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INDIVIDUAL VERSUS TRIADIC PERFORMANCE ON A MULTIDIMENSIONAL COMPLEMENTARY TASK AS A FUNCTION OF INITIAL ABILITY LEVEL

by

Laurence G. Branch

A Dissertation Submitted to the Faculty of the Graduate School

of Loyola University in Partial Fulfillment of

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Life

Laurence G. Branch was born on October 31, 1944, in Cleveland, Ohio. He attended St. Robert Grade School in Shorewood, Wisconsin, from 1950 to 1958. He attended Marquette University High School in Milwaukee, Wisconsin, from 1958 to 1962, graduating in June, 1962. For undergraduate work, he attended Marquette University (the extension in St. Bonifacius, Minnesota) from 1962 to 1964; the University of Wisconsin in Milwaukee from 1964 to 1965; and Marquette University in Milwaukee from 1965 to 1967, from which he graduated in June, 1967, with the degree of Bachelor of Arts and a major in psychology.

The author began his graduate studies at Loyola University in September, 1967, and obtained the degree of Master of Arts in February, 1969.

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Abstract

The hierarchical model proposed by Laughlin, Branch, and Johnson for predicting group performance on a unidimensional complementary task by an explicit consideration of the differential relevant resources of the group members was tested in a multidimensional complementary task situation with group size of three. The explicit tenents of the unidimensional model are: (a) The unique or unshared resources of the group members of equal ability levels can be combined to produce greater performance than the members of the same ability level could do either alone or with a smaller number of comparable ability members, except for the low ability members where the overlap of resources seems to be virtually complete. (b) A person of greater task relevant resources possesses all the resources of a person of less resources. (c) The shared or nonunique resources of members of comparable ability decrease as the level of relevant resources increases.

From these tenents, the predicted order of improvement for each ability level was: High: H·HH (a high working with two high partners) > (H·HM = H·HL) > (H = H·MM = H·ML = H·LL); Medium: M·HH > (M·HM = M·HL) > M·MM > M.ML > (M = M·LL); Low: L·HH > (L·HM = L·HL) > L·MM > L·ML > L·LL = L. The predicted order of absolute second-administration performance for the 13 conditions was: HHH > (HHM = HHL) > (H = HMM = HML = HLL) > MMM > MML > (M - MLL) > LLL = L. The predicted order of performance of comparable ability triads less their controls across levels was: (HHH - H) > (MMM - M) > (LLL - L).

231 male and 231 female college students completed the "Moon Problem" task as individuals and were trichotomized as high (H), medium (M), or low (L) ability on the basis of their scores. They then retook the problem

either alone or with two partners in one of the ten possible ability combinations of triads (HHH, HHM, HHL,... LLL).

The results indicated that the unidimensional model was accurate in 63% of its predictions in the present study, whereas the model had been accurate on 91% of its predictions for triadic performance on a unidimensional task. Furthermore, the results lead to the following reappraisals of the model when applied to a multidimensional task situation: (a) The assumption that lower ability members cannot hinder the performance of the group appeared less tenable. (b) The tenent that higher ability members possess all the relevant resources of lower ability members was questionable. (c) The tenent that the level of unique resources is directly related to the level of resources was not supported. (d) The implication of the model that the unique resources of three members of the highest level of resources in a triad should exceed the pooled unique resources of two comparable ability members in a triad, who in turn should exceed the unique resources of one comparable ability member in a triad was not supported, indicating that the level of unique resources is less in a multidimensional task than was found in a unidimensional task. (e) The finding in unidimensional task studies that the level of unique resources at the lowest level was so minimal as to obviate the increase in performance of three L's relative to the performance of a single L working alone was not supported for the multidimensional task situation; the level of unique resources at the low level allowed three L's to exceed an L working alone. (f) The implication of the unidimensional model that the pooled unique resources of lower ability members did not exceed the resources of a higher ability member was questionable.

INDIVIDUAL VERSUS TRIADIC PERFORMANCE ON A MULTIDIMENSIONAL COMPLEMENTARY TASK AS A FUNCTION OF INITIAL ABILITY LEVEL

Laurence G. Branch

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The history of the experimental analysis of problem solving is prodigious and the approaches varied. The phenomenon of problem solving is very similar to and often indistinguishable from decision making, concept formation, productivity, and even the basic operant learning paradigm itself. Common to all of these phenomena is the paradigm: the subjects, with all their varied personal characteristics, are in a stimulus situation which is controlled by the experimenter and the salient characteristics of which are communicated to the subject in some manner, and the subject then makes what seems to him to be the appropriate response, while the correct behavior is reinforced or at least ascertainable (by the experimenter if not also by the subject). Countless studies have been done within this paradigm, some using animals, others using humans, some focusing on the individual, others concerned with the group. Among those studies using human groups, as the present study did, three segments of the total problem solving situation have been emphasized: (a) the group structure, or the communication patterns, coalitions, attractions, and power differentials which evolve or are assigned during problem solving (Collins and Raven, 1969; Shaw, 1964; Gamson, 1964; Lindzey and Byrne, 1969); (b) the group process, or the activities that take place between the subjects' understanding of the task demands and the task responses, which can include considerations of leadership

(Gibb, 1969a; Gibb, 1969b; Fiedler, 1964), considerations of phases within the process (Bales and Strodtbeck, 1968), considerations of the approaches or working norms of the members (Smoke and Zajonc, 1962; Restle and Davis, 1962); and more tangentially but nevertheless with probable significance, considerations of the motivations of the group members, their attitudes, personality, and ability to perceive the intentions of the others members accurately, to mention just a few; and (c) the group product, or the specific task related output or responses.

Within the area of research concerned with the products of human problem solving groups, three approaches can be considered. First, the approach of devising rational models and *post hoc* models designed to understand problem solving groups has been used. This orientation relied heavily on the assumption that understanding the group process or the working norms of the group was essential to predicting the group product. In accordance with this orientation then, Smoke and Zajonc (1962) maintained that predicting group performance or the product is a function of the working norms for reaching a decision within the group, and therefore proposed the following rational models for reaching a decision in small groups: (a) the Dictatorship model, in which the group response is solely a function of one member's decision; (b) the Oligarchy model, in which a few members of the group make the decisions for the whole group; (c) the Unanimity model, in which the group response reflects the total agreement of all the members; (d) the Fixed model, in which some specified number of group members must agree on a response alternative in order for that alternative to become the group's response; (e) the Quorum model, in which the group response reflects a mandate from at least some specified number of the members; (f) the Minimal Quorum model, in which a response alternative is adopted if at least one member of the group advocates it; and (g) the Independent model, in which the group response is independent of the individual members, but rather is a function of some external criterion or authority. The researcher's control, then, over which decision model the group operates within greatly increases his predictive power of the group product.

In this same general approach, Restle and Davis (1962) proposed two rational models of group process that could be used to predict group product: the Equalitarian model, in which each member of the group has an equal part in the group product regardless of differential abilities; and the Hierarchical model, in which the group forms an intellectual hierarchy that gives preeminence to the members with relevant abilities.

The common points of the rational model approach are that the models are generally intuitive, concerned with the group process as a means to understanding the group product, and typically not designed to make specific predictions concerning group product.

The second basic approach to group problem solving products was to determine which independent manipulations aided the group in its performance and which independent manipulations hindered the group. N. R. F. Maier (1967) summarized the findings resulting from this approach. Enumerating the assests of the group, by which the group is therefore potentially more productive than an individual, Maier lists: (a) a greater sum total of knowledge and information in the group; (b) participation in the problem solving increases the acceptance of the solution; (c) a greater number of approaches to the problem exist within the group; and (d) participation likewise increases comprehension of the resultant decision. The liabilities of a group, according to Maier, are: (a) social pressures leading to conformity that can stifle minority suggestions and discussions; (b) once some form of consensus has been reached and reached independently of the quality of the solution, subsequent high quality solutions are not considered (a phenomenon which has implications for public opinion manipulators); (c) individual domination, which is generally unrelated to problem solving ability; and (d) conflicting secondary goals like winning the argument or having your view accepted solely because it is yours. Finally, Maier listed those factors which can be either an asset or a liability depending upon how the group uses them: (a) disagreement, which can produce either innovation or strained feelings; (b) conflicting interests, which can lead different members to focus on different aspects of the task, which in turn can lead either to a higher quality total solution or miscommunication; (c) risk taking, the results of which can only be judged in terms of whether the greater risk advocated by the group leads to increased performance or not; (d) time requirements; and (e) a consideration of who changes, for if the high problem solving ability member changes, the group is hindered; whereas if the low ability member changes, the group is aided.

The third basic approach reflects a vigorous experimental examination of the factors which affect group product, with a greater concern for predicting group product than was found in the first approach and with less concern for maximizing group performance than was evidenced in the second approach. This experimental approach emphasizes the prediction of the group product under specific conditions. Many researchers have contributed significant findings within this experimental approach, and occasionally from slightly differing orientations. However, all the findings can be molded easily into the framework proposed by Steiner (1966).

Steiner (1966) contended that potential group productivity is a function of (a) the nature of the task, (b) the size of the group, (c) the coordination patterns that develop in the process, (d) the motivational factors of the members, and (e) the relevant resources of the members. Potential group productivity or product, then, is equal to actual group productivity plus that segment which has been lost due to faulty processes or inefficiencies within the group.

Steiner then proceeded to taxonomize the task variable. He included (a) the additive task, in which all the members perform the same function, as in pulling on a rope; (b) the disjunctive task, in which all the members again perform the same function, but the outcome is not the joint product but rather is a function of the most competent member, as in the mathematical puzzles in which all the members perceive the solution as soon as one member discovers and describes it; (c) the conjunctive task, in which all the members again perform the same function, but the outcome depends upon the least competent member, as in a mountain climbing task in which the group is only as successful as its least competent climber; (d) the compensatory task, in which all the members again perform the same function, but the group outcome is the mean of all the individual outcomes, as in determining the percentage of adults who smoke, in which few individuals estimate correctly but the mean of all the estimates is very nearly correct; and (e) the complementary task with either unshared resources, as in the "Jack-Sprat" nursery rhyme in which the group members divide the labor and no overlap of proficiency exists, or the complementary task with shared resources, as in the business task of preparing a budget, in which each member with overlapping proficiencies completes a segment of the task.

The second of Steiner's variables which affect the group product is group size. While no systematic studies have been conducted using group size as an independent variable, certain considerations are necessary. For example, the findings of Asch (1965) that only three confederates were necessary to produce maximum compliance in naive subjects has application to group size of four or more. Indeed, Laughlin and Branch (unpublished) have reported evidence that conformity pressures by low ability members can hinder the maximization of group performance. Furthermore, to the extent that a lesser amount of compliance can be produced by two or even one confederate, this factor must be considered.

The third variable outlined by Steiner is the differential coordination patterns that develop during the process of problem solving. These patterns, already mentioned in the preceding pages under the heading of the first segment of the problem solving phenomenon receiving emphasis, have been demonstrated to be significantly related to problem solving. Specifically, Bavelas (1968) and Shaw (1964) have both independently demonstrated that centralized or channelized communication networks imposed upon the group yielded less satisfaction among the members for all tasks but increased production on very simple tasks; whereas the decentralized or open communication networks yielded greater satisfaction among the members and facilitated solutions to complex tasks. Shaw interpreted these findings in terms of an independence-saturation hypothesis; namely, that the decentralized nets allowed all the members to feel independent, which acted as a morale booster, and that these nets only hindered the productivity when the members had a saturation of messages.

Related to this factor of coordination patterns that develop within the group is the phenomenon referred to by Collins and Guetzkow (1964) as the maintenance system, by Homans (1950) as the internal system, by Bales (1958) as the equilibrium problem, and by Roby and Lanzetta (1958) as group output activities. Basically, all the above researchers were referring to the phenomenon that as the group proceeds to respond to the units of the external task itself and to be reinforced for the correct response to the various subparts of the task, invariably interpersonal or internal or maintenance problems arise. In order for the members to continue to be productive on the external task itself, the internal problems must be resolved. This resolution is therefore a factor within the coordination patterns-variable. This same factor has received attention from Fiedler (1964) from the orientation of the functions of the leader. Fiedler contended that a task function must be performed (which is directing the energies of the members to the external task itself) and that a maintenance function must be performed for the group to respond effectively.

Yet another factor related to the coordination variable is the aforementioned working norms of the group members themselves. If the members operate under equalitarian norms (Restle and Davis, 1962) and thereby allow each member to equally share the working time of the group as opposed to the hierarchical norms in which those group members with greater relevant resources are given preeminence, then the group product is decreased due to the coordination variable.

The fourth variable mentioned by Steiner as influencing the group product is the motivation of the members. As was mentioned in the review of Maier's article (1967), differential susceptibility to conformity pressures had a bearing on group productivity. Again, however, as was the case with the group size variable, no systematic experimental work has been done on the factor directly relating to group productivity, but certain tangential considerations are necessary. For example, the majority of research on group problem solving assumed that the members have a cooperative motive, but in those instances where this assumption does not appear warranted, the investigator is well advised to search the literature on mixed motives (Vinacke, 1969).

The final variable affecting group performance included by Steiner is the ability level of the members. According to Steiner, the effects of ability must be considered in connection with the specific type of task. In an additive task, potential group performance is simply the sum of the individual abilities; in the conjunctive task, potential performance is simply equal to the ability of the least competent member; in the disjunctive task, equal to the ability of the most competent; and in the compensatory task, equal to the mean ability of all the members. In the complementary task with partly shared resources, however, each member of the group is assumed to possess some uncorrelated information which is relevant to one or more of the subtasks, and to the extent that the group pools unique or unshared resources, the group is able to surpass the productivity of its most competent member; and the potential group productivity therefore increases as a function of the group size.

In an investigation of Steiner's concepts and the complementary task model, Laughlin, Branch, and Johnson (Laughlin and Johnson, 1966; Laughlin, Branch, and Johnson, 1969; Laughlin and Branch, unpublished) have reported a series of studies in which they have demonstrated the effects of initial relevant resources upon subsequent performance of dyads, triads, and tetrads on a unidimensional complementary task. This series of studies used the Terman Concept Mastery Test (Part 1) as a unidimensional complementary task to directly test the predictions of Steiner's model. This task requires the identification of synonyms and antonyms. Because each pair of words can be considered as a subtask and because those members of the group who possess relevant information about the determination of a given subtask can contribute to that given subtask, the task can therefore be considered complementary. From another point of view, a division of the task into subtasks consisting of pairs of words is possible, and a division of labor among those who possess relevant information is possible, therefore the task meets the criteria of complementarity. Furthermore, the task can be considered unidimensional because its determination requires only verbal ability.

The findings from the Laughlin, Branch, and Johnson series supported Steiner's contention that the group can pool their unshared resources and thereby surpass the performance of its most competent member. However, the design of the series allowed the formulation of an extended model of group performance on a unidimensional complementary task. The model as proposed contained three implicit assumptions and three explicit tenents. The three assumptions are: (a) the groups will respond to maximize their performance; (b) the groups can recognize the differential resources of its members and will give preeminence to the higher ability members; and (c) the lower ability members do not hinder the performance of the group. The tenents of the model are: (a) the unique or nonoverlapping resources of the members of equal ability levels can be pooled to produce greater productivity than a member of comparable ability could do alone or with a smaller number of equal ability members (except at the lowest level of ability, where the data of the Laughlin, Branch, and Johnson series demonstrated that the amount of unique resources is so minimal as to obviate the pooling of any unique information, such that the performance of a dyad, triad, or tetrad of low ability members is not significantly greater than the performance of a single low member); (b) a person of greater resources possesses all the information of a person of less resources; and (c) the overlap of resources which represents the shared or nonunique resources of members of comparable ability decreases as the level of relevant resources increases; or from the other point of view, the unshared or unique resources of members of comparable ability increase as the level of ability increases.

The results of the Laughlin and Branch (unpublished) experiment demonstrated that the third assumption (that lower ability members do not hinder the performance of the group) was invalid in certain specific instances in which the group size was increased to four and three low ability members were working with a single high ability member.

The application of these tenents lead to predictions of both the absolute level of group performance and of the improvement of a member within a group. Consider the following predictions of triadic performance.

The absolute level of group performance. On the basis of the second tenent (that a person of greater resources possesses all the resources of a lower ability member) which means that a medium (M) and/or a low (L) resource person cannot aid the performance of a triad containing a high (H) resource person, and on the basis of the third assumption (that lower ability members do not hinder the performance of higher ability members either): HMM = HML =

HLL = H-alone. And by the same reasoning that a L member can neither aid nor hinder a group with a M member as its most competent member, MLL = M-alone. Furthermore, on the basis of the preceding and on the basis of the first tenent (that the unique resources of members of comparable ability can be combined to surpass the performance of a comparable person working alone or with a smaller number of comparable partners), which means that three H's will exceed two H's in a group who in turn will exceed one H, and similarly for M's: HHH > HHM = HHL > HMM = HML = HLL = H-alone > MMM > MML > MLL = M-alone > LLL = L-alone (because the low members possess minimal unique information, as indicated before).

Improvement as a function of the partners. Again, on the basis of the second tenent (that a higher ability person possesses all the resources of a lower person) and because a lower person does not hinder a higher person: H·MM (the improvement of a high member working with two medium partners) = H·ML = H·LL = H-alone. That is, partners of lesser ability do not aid a member in improvement, nor do they hinder him. Similarly, because of the two preceding reasons and because of the first tenent allowing comparable ability members to pool their resources, a member working with two high partners will improve more than a comparable member working with only one high partner, and so forth. Thus, for H members: H·HH > H·HM = H·HL > H·MM = H·ML = H·LL = H-alone. For M members: M·HH > M·HM = M·HL > M·MM > M·ML > M·LL = M-alone. For L members: L·HH > L·HM = L·HL > L·MM > L·ML > L·LL = L-alone.

At the risk of redundancy but to insure that the application of the assumptions and tenents is adequately comprehensible, the explicit formulation of some of the above predictions follows. For example, M·HM is predicted equal to M·HL because the H member in each triad possesses all the resources of the lesser ability members, and therefore it is inconsequential whether the third member is M or L. For another example, L·HL > L·MM > L·ML was predicted because the H member in the first triad possesses more resources than any member in the other two triads, hence the L·HL will improve more than a L not working with a H; and the L·MM will exceed the L·ML because the highest level of resources in both triads is medium, and therefore the triad with two M's has more unique information to pool together than a triad with only one M.

It is salient at this point to question whether the unique resources that two M's can pool together might exceed the resources of one H. The answer is that the Laughlin, Branch, and Johnson series empirically demonstrated that in fact two M's did not exceed one H in a unidimensional complementary task.

The final prediction of the model is based on the third tenent. Because the unique resources which can be combined in a triad increase as the ability level of the triad increases, it is predicted that the unique resources of three H's should exceed the unique resources of three M's, which in turn should exceed the unique resources of three L's. A conservative test of this tenent compares the score of three H's minus the score of H-individual, which reflects the shared resources of all three H's plus the three parts of unique information minus the shared resource component and the unique resource component of the H-individual, with the score of three M's minus M-individual, in turn compared with three L's minus L-individual: HHH - H > MMM - M > LLL - L.

For triads working on a unidimensional complementary task (Laughlin, Branch, and Johnson, 1969), this model was accurate in its predictions of improvement in 57 out of 63 specific comparisons (91%), in its predictions of group performance in 71 out of 78 comparisons (91%), and in its predictions of increasing unique information as ability increases. For tetrads, (Laughlin and Branch, unpublished), its predictions of improvement were accurate in 145 out of 165 comparisons (88%), its predictions of group performance were accurate in 124 out of 153 comparisons (81%), and its prediction of increasing unique information as ability increases was accurate.

The goal of the present study was to empirically test the predictions of the unidimensional complementary task model for triads working on a task that in some respects can be considered multidimensional. A multidimensional task requires the utilization of more than one dimension of ability or knowledge or resources for the solution. For example, playing hockey can be considered a multidimensional task because it requires the ability to skate well, the ability to control the puck, and the knowledge of what the other players intend to do. So from one point of view, because there are some people who can skate well, but not control the puck or know what other hockey players can be expected to do, the task can be considered to reflect at least three distinct dimensions. The epistemological problem, however, is that it is equally justifiable to maintain that the task of playing hockey reflects simply the ability to play hockey - a simple, single dimension. This problem is complicated for some laboratory tasks, in which the distinct dimensions that one researcher points to are nevertheless all cognitive abilities, so that another researcher can maintain that the task simply reflects general cognitive ability. With this epistemological problem unresolved, the present study nevertheless used a task which can be considered multidimensional from an intuitive basis.

As suggested by Laughlin, Branch, and Johnson (1969), further research should test the unidimensional complementary task model for multidimensional tasks. From one point of view, the predictions of the unidimensional model should apply to group performance on a multidimensional task because: (a) Just as the experiments on the unidimensional task did not consider the manner by which the individuals arrived at their specific level of relevant resources as influencing how these resources can be combined in the group situation, so also the manner by which the specific dimensions are united within a given individual to yield the level of individual task relevant abilities need not be considered as influencing the manner by which this quantity of individual resources can be pooled with the resources of the other group members. (b) And therefore, once committed to the assumption that composition of dimensions within an individual is not significant to how this level of ability is pooled with other members, the first two tenents of the model can easily follow (that a person of greater ability possesses all the resources of a person of lesser ability and that members of comparable resources can pool their unique information to surpass the performance that either of them could accomplish alone). (c) And therefore, the only additional tenent to consider is the third (that unique information increases as the ability level increases). And indeed, one legitimate assumption is that low resource members know a little about all the relevant dimensions, the medium members a little more, and the high members know a lot about all the relevant dimensions; all of which translates into the tenent that as the ability level increases, the unique information increases.

But from another point of view, it can be argued that the tenents of the unidimensional model do not apply to a multidimensional task because a low level of initial resources might reflect a high knowledge on one dimension and minimum knowledge on two other dimensions, while a medium level of resources might reflect considerable knowledge on two dimensions but little on a third, and a high level of resources might reflect considerable knowledge on all three dimensions; all of which can result in the level of unique resources being inversely related to initial ability, the opposite of the third tenent of the unidimensional model.

The resolution of this controversy had to be based on empirical evidence. Therefore, because neither point of view was more compelling than the other, a reliance upon the law of parsimony was accepted. That is, just as the unidimensional model was accurate across group size, it was assumed that the model will remain accurate for a multidimensional task, until data indicate otherwise. Therefore, the present study was designed to test the predictions as outlined previously of the unidimensional complementary task model for group performance on a multidimensional task as a function of initial ability level.

Method

The method was similar to that of Laughlin, Branch, and Johnson (1969). The initial subjects were 519 undergraduate students enrolled in various psychology courses at Loyola University, Chicago (165 males and 65 females), Mundelein College of Chicago (3 males and 130 females), and Lewis College of Joliet, Illinois (78 males and 78 females). The first 257 of these Ss were administered the task as individuals during a regularly scheduled class period with class sizes ranging from 9 to 54. No time limit was imposed, but most Ss finished in 10 to 15 minutes and handed in their solutions. The Ss in each intact class were then immediately assigned at random to like-sexed triads or to individual control conditions for the second administration of the same task. The triads were instructed to work as a cooperative group, discussing each item, reaching a mutual solution to each phase of the problem, and recording the group's solution on a single sheet. Again, no time limit was imposed, but most groups finished in about 20 minutes. Both administrations of the task were completed in a single class period.

After all 257 individual first solutions were scored, these Ss were trichotomized. Those Ss scoring 40 deviations or less were designated as high (H); those scoring between 40 and 52 deviations were designated as medium (M); and those scoring 52 or more deviations were designated as low (L).

The next 177 Ss followed a modified procedure. After the Ss handed in their individual first solutions, the regular instructor proceeded with a 15 minute lecture while the E scored the solutions. Then the Ss were assigned to the various ability combinations for the second administration on the basis of the cutoff points determined from the first 257 Ss.

The last 85 Ss were all male volunteers from the Loyola University pool of students enrolled in introductory psychology classes. After these Ss handed in the initial solutions, E asked them to remain while the initial scoring took place. Ss were not allowed to discuss the task at this time. E then assigned them to the various ability combinations for the second administration in order to obtain 7 replications in each of the 10 triad and 3 individual second-administration conditions for both males and females. Replications beyond 7 were eliminated. The utilized Ss were therefore 462 students, including 156 males and 56 females from Loyola University, 3 males and 97 females from Mundelein College, and 72 males and 78 females from Lewis College. The means for the utilized H, M, and L thirds were respectively 33.48 deviations, 46.00 deviations, and 57.22 deviations for the males; and 35.25 deviations, 46.05 deviations, and 58.16 deviations for the females. These sex means did differ significantly at the .05 level (F = 4.78, df = 1, 456), and therefore the data were analyzed with a sex factor.

The task itself, called the "Moon Problem," was composed by the National Aeronautics and Space Administration, which also has recommended the ideal solution to the task (see Appendix I). The task requires the rank ordering of 15 items in terms of their importance for allowing members of a space crew to travel 200 miles on the moon to a mother ship after the members' spacecraft had been forced to land. The score for any solution was the sum of the absolute deviations from the recommended order. Hence a low score indicated close agreement with the recommended order and was therefore designated as H. The ranking of any specific item can be considered as a subtask, while the contributing of information by those members who possess relevant resources for a given item can be considered as a division of labor; hence the task meets the criteria of complementarity. While no empirical validations have been conducted, from an intuitive basis the recommended solution is based on principles of physics, of biology, of chemistry, of electronics, some knowledge of the moon's surface, and some ingenuity. Therefore, to the extent that the information about biology is distinct from the information about electronics for example, the task can be considered multidimensional.

Additional information concerning the task is contained in "A Handbook of Structured Experiences for Human Relations Training" (1969).

As mentioned, the data obtained were deviation scores. The significance of the use of this metric is not well known. However, this metric is different from the metric used in scoring the Terman Test, the unidimensional task used to evolve the model being tested in the present study. In scoring the Terman Test, each item is independent and it is assumed that the score reflects interval data. In using deviation scores, each item is not independent. However, the deviation scores certainly reflect at least an ordinal scale ("The ordinal scale connotes an ordering with rank-order positions usually specified by number" McNemar, 1962, page 374). In addition, if the assumption claimed by the researcher that misranking the most important item by one position is statistically as important as misranking the least important item by one position (notice that the phrase was "statistically as important," for indeed misranking the most important item could mean death in the practical situation, while misranking the least important item would be of little consequence) is granted, then the deviation metric can be considered as interval data also ("An interval scale is one for which equal units can be claimed" McNemar, 1962, page 374). Therefore the nonindependence of items for the multidimensional task is the only difference from the scoring of the unidimensional task, a difference which can not be obviated.

Results

The improvement score for each subject was computed by subtracting his first solution score from either the second administration score of his triad or from his own second administration score for the individuals in the control conditions, and then changing the signs such that an improvement from a score of 20 deviations to a score of 16 deviations was expressed as plus four units of improvement. A 2 by 3 by 2 analysis of variance was performed on the improvement scores and these results are presented in Table 1. The data demonstrated that triads improved more than individuals ($F = 44.24$, $df = 1{,}450$, $p < .001$), that improvement was significantly influenced by S's initial ability ($F = 55.66$, $df = 2{,}450$, $p < .001$), that females improved significantly more than males ($F = 10.24$, $df = 1{,}450$, $p < .001$), that the interaction between condition and initial ability significantly influenced improvement ($F = 5.05$, $df = 2{,}450$, $p < .001$), which was reflecting the specific lack of improvement in the Low-Alone condition, and that all the other possible interactions were not significant. The results of the Duncan multiple-range tests showed that initially low Ss improved more than either M or H Ss and that M Ss improved more than H Ss, all significant beyond the .001 level.

Improvement as a function of the two partners' abilities. The mean improvement scores for male and female H, M, and L Ss when working with either HH, HM, HL, MM, ML, LL partners or when working alone are presented in Table 2. Row 1 gives the mean improvement scores for male and female H Ss retaking the task in the seven possible conditions. A 7 by 2 analysis of improvement for H Ss, the results of which are presented in Table 3, indicated that improvement is significantly influenced by partners' abilities ($F = 9.86$, $df = 6{,}140$, $p < .001$), but improvement is not significantly influenced

Table 1

Analysis of Variance (ANOVA) for Improvement

Scores as a Function of Condition, Ability, and Sex

Source of Variation	SS	df	MS	F	Level
Condition (alone or in triads)	4122.185	1	4122.185	44.235	.001
Initial Ability (H, M, or L)	10,373.662	2	5186.831	55.659	.001
Sex	954.320	1	954.320	10.241	.001
Condition X Ability	940.947	2	470.474	5.049	.001
Condition X Sex	95.432	1	95.432	1.024	ns
Ability X Sex	288.329	2	144.165	1.547	ns
Condition X Ability X Sex	190.205	2	95.103	1.021	ns
Within Cell Error	41,934.973	450	93.189		
Total	58,900.052	461			

Table 2

Mean Improvement Scores for H, M, and L Males and Females Working with Two Partners or Alone

	Males							Females						
	Ss working with:						Working alone	*Ss* working with:						Working alone
	HH	HM	HL	MM	ML	LL		HH	HM	HL	MM	ML	LL	
H	8.78	5.29	9.28	0.57	-2.29	-9.71	0.86	9.90	6.71	6.29	4.29	0.57	-4.00	-1.43
	(21)	(14)	(14)	(7)	(7)	(7)	(7)	(21)	(14)	(14)	(7)	(7)	(7)	(7)
M	17.43	15.14	11.43	8.00	4.00	2.86	-0.57	18.00	15.00	15.14	11.43	7.71	7.71	4.57
	(7)	(14)	(7)	(21)	(14)	(7)	(7)	(7)	(14)	(7)	(21)	(14)	(7)	(7)
L	30.57	23.71	12.14	16.57	13.43	9.05	2.00	28.86	25.14	19.71	21.43	17.29	18.48	-0.86
	(7)	(7)	(14)	(7)	(14)	(21)	(7)	(7)	(7)	(14)	(7)	(14)	(21)	(7)

Note. - *n*'s in parentheses.

Table 3

ANOVA for Improvement for High Subjects as a Function of the Partners and Sex

Source of Variation	SS	df	MS	F	Level
Partners	3935.056	6	655.843	9.86	.001
Sex	34.298	1	34.298	0.52	ns
Partners X Sex	266.130	6	44.355	0.67	ns
Within Cell Error	9311.334	140	66.510		
Total	13,546.818	153			

by the sex of the S himself ($F < 1$), nor by the interaction ($F < 1$). The 21 possible specific comparisons of the seven conditions were tested by Kramer's adaptation of the Duncan multiple-range test for unequal numbers of replications (Kramer, 1956). The predictions and the obtained levels of significance for the 21 comparisons involving the H Ss are presented in Table 4. Contrary to the predictions of the unidimensional model, initially high scoring Ss working with two partners of high ability (H·HH) did not improve significantly more than H·HM or H·HL; but as predicted, exceeded the other four conditions. As predicted, H·HM = H·HL, and both exceeded each of H·ML, H·LL, and H; but contrary to prediction, neither H·HM or H·HL exceeded H·MM. As predicted, H·MM, H·ML, and H did not differ from each other, nor did H·ML differ with H·LL; but contrary to prediction, H·MM and H each differed from H·LL. Stated from another point of view, the model predicted 14 significant differences, while the data only supported 10 of these; and the model did not predict a significant difference in 7 instances, while the data demonstrated a significant difference in 2 of these.

Row 2 of Table 2 gives the mean improvement scores for male and female M Ss in the seven possible conditions. The results of a 7 by 2 ANOVA of improvement for M Ss are presented in Table 5, and indicated that improvement of M Ss is also a function of the partners' abilities ($F = 8.13$, $df = 6{,}140$, $p < .001$), that improvement is significantly greater for M females than M males ($F = 4.60$, $df = 1{,}140$, $p < .05$), and that improvement is not a function of the interaction ($F < 1$). The 21 possible specific comparisons for the seven conditions were made by the Kramer test and both the predictions and the obtained levels of significance are presented in Table 6. Contrary to predictions, M·HH did not exceed M·HM or M·HL; but as predicted, exceeded

Table 4

Predictions and Obtained Levels of Significance of Comparisons by Kramer Multiple-Range Tests for H Subjects in Seven Conditions

Condition	H·HL	H·HM	H·MM	H	H·ML	H·LL
H·HH	s/ns	s/ns	s/.05	s/.001	s/.001	s/.001
H·HL		ns/ns	s/ns	s/.01	s/.01	s/.001
H·HM			s/ns	s/.05	s/.05	s/.001
H·MM				ns/ns	ns/ns	ns/.01
H					ns/ns	ns/.05
H·ML						ns/ns

Note. - A cell heading like "H·HM" should be read as "a high person working with a high and a medium partner." The numerator of each cell is the prediction; the denominator is the obtained significance level.

Table 5

ANOVA for Improvement for Medium Subjects

as a Function of the Partners and Sex

Source of Variation	SS	df	MS	F	Level
Partners	3394.923	6	565.821	8.13	.001
Sex	320.026	1	320.026	4.60	.05
Partners X Sex	124.688	6	20.781	0.30	ns
Within Cell Error	9747.714	140	69.627		
Total	13,587.351	153			

Table 6

Predictions and Obtained Levels of Significance of Comparisons by Kramer Multiple-Range Tests for H Subjects in Seven Conditions

Condition	M·HM	M·HL	M·MM	M·ML	M·LL	M
M·HH	s/ns	s/ns	s/.01	s/.001	s/.001	s/.001
M·HM		ns/ns	s/.05	s/.001	s/.01	s/.001
M·HL			s/ns	s/.05	s/.05	s/.01
M·MM				s/ns	s/ns	s/.01
M·ML					s/ns	s/ns
M·LL						ns/ns

the other four conditions. As predicted, M·HM = M·HL, and both exceeded each of the other four conditions which did not contain a H member, except M·HL did not differ with M·MM, which is contrary to prediction. Contrary to prediction, M·MM did not exceed M·ML or M·LL, but M·MM did exceed M as predicted. Contrary to prediction, M·ML did not differ with M·LL or M. And as predicted, M·LL did not exceed M. The summary of the model's predictions for M _S_s then was 12 out of 19 predicted differences obtained and the 2 instances in which no difference was predicted yielded no difference.

Row 3 of Table 2 gives the mean improvement for male and female L _S_s in the seven possible conditions. The results of a 7 by 2 ANOVA of improvement for L _S_s is presented in Table 7. These results indicated that improvement for L _S_s is also a function of the partners' abilities (F = 13.61, df = 6,140, p <.001), that improvement is significantly greater for L females than L males (F = 9.94, df = 1,140, p <.005), and that improvement is not a function of the interaction (F = 1.26, df = 6,140, p >.25). The 21 possible specific comparisons for the seven conditions were made with Kramer's test and the predictions and obtained levels of significance are reported in Table 8. Contrary to prediction, L·HH did not exceed L·HM, but did exceed the other five conditions as predicted. Contrary to prediction, L·HM did exceed L·HL; contrary to prediction, L·HM did not exceed L·MM, but as predicted did exceed the other three conditions. Contrary to prediction, L·HL did not exceed L·MM, L·ML, or L·LL; but as predicted did exceed L. Contrary to prediction, L·MM did not exceed L·ML or L·LL; but did exceed L as predicted. Contrary to prediction, L·ML did not exceed L·LL; but as predicted exceeded L. Contrary to prediction, L·LL exceeded L. The summary of the model's predictions for L _S_s was 11 out of 19 predicted differences obtained, while the 2 predictions

Table 7

ANOVA for Improvement for Low Subjects as

a Function of the Partners and Sex

Source of Variation	SS	df	MS	F	Level
Partners	7305.238	6	1217.540	13.61	.001
Sex	888.960	1	888.960	9.94	.005
Partners X Sex	678.469	6	113.078	1.26	ns
Within Cell Error	12,520.190	140	89.430		
Total	21,392.857	153			

Table 8

Predictions and Obtained Levels of Significance of Comparisons by Kramer Multiple-Range Tests for L Subjects in Seven Conditions

Condition	L·HM	L·MM	L·HL	L·ML	L·LL	L
L·HH	s/ns	s/.01	s/.001	s/.001	s/.001	s/.001
L·HM		s/ns	ns/.01	s/.01	s/.001	s/.001
L·MM			s/ns	s/ns	s/ns	s/.001
L·HL				s/ns	s/ns	s/.001
L·ML					s/ns	s/.001
L·LL						ns/.001

of no difference proved to be significantly different in both cases.

In summary, the model was accurate on 40 out of 63 predictions (63%) for improvement of individuals in the three levels of initial ability as a function of their partners' abilities.

Absolute order of second administration performance. A 13 by 2 ANOVA, the results of which are presented in Table 9, demonstrated that the scores obtained on the second administration were a function of the condition (F = 17.32, df = 12,156, $p < .001$), but that second administration scores were not significantly influenced by sex (F = 2.00, df = 1,156, $p > .15$), nor by the interaction ($F < 1$).

The means of the deviation scores for males and females in the 13 conditions along with the predictions and the obtained levels of significance of all the possible specific comparisons by the Duncan multiple-range tests are reported in Table 10. Bear in mind that this table represents deviation scores, hence the absolute numbers increase as performance decreases. The obtained order of means (collapsing across the sex variable because sex did not demonstrate a significant influence nor did the interaction) differed from the predicted order in three instances. First, the HHM and the HHL triads were reversed; second, the HLL triads were exceeded by four conditions (H, MMM, MML, and MLL); and third, the M individuals and the LLL triads were reversed.

The predictions of the model were accurate on 50 out of the 78 specific comparisons (64%). This relationship yielded a rank order correlation of .90. For the conditions containing H Ss, the predictions were inaccurate in 20 out of 63 comparisons (68% accuracy). The predictions maintaining that three H's would exceed two H's in a triad, which in turn would exceed a sin-

Table 9

ANOVA of Second Administration Performance

as a Function of Condition and Sex

Source of Variation	SS	df	MS	F	Level
Condition	13,542.066	12	1128.506	17.32	.001
Sex	130.308	1	130.308	2.00	ns
Condition X Sex	736.263	12	61.355	0.94	ns
Within Cell Error	10,166.858	156	65.172		
Total	24,575.495	181			

Table 10

Mean Scores on Second Administration and Predicted and Obtained Levels of Significance of Comparisons by Duncan Multiple-Range Tests for the 13 Ability Conditions

	HHH	HHL	HHM	HMM	HML	H	MMM	MML	MLL	HLL	LLL	M	L
Males	25.71	23.71	28.00	32.29	34.57	32.86	37.14	41.71	43.43	43.14	49.14	47.14	57.71
Females	26.00	31.14	27.14	30.57	30.29	36.00	34.57	38.29	39.71	41.14	38.86	42.86	58.00
Mean	25.86	27.43	27.57	31.43	32.43	34.43	35.91	40.00	41.57	42.14	44.00	45.00	57.86
HHH		s/ns	s/ns	s/ns	s/ns	s/.05	s/.01	s/.001	s/.001	s/.001	s/.001	s/.001	s/.001
HHL			ns/ns	s/ns	s/ns	s/.05	s/.05	s/.001	s/.001	s/.001	s/.001	s/.001	s/.001
HHM				s/ns	s/ns	s/.05	s/.05	s/.001	s/.001	s/.001	s/.001	s/.001	s/.001
HMM					ns/ns	ns/ns	s/ns	s/.05	s/.01	ns/.01	s/.001	s/.001	s/.001
HML						ns/ns	s/ns	s/.05	s/.01	ns/.01	s/.001	s/.001	s/.001
H							s/ns	s/ns	s/.05	ns/.05	s/.01	s/.01	s/.001
MMM								s/ns	s/ns	s/ns	s/.05	s/.01	s/.001
MML									s/ns	s/ns	s/ns	s/ns	s/.001
MLL										s/ns	s/ns	ns/ns	s/.001
HLL											s/ns	s/ns	s/.001
LLL												s/ns	ns/.001
M													s/.001

gle H in a triad were not supported, and this accounted for 8 of the 20 inaccurate predictions. The poor performance of the HLL triads accounted for 8 other unverified predictions. HMM, HML, and H conditions each significantly exceeded HLL when no difference was predicted; and HLL did not significantly exceed MMM, MML, MLL, M, or LLL when differences were predicted. The failure of either the HMM, HML, or the H condition to significantly exceed the MMM triads accounted for 3 other unobtained predictions. The final prediction which was not obtained reflected the obtained non-significant difference between H and MML.

For the conditions containing M Ss but not H Ss, the predictions were inaccurate in 7 out of 14 specific comparisons (50%). The obtained failure of MMM triads to exceed MML or MLL; the obtained failure of MML to exceed MLL, LLL, or M; the obtained failure of MLL to exceed LLL; and the obtained failure of M to exceed LLL triads constituted the seven mispredictions.

The only prediction for conditions containing L Ss but not a H or a M was not supported, but in fact LLL significantly exceeded L.

Second administration performance for comparable ability triads minus their control. It was predicted that (HHH - H) > (MMM - M) > (LLL - L). The prediction was tested by randomly pairing the 7 male and the 7 female HHH triads with the same-sexed H individual, and then subtracting the second administration H score from the second administration HHH score for each random pair. The same procedure was followed in the M and L conditions. The resulting difference scores (HHH - H), (MMM - M), and (LLL - L) for males and for females were subjected to a 3 by 2 ANOVA, the results of which are presented in Table 11. The F value for both factors and the interaction was less than one.

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Table 11

ANOVA of Second Administration Performance of Equal Ability Triads Minus Their Control as a Function of Ability and Sex

Source of Variation	SS	df	MS	F	Level
Ability	235.619	2	117.810	0.67	ns
Sex	160.095	1	160.095	0.91	ns
Ability X Sex	269.905	2	134.953	0.77	ns
Within Cell Error	6310.857	36	175.302		
Total	6976.476	41			

Discussion

The series of studies by Laughlin, Branch, and Johnson concerned with dyad, triad, and tetrad performance on a unidimensional complementary task as a function of initial resources was developed from Steiner's theoretical paper and yielded an extended empirical model of group performance. The assumptions and tenents of the model lead to direct predictions which can be summarized in the statement that the person working with a larger number of greater or of comparable ability partners will improve relative to his performance alone, or with a lesser number of greater or of comparable ability partners, or with partners of less ability. The predictions of the model received strong support when tested over group size on the unidimensional task. However, in a comparably designed study, the accuracy of the predictions decreased from 91% for a unidimensional task (Laughlin, Branch, and Johnson, 1969) to 63% in the present study. The reliance upon the law of parsimony appeared unjustified in this instance.

A reevaluation of the assumptions and tenents of the unidimensional model for a multidimensional task. The first tenent of the unidimensional model was that the unique resources of the members can be pooled to allow the group to surpass the performance of its most competent member. This tenent is actually a redefinition of the complementary task situation in that it states that the division of labor potential of the task allows the various members to contribute to the total product on the basis of their resources. Hence the only direct test of this tenent was the global comparison of improvement for groups versus individuals, which demonstrated that groups were superior. Therefore the first tenent appeared justifiable for the multidimensional task situation.

The most direct test of the second tenent of the unidimensional task model, namely that a person of greater task-relevant resources possesses all the resources of a person of lesser resources, or from the other point of view, that a person of lesser abilities does not aid the performance of a person of greater ability, was contained in the predictions of second administration performance that HMM, HML, and HLL would not exceed H alone, that MLL would not exceed M alone; and in improvement, that H·MM, H·ML, and H·LL would not exceed a H working alone, and M·LL would not exceed M alone. In each and every of the above cases, the person working with partners of less ability did not improve significantly more than the comparable control working alone, nor did the second administration performance of a triad composed of a person working with two partners of less ability significantly exceed the performance of the comparable control. Hence the application of the second tenent of the unidimensional model was justifiable for the multidimensional task situation.

The third tenent of the unidimensional model was that the level of unique information increases with the increase in level of ability. The direct test of this was the comparisons between HHH - H, MMM - M, and LLL - L. Whereas this tenent had been supported in the unidimensional task, it failed to be supported in the present study. In fact, the mean number of errors avoided in the HHH - H cell was 8.57, in the MMM - M cell it was 9.15, and in the LLL - L cell it was 13.86. This nonsignificant trend was actually in the opposite direction, namely that the level of unique resources is inversely related to initial ability level. Therefore, the application of the third tenent of the unidimensional model appeared unjustifiable for the multidimensional task situation.

In summary then, the direct tests of the three tenents of the unidimensional model demonstrated that the applicability of the first two tenents to multidimensional task situations was justifiable, while the application of the third tenent was not supported. But the third tenent was the sole basis for only one comparison, leaving 51 other predictions which were not supported to be explained. Each of these predictions was based on some interaction between the tenents and the assumptions, and these are considered next.

First, the fact that H·LL was significantly exceeded in improvement by H·MM and by H alone, while the model did not predict a difference on the basis of the second tenent that a person of greater ability possesses all the resources of a person of less ability and on the basis of the assumption that persons of less ability do not hinder the performance of a higher ability member; the fact that L·HL did not exceed L·MM, L·ML, or L·LL, while the model predicted a difference on the basis that the H partner would contribute significantly more than a non-H partner; and the fact that HLL was exceeded by HMM, HML, and H individuals, while the model again did not predict a difference on the same basis as before; and the fact that HLL triads did not exceed MMM, MML, MLL, LLL, or M individuals, while the model predicted a significant difference on the basis that a higher ability member possesses all the resources of lower ability persons and on the basis that lower ability members do not hinder the performance of a higher ability member; all 13 of these predictions which failed to be supported indicated that lower ability members can hinder the group performance. When Laughlin and Branch (unpublished) reported HLLL tetrads did not exceed MMMM, MMML, and MMLL tetrads and interpreted these findings in terms of the H member yielding to the conformity pressures of the three L members, this form of hindrance was not as pronounced as found in the present study. On the one hand, HLLL tetrads nevertheless did exceed the performance of MLLL and LLLL tetrads and M individuals, while in the present study the comparable comparisons did not demonstrate comparable results. The hindrance factor in the HLL triads suggests a phenomenon of such magnitude that the resources of the H member were not utilized to any greater degree than if the H member had been another L member (HLL triads did not significantly exceed LLL triads). Furthermore, the conformity interpretation is not totally adequate in the present instance because the conformity literature has demonstrated that maximum conformity is exhibited with a minimum of three confederates (Asch, 1965). Certainly, just as some conformity results from two confederates, some of the poor performance of the HLL triads can be attributed to conformity pressures, but the major portion of the decrement in performance from the predicted might be attributable to hindrance by the lower ability members over and above their exertion of conformity pressures. Hence, the assumption of nonhindrance which was justifiable in the unidimensional task situation did not appear warranted for the multidimensional task situation.

Second, consider the following 19 findings which failed to support the predictions of the model, all of which were based on the first two tenents in conjunction with the assumptions such that three of the highest level of ability in a given triad should exceed the performance of two of the specific highest ability, which in turn should exceed the performance of just one of the specific highest level. H·HH did not improve significantly more than H·HM (that is, a member working with two partners of the highest ability level in the triad did not exceed the performance of a comparable member working with just one partner of the highest level of the triad); H·HH did not significantly exceed H·HL; H·HM and H·HL did not exceed H·MM (that is, a member working with one partner of the highest level within the triad did not exceed a comparable member working with no partners of the highest level within the triad); HHH triads did not perform significantly better than HHM, HHL, HMM, or HML triads; M·HH did not improve more than M·HM or M·HL; M·MM did not significantly exceed M·ML or M·LL; M·ML did not differ with M·LL or M individuals; the scores of MMM triads did not surpass the performance of MML or MLL triads; MML did not exceed MLL triads; L·HH did not improve more than L·HM; L·MM did not significantly exceed L·ML. This block of findings might have been interpreted as indicating that the lower ability members of a triad do in fact contribute some significant amount of information to the group product, had it not been for the more direct test of the contribution of lower ability members discussed in the preceding pages which indicated that the lower ability members do not significantly aid the performance of a higher ability member. Therefore, the most plausible alternative explanation which is common to all the above 19 findings is that the level of unique resources for any given level of ability is less in this particular multidimensional task than was found in the unidimensional task used by Laughlin, Branch, and Johnson. This contention of a decreased level of unique resources is tangentially supported by the fact that the rank order correlation between the predicted order of second administration performance and the obtained order was .90, while the model was nevertheless inaccurate in 28 out of 78 specific predictions. That is to say, the predictions of the unidimensional model were much more accurate on the basis of order as witnessed by the correlation coefficient, which is not dependent on the size of the interval or difference between adjacent levels of performance, than on the basis of specific comparisons, which are dependent on the size of the interval. To the extent then that the predictions failed to be supported because the numerator of the comparisons, the interval, was not sufficiently large, the data indicated that the level of unique resources was less for this multidimensional task than had been present in the unidimensional task situation which gave rise to the model. The consideration of whether this particular multidimensional task is atypical of other multidimensional tasks or whether this finding is generalizable to other multidimensional task situations will be deferred to a subsequent consideration.

Third, L·LL did improve significantly more than L individuals and LLL triads did perform significantly better than L individuals on the second administration. These results indicated that the resources at the lowest level of ability are not virtually completely shared in a multidimensional task situation, a finding that was ubiquitous across group size with the unidimensional task in the Laughlin, Branch, and Johnson series.

Fourth, related to the previously discussed finding that the level of unique resources within ability levels did not increase with ability, but did in fact remain constant across ability level with some trend evidence that the unique resources within ability level was actually negatively related to ability level, were the results indicating that H individuals did not exceed MMM triads in second administration performance as predicted and that M individuals did not exceed LLL triads. Whereas in the results of the unidimensional task situation, it was demonstrated that the combined unique resources of lower ability members did not equal the level of performance of a higher ability individual, this phenomenon might have reflected the fact that unique resources increased with ability level. Now in the multidimensional task situation, with a relatively greater amount of unique resources at the lower level, the pooled information of three lower ability members exceeded the performance of one higher member working alone.

To summarize then, the results have lead to the following reappraisals of the unidimensional complementary task model when applied to a multidimensional task situation: (a) The assumption that lower ability members can not hinder the performance of the group appeared less tenable. (b) The tenent that higher ability members possess all the relevant resources of lower ability members was questionable. (c) The tenent that the level of unique resources is directly related to the level of resources was not supported. (d) The implication of the model that the unique resources of three members of the highest level of resources in a triad should exceed the pooled unique resources of two comparable ability members in a triad, who in turn should exceed the unique resources of one comparable ability member in a triad was not supported, indicating that the level of unique resources is less in a multidimensional task than was found in a unidimensional task. (e) The finding in unidimensional task studies that the level of unique resources at the lowest level was so minimal as to obviate the increase in performance of three L's relative to the performance of a single L working alone was not supported for the multidimensional task situation; the level of unique resources at the low level allowed three L's to exceed an L working alone. (f) The implication of the unidimensional model that the pooled unique resources of lower ability members did not exceed the resources of a higher ability member was questionable.

One definite implication of the six preceding reappraisals was that the medium and low ability members have greater control over the group performance in the multidimensional task situation in that they can hinder or aid the group to a more significant degree than was possible in the unidimensional task situation.

An examination of the process of problem solving in the multidimensional task situation. Even with the preceding reevaluation of the unidimensional model in its application to the multidimensional task situation, some predicted differences which failed to be supported still require additional consideration. Whereas the unidimensional model presupposed that the members could recognize both their own and the other members' differential relevant resources and respond accordingly on a hierarchical basis, perhaps in the multidimensional task situation the members can not as readily recognize the differential abilities. Stated differently, the performance of groups on a unidimensional complementary task depended on the division of labor potential of the task being maximized by the division of ability potential of the members, but this maximization can be attenuated by an inability of the members to recognize their division of ability potential. To consider this possibility in greater depth, a review of an article by Johnson and Torcivia (1967) in which the detrimental effects of a member's inability to recognize his own abilities were demonstrated and a review of the work of Davis (1969) in which the effects of the processes of the group in relation to their product are discussed are both helpful.

Johnson and Torcivia (1967) administered a mathematical puzzle to individuals, and then paired some subjects to work on the problem again while asking some other subjects to again work on the task as individuals. The pairs were comprised of subjects who were initially both correct, initially mixed (one correct and one incorrect), initially both wrong with the same answer, or initially both wrong with different answers. The mixed pairs performed better than either type of both wrong pairs, but were exceeded by the both correct pairs. However, the important finding for the present discussion was that the direction of change in the mixed pairs could be predicted by using the obtained information on which member of the pair was more certain of his initial proposed solution. That is, the certainty of a member concerning his incorrect solution (the inability of a member to recognize his own relevant resources) inhibited the group from adopting a hierarchical process for obtaining the task product. With the Terman Test as the unidimensional task, it was demonstrated by the data that the group product was a function of the differential relevant resources of the members, and it is therefore reasonable to assume that the members adopted a hierarchical process, and therefore reasonable to assume that the members could recognize their own relevant resources and the differential abilities of the other members. With a mathematical puzzle as the task, it was demonstrated that the group product was attenuated from maximization by the inability of some members to recognize their own realistic relevant resources. Although this is a post hoc explanation and therefore unable to be substantiated by data from the present study, it was possible that the group product was also attenuated from maximization because some members were unable to recognize their relevant resources applicable to the "Moon Problem."

This attenuation from maximum performance can also be a function of the inability of the members to recognize the differential relevant resources of the others in the group. Related to this, Davis (1969) maintained that ad hoc groups can adopt either equalitarian norms of process, which means that the group will organize for work by setting up a structure to operate within that reinforces responses directed toward establishing and maintaining an affable atmosphere; or hierarchical norms of process, which give preeminence to those members with more relevant resources. Davis further pointed out that the equalitarian norms are precursors to the hierarchical norms because individual differences in ability are not evident prior to sustained interaction, and hence each member must be given an equal amount of the group's working time until the differential relevant resources of all the members are recognized. "A group that remains in existence long enough to discover members' talents could eventually organize for a more satisfactory use of resources - namely, an intellectual hierarchy that is correlated with member abilities" (Davis, 1969; page 52).

The decrement from maximum performance as a function of the differential resource potential in the present study could be attributable in part to the adoption of equalitarian norms by the members of the group. However, the unidimensional model of Laughlin, Branch, and Johnson is undeniably a model for group product on the basis of a hierarchical process, specifically on the basis of the levels of initial relevant resources. But it also is a model which emerged from the actual performance of ad hoc groups working on a unidimensional problem solving task. This apparent contradiction between Davis's hypothesis that groups initially adopt the equalitarian process and then over time evolve into a hierarchical process and the findings of Laughlin, Branch, and Johnson that groups immediately adopted a hierarchical process on a unidimensional task can be resolved by conceding that the members of a small group can immediately ascertain their own relevant verbal abilities (the person either knows the meaning of the words or he does not, and he knows this himself) and the relevant verbal resources of the others (the other members either admit that they do not know the meaning of the words or they demonstrate that they do know its meaning). Hence, the members can immediately adopt the hierarchical process. To restate this phenomenon in Steiner's terms, the potential group productivity means group performance on the basis of a hierarchical model, and that one form of losses due to faulty processes refers to the decrement in performance that results from the group members having to take the time to know their differential abilities for the task requirements. Again, however, this is a post hoc explanation and therefore no data can be offered in its support.

Further research is suggested therefore to obtain data concerning these two post hoc explanations of the decrement from maximum performance reflected in the present study. One planned study requires the subjects to work on both a unidimensional task (the Terman Test) and a multidimensional task (unspecified as yet) both as individuals and then in one of the 10 triadic conditions or one of the three control conditions. After completing each task the first time, the subjects will be asked to rate how certain he is of his solutions and how much information he thinks he had relative to the solution in comparison to how much information he thinks other students might have relative to the solution. Then after completing each task the second time, the subject will again be asked to rate his certainty and his amount of relevant resources, and the certainty and amount of relevant resources he thinks each of the other group members possessed. It would then be possible to ascertain whether the factor of recognizing both the subjects own level of resources and the differential abilities of the other members is more difficult in a multidimensional task situation than in a unidimensional task situation. Another planned study requires the subjects to work on two multidimensional tasks, both of which require the same relevant resources for solution. Using the same design and questionnaires as developed in the first proposed study, it would then be possible to ascertain if indeed once the members of groups working on a multidimensional task do evolve to a hierarchical process, does the performance decrement cease and the group maximize their performance on the basis of relevant resources.

A critical evaluation of the multidimensional task used in the present study. It has been shown how the assumptions and tenents of the unidimensional model would have to be altered to apply to a multidimensional task situation on the basis of the data obtained in the present study. Additional post hoc explanations have been offered for the decrement in performance of the triads from the predicted performance on the basis of maximum use of the division of ability potential. However it is possible that the "Moon Problem" itself did not present an unbiased test of group performance on a multidimensional task. The failure of three H's to exceed triads containing two H's, which in turn failed to exceed triads containing only one H as obtained in the present study is reminiscent of the data obtained by Goldman (1965) in the first test of Steiner's model for group performance on a complementary task. Goldman used the Wonderlic Test under power conditions with college students, obtained some data which was statistically significant, and interpreted these data as representative for all complementary tasks. Laughlin and Johnson (1966) pointed out that the Wonderlic Test under power conditions contained an inherent ceiling confound, such that the high initial ability subjects had no room to improve, and hence the data obtained by Goldman was not applicable to other complementary tasks not containing a ceiling. The present study has also obtained some data that was statistically significant and interpreted these data as representative for multidimensional complementary task situations. The serious limitation is that the "Moon Problem" might be analogous to the Wonderlic under power conditions. It is therefore suggested by the author that additional multidimensional tasks be developed for use in group problem solving studies in order to ascertain whether the data obtained from the present study were specific to the task used or whether the data can be generalized to other multidimensional tasks. And in the development of future multidimensional tasks, consideration should also be given to determining the level of resources for each task dimension so that incorporation of this factor into a general model of group performance on a multidimensional task is possible if warranted.

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Appendix I

The Task as Administered to the Subjects

NAME: ____________________

MOON PROBLEM

You are a member of a space crew originally scheduled to rendevous with a mother ship on the lighted surface of the moon. Due to mechanical difficulties, however, your ship was forced to land at a spot some 200 miles from the rendevous point. During re-entry and landing, much of the equipment aboard was damaged and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200 mile trip. Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance for your crew in allowing them to reach the rendevous point. Place the number 1 by the most important item, the number 2 by the second most important and so on through number 15, the least important.

_____Box of matches

_____Food concentrates

_____50 feet of nylon rope

_____Parachute silk

_____Portable heating unit

_____Two .45 caliber pistols

_____One case dehydrated Pet milk

_____Stellar map (of the moon's constellation)

_____Two 100 lb. tanks of oxygen

_____Life raft

_____Magnetic compass

_____5 gallons of water

_____Signal flares

_____First aid kit containing injection needles

_____Solar powered FM receiver-transmitter

The Solution of the Task and the Rationale as Recommended by NASA

Recommended Ranking	Rationale
1. Two 100 lb. tanks of oxygen	No air on moon
2. 5 gallons of water	You can't live long without this
3. Stellar map of moon's constellation	Needed for navigation
4. Food concentrates	Can live for some time without food
5. Solar-powered FM receiver-transmitter	Communication
6. 50 feet of nylon rope	For travel over rough terrain
7. First aid kit containing injection needles	First aid kit might be needed but needles are useless
8. Parachute silk	Carrying
9. Life raft	Some value for shelter or carrying
10. Signal flares	No oxygen
11. Two .45 calibre pistols	Some use for propulsion
12. One case dehydrated Pet milk	Need H_2O to work
13. Portable heating unit	Lighted side of the moon is hot
14. Magnetic compass	Moon's magnetic field is different from earth's
15. Box of matches	No oxygen

APPROVAL SHEET

The dissertation submitted by Laurence G. Branch has been read and approved by members of the Department of Psychology.

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 dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

March 3, 1971
Date

Homer H. Johnson PhD
Signature of Adviser