with at least one partner of greater ability improve more than L sub-

jects working with partners of comparable ability or working alone; but L subjects working with partners of comparable ability do not improve more than L subjects working alone.

Stated from a different point of reference, a subject working with at least one partner of greater ability will always improve more than the subject would by working with partners of comparable or less ability or working alone. And subjects working with partners of comparable ability will only improve more than the subject could by working alone if the triad is composed of all high ability subjects. The most succinct way of summarizing the results is: Work with at least one higher partner, or else work alone.

The results of this exploratory investigation were in complete accordance with five of the predictions, while lending partial support to the other two predictions.

The first prediction (that over all levels of initial ability, triads will improve more on a retest than will individuals) was unequivocally supported. Triads had the opportunity to pool their relevant resources, while individuals did not.

The second prediction (that triadic improvement will be inversely related to initial ability) was supported by the absolute-gain analyses, but not as completely by the percent-gain analyses, as explained in the first part of the discussion.

The third prediction (that over all levels, subjects working with at least one partner of greater ability will improve more than will comparable subjects working with partners of comparable and/or less ability, or working alone) was also supported in every instance. This prediction was based on the logical supposition that subjects working with a partner of greater resources

has a better opportunity to capitalize on the unique resources of this partner, whereas the possibility of as great a quantity of unique resources coming from partners of comparable or less resources is greatly diminished.

The fourth prediction (that over all levels, subjects working with partners of comparable ability will improve more than will subjects of the same initial ability working with only one partner of comparable ability and the other of less ability, or working with partners of less ability, or working alone) was demonstrated with the high ability subjects. However, while the medium subjects working with a pair of medium partners did improve more than medium subjects working with a medium-low pair or a low-low pair, a triad of mediums did not improve more than the medium individuals. Likewise, a triad of low resource subjects did not improve more than the low individuals. The most plausible explanation of this phenomenon is that, as Laughlin and Johnson indicated, there is even less unique information among the medium and the low subjects than anticipated. Relating this to the Venn Diagrams of Figure 1, then, any pair of circles representing the resources of either medium or low ability persons should be constructed to approach even more concentricity or homogeneity, thereby indicating a greater degree of shared information.

The fifth prediction (that for the high level of resources, subjects working with one partner of comparable resources and the other of less ability will improve more than will comparable subjects working with partners of less ability or working alone) was unequivocally supported. Likewise, the sixth prediction (that for the medium level of ability, subjects working with only one partner of comparable ability and the other of less ability will not improve more than comparable subjects working with partners of less ability or working alone) and the seventh prediction (that over all levels, subjects working with

partners of less ability will not improve more than subjects of the same initial ability working alone) were both completely supported. The explanation of all three predictions rests in the accurate understanding of the degree of overlap of information and the degree of unique information which the members of a specific triad bring into the group problem solving situation.

Discussion of whether this study can be considered as support for Steiner's model. Although Laughlin and Johnson interpreted their results as supporting the Steiner model of a complementary task with partly shared information, the author maintains that the Terman Concept Mastery Test cannot comply with the explicit assumption of Steiner's model, namely, that the items "relevant to the solution of a problem ... are uncorrelated across the members of a large population (p. 281)." A task identifying synonyms and antonyms does not adhere to this assumption because those items with a low degree of difficulty will be passed by a large percentage of the members of the population by definition and those items with a high degree of difficulty will be passed by a much smaller percentage, thereby evidencing a systematic correlation between items relevant to the solution and members of the population when categorized by initial ability level -- a prima facie violation of the assumption stated by Steiner. Therefore, the Laughlin and Johnson study and the present study should not be interpreted as unequivocal support of the Steiner model, but rather both should be considered as explorations into a complementary-task-with-partly-shared-information situation analogous to Steiner's model. And finally, therefore, the need for more complete taxonomies of problem solving tasks is again evident.

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APPROVAL SHEET

The thesis submitted by Mr. Laurence G. Branch has been read and approved by the director of the thesis. Furthermore, the final copies have been examined by the director and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

September 26, 1968
Date

Patrick R. Laughlin
Signature of Advisor