

## Group Versus Individual Performance: Are $N + 1$ Heads Better Than One?

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Experimental comparisons of groups and individuals were analyzed on four dimensions: task, process, individual differences, and methodology. A standardized terminology based on Lorge, Fox, Davitz, and Brenner was developed to preserve operational definitions in the comparisons of (a) group versus individual, (b) group versus the most competent individual in an aggregate, (c) group versus pooled responses of an aggregate, and (d) group versus math models of performance. Research supported Steiner's theory of process loss but also suggested evidence for process gain. To avoid confounding of group conditions and subject variables, this review focused on the results of random assignment of subjects to conditions.

Belief in the adage that two heads are better than one can be seen in the acceptance of juries as a basic component of our legal system and in the widespread use of committees. Over the last 60 years variations on this adage have inspired a considerable amount of research comparing individual and group performance (see reviews by Davis, 1969a; Dion, Baron, & Miller, 1970; Duncan, 1959; Hare, 1976; Kelley & Thibaut, 1954, 1969; Lamm & Trommsdorff, 1973; Lorge, Fox, Davitz, & Brenner, 1958; Ray, 1955; Shaw, 1976; Vinokur, 1971; Zagona, Willis, & MacKinnon, 1966; see also Davis, Laughlin, & Komorita, 1976; Helmreich, Bakeman, & Scherwitz, 1973; Zander, 1979). The purpose of the present review is to establish a delineated but multidimensional base of findings about individual and group performance. Figure 1 presents a summary of the variables to be covered, four types of group versus individual comparisons, and two theoretical implications.

Because this review was intended to be exhaustive, several boundaries were defined. Following a model by Hare (1976), social

climate was dichotomized as individuals interacting versus individuals working separately; task completion was dichotomized as group product versus individual product. The domain of this review then is those studies where individuals working together on a group product were contrasted with individuals working separately on individual products. This delineation excluded social facilitation articles that reported only individual measures, risky shift studies that reported individual measures before and/or after group interaction, studies of mock juries that used individual scores to predict group outcome (see Davis, 1980; Davis, Kerr, Stasser, Meek, & Holt, 1977; Penrod & Hastie, 1979), and many articles related to the analysis of task dimensions (see Davis, 1969a; Duncan, 1959; Guilford, 1956; Lamm & Trommsdorff, 1973; McGrath & Altman, 1966; Steiner, 1972; Zajonc & Taylor, 1963r). Psychotherapy research was omitted for lack of a group goal when individual objectives were established for each member (see Hartman, 1979; Lorge et al., 1958, p. 340). An adequate discussion of group process and of complex math models of group performance was beyond the scope of this review; several major references are cited later in the article.

In addition, a conservative methodological position was taken by excluding most studies that did not use random assignment of sub-

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I would like to thank George Fairweather, Esther Fergus, Eugene Jacobson, Norbert Kerr, Neal Schmitt, and the reviewers for *Psychological Bulletin* for their comments on earlier versions of this article.

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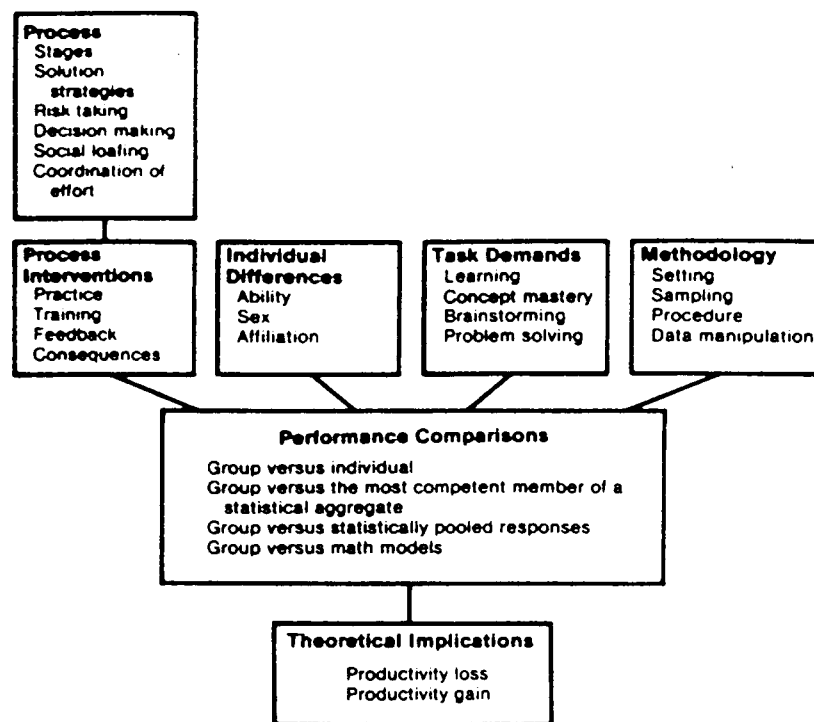


Figure 1. Summary of variables affecting individual and group performances.

jects to conditions to minimize confounding from subject variables. Use of random assignment has been promoted as a basic protection against confounding in applied social research (Sellitz, Wrightsman, & Cook, 1976), for theoretical research (Lana, 1969), and for experimental psychology research in general (Underwood, 1957).<sup>1</sup> Many studies comparing individuals and groups, however, did not show this concern. Out of 139 experimental studies examined, only 33% reported randomization, approximately 17% did not use random assignment, and the remaining 50% did not specify. Although group performance may be unrelated to many personality variables (Heslin, 1964; Mann, 1959), it seemed to be related consistently to the sociability scale and the first factor of the California Psychological Inventory (Bouchard, 1969) and to the subject's preference to work alone or in a group (Davis, 1969rb). In the present review, results of randomized designs are identified by an "r" following the citation. Results from nonrandomized designs are cited as usual. Theoretical articles and studies that did not

report randomization are included according to their heuristic value. Numerous unpublished studies and citations from secondary sources have been omitted. Because most studies in the present review have not been conceptually or methodologically replicated, they should be considered preliminary evidence for their conclusions.

Reference sources for this review included literature reviews, *Psychological Abstracts*, and the 1970-1981 issues of *Annual Review of Psychology*, *Journal of Applied Psychology*, *Journal of Personality and Social Psychology*, *Journal of Social Psychology*,

<sup>1</sup> "The policy of some journal editors has grown to be one in which they essentially refuse to accept a statement by an investigator that 'subjects were assigned to the various condition on a random basis.' . . . The editorial policy requires the investigator to state exactly how his subjects were assigned to groups and then the editor decides whether the method could or could not introduce bias. . . . It is the obligation of the investigator to convince the reader, by use of supporting data or logical considerations, that his results have a low probability of being biased by the method of forming groups" (Underwood, 1957, p. 93).

*Organizational Behavior and Human Performance, Psychological Bulletin, and Sociometry.* Although a few articles comparing groups and individuals in the classroom may have been omitted, little research has been done in this area (Johnson & Johnson, 1975; Johnson, Johnson, & Scott, 1978r). Reference lists from articles and books supplied studies that dated back to 1920 (i.e., Allport, 1920) and randomized research that dated back to 1932 (i.e., Shaw, 1932r). This review, then, covers 61 years of study and 50 years of randomized research.

### Terminology

Rather than retaining the terms used by cited authors, I have adopted a revision of the terminology of Lorge et al. (1958) to convey experimental conditions. The classification of conditions is presented in Table 1.

The need for precise terminology can be seen in the history of individual versus group comparisons. In early research on judgment, interacting groups were not distinguished from aggregates: Researchers concluded that the average of judgments made by a group was usually more accurate than a judgment made by an individual (Bruce, 1935-1936; Eysenck, 1939; Gordon, 1923, 1924; Smith, 1931) and that group superiority increased when an unfamiliar object was judged (Klugman, 1945). Subsequent research showed, however, that combining judgments from 50 individuals was no more accurate than combining 50 judgments from one individual (Farnsworth & Williams, 1936r). The superiority of group judgment had resulted from the aggregation of random errors and the computation of the mean (Stroop, 1932r). The accuracy of aggregated judgments was actually impaired for objects that were unfamiliar or distorted, insofar as errors of judgment tended to be similar and therefore cumulative.

Support for distinguishing coacting from noncoacting aggregates was indicated in the discovery of social facilitation effects (Zajonc, 1965r) and audience effects (Davis, 1969rb; Laughlin & Jaccard, 1975r). Individual performance tested in a coacting aggregate (i.e., in the presence of others) may

Table 1  
*Classification of Individual and Group Conditions*

Interpersonal context	Performance score	Abbreviation for condition
<b>Individual</b>		
Isolated	Individual	I
	Coacting	CI
<b>Statistical aggregate<sup>a</sup></b>		
Isolated	Best member	SB
	Pooled responses	SP
	Complex model	SM
Coacting	Best member	CSB
	Pooled responses	CSP
	Complex model	CSM
<b>Group</b>		
Dispersed	Group product	DG
	Coacting	CG

<sup>a</sup> Lorge et al. (1958) called this a "statisticized group."

be affected by identified interpersonal cues (explicit coaction) or by unidentified interpersonal cues (implicit coaction; Foot, 1973). Confounding from these effects is eliminated when the individual is tested in an isolated (i.e., noncoacting) setting (Hare, 1976). The present review, however, has not presented evidence that the differences between coacting and noncoacting conditions has consistently affected the comparison of groups and individuals or the comparison of groups and statistical models. The distinction is included here for heuristic purposes.

The classification presented in Table 1 is accompanied by several qualifiers. First, performance of Individuals (I) in an isolated setting may have been affected by the presence of an experimenter (see Bouchard, 1969; Kerr & Sullaway, in press; Madsen & Finger, 1978r). Also, the designation I or CI (Coacting Individual) may represent an inference from a methodology section that did not directly state whether subjects were in the presence of others. In Dispersed Groups (DG), interaction was limited: Members communicated by telephone (Howell, Gettys, Martin, Nawrocki, & Johnston, 1970r) or through written exchange of information (Madsen & Finger,

1978r), or they were led to believe their performance was being evaluated as a group (Rettig, 1966r). Second, note that coacting groups may have been either practiced groups whose members were accustomed to working together or ad hoc groups whose members were not accustomed to working together. Only one study (Dunnette, Campbell, & Jaastad, 1963) of a practiced group was included in the present review.

Third, many studies tested performance in stages. In the following pages, these are indicated by hyphenated abbreviations; for example, I-CG4 indicates that subjects participated individually and then in a coacting group of four members. In a comparison of substages, the last abbreviation indicates the stage in which the comparison measure was taken; for example, in the second stage of a three-stage experiment (CI-CG6-CI vs. CI-CI-CI), coacting groups who previously performed as coacting individuals (CI-CG6) may be compared with coacting individuals who previously performed as coacting individuals (CI-CI; see Laughlin & Adamopoulos, 1980r). In the following pages, I intend to minimize the reader's dependence on abbreviations while also attempting to avoid repetitious use of the cumbersome phrases that convey experimental conditions. Therefore, coacting groups are called "groups", isolated individuals are called "individuals", and conditions that combine individual and group characteristics (e.g., coacting individuals) are qualified as such. Abbreviations are included to confirm operational definitions and to indicate group size (e.g., CG6). Group size was omitted when the finding applied to more than one study or was the result of combining data from groups of several sizes.

Fourth, note that the members of isolated statistical aggregates (the most conservative measure of a statistical aggregate) did not meet or interact and therefore did not represent a psychological entity. Averaging, best member of a statistical aggregate (SB), and statistical pooling (SP) were models of group behavior based on combinations of individual performance. In statistical-pooling models, experimenters summed the behavior or best ideas of several individuals who had worked separately. These and more complex

models attempted to describe social processes or social combination schemes that were impossible or inordinately difficult to observe (Davis, 1969a). Are groups superior to aggregates? Are groups superior to the best individual in an aggregate? Can group interaction lead to the development of new ideas from existing resources? Questions such as these are addressed in the following pages.

### Task Categories

Much problem-solving research has indicated that performance was affected by the task involved (Hackman & Morris, 1976; Hare, 1976; Hoffman, 1965). Task demands often elicited performance strategies that interacted with characteristics of the group (Hoffman, 1965; Hoffman & Smith, 1960). Several task categories and taxonomies have been suggested (e.g., Davis, 1969a; Duncan, 1959; Guilford, 1956; Lamm & Trommsdorff, 1973; McGrath & Altman, 1966; Steiner, 1972).

In the comparison of groups and individuals, most experimenters seemed to select a task that illustrated a particular performance dimension. Some studies reported more than one assessment of performance—for example, quantity of solutions (e.g., Laughlin, Kerr, Davis, Halff, & Marciniak, 1975r), quality of solutions (e.g., Campbell, 1968r), trials to solution (e.g., Laughlin & Jaccard, 1975r), and time to solution (e.g., Davis, 1969rb)—whereas others tested the generality of their findings along a task dimension—for example, difficulty (Bray, Kerr, & Atkin, 1978r), sensory modality (Laughlin, Kalowski, Metzler, Ostap, & Venclovas, 1968r), or sanction (Sampson, 1963r). Results sometimes depended on the dependent variable used. In the following pages, studies are discussed in six categories that reflect task demands: learning / concept attainment, concept mastery and creativity, abstract problem solving, brainstorming, and complex problem solving.

### *Learning/Concept-Attainment Tasks*

In learning tasks, group performance was consistently superior to the performance of

an individual. For example, in a study of concept identification using visual, auditory, and mixed visual-auditory stimuli (Laughlin, Kalowski et al., 1968r), groups (CG2) generally required fewer trials to solution than did individuals (I); superiority was greatest for the task (visual) that required the most trials to solution. In a motor learning task (pursuit rotor), groups (CG2-CG2 and CG4-CG4) were superior to individuals (I-I) for mean percentage of time on target (Wegner & Zeaman, 1956r); groups benefited from multiple sources of random error that counteracted each other.

In verbal learning tasks, groups seemed to benefit from error correction when the group pooled its responses. In syllable recall (Ryack, 1965r), pooling of responses increased the probability that a syllable would be correctly recalled. Groups (CG2) and statistical pooling (SP) produced a similar number of errors to criterion and made fewer errors than did the average individual (I) or the best individual (SB) in a statistical aggregate. In number recall (Morrisette, Crannell, & Switzer, 1964r), groups (CG5) made both fewer errors and fewer correct responses than did statistical pooling (SP), but this may have been caused by time limitations (6 minutes), insofar as group members contributed sequentially, whereas members of statistical aggregates contributed simultaneously.

In concept attainment, group performance seemed to involve more than pooling responses and correcting errors. Groups and individuals used qualitatively different learning strategies. When presented with form display and sequence display concept-attainment tasks, groups (CG2) used a focusing strategy more often than did individuals (I) or the best member of a statistical aggregate (SB; Laughlin, 1965r; Laughlin & Jaccard, 1975r). Focusing was defined as

[testing] the relevance of all the possible hypotheses involved in a particular attribute or attributes by choosing a card differing in one (conservative focusing) or more (focus gambling) attributes from a positive focus card. (Laughlin, 1965r, p. 323)

Groups also made fewer repetitions of card choices and hypotheses, made fewer untenable hypotheses, and required fewer card

choices and hypotheses to solution than did individuals, but they required the same number of card choices to solution as did best members of statistical aggregates and required more time to solution than did individuals.

In a follow-up, use of a focusing strategy by individuals (I) and groups (CG2) was studied for eight concept rules (Laughlin, McGlynn, Anderson, & Jacobson, 1968r). Groups used the focusing strategy more than did individuals for concept rules that required the fewest card choices to solution (i.e., for conjunctive absence, exclusion, exclusive disjunctive, and biconditional but not for conjunctive, inclusive disjunctive, conditional, or disjunctive absence). Discussion may have led to adoption of the focusing strategy, but no confirming data were reported. Groups again made fewer untenable hypotheses and required fewer card choices to solution than did individuals for all concept rules, although superiority declined over successive problems. To see whether performance was determined by the best member's ability, interproblem correlations were computed. No group member was consistently "better" than the other: Group superiority seemed to be due to facilitative problem-solving processes beyond the dominance of one problem solver. One problem solver or a subset of the group, however, may have affected others through incidental learning (Laughlin & Jaccard, 1975r). In concept attainment, observers (I or CI) of a group (CG2) that used focusing strategies subsequently required fewer trials to criterion than did those who had observed no one, and the latter required fewer trials to criterion than did those who had observed an individual who failed to use focusing strategies. Groups whose members had observed together (CI-CG2) required fewer trials to criterion than did groups whose members had observed individually (I-CG2).

For math education classes for fifth and sixth graders (Johnson et al., 1978r), learning scores of groups and individuals showed a narrow transfer of training effect. Retention scores of groups who had learned as a group (CG4-CG4) were superior to scores of groups who had learned as individuals (CI-CG4). When the retention test was

taken individually, however, scores for those who had learned as individuals (CI-CI) were higher than for those who had learned in a group (CG4-CI). Individuals who had learned in a group (CG4-CI) showed a more positive attitude toward peers and teachers, a stronger sense of success, and a stronger sense of personal causation than those who learned as individuals (CI-CI).

To summarize: In research involving learning and concept-attainment tasks, group performance was usually superior to individual performance because of the group's ability to pool their resources, to correct errors, and to use qualitatively different learning strategies. Groups tended to use a focusing strategy more often than did individuals for concept attainment, but group superiority was not found for all concept rules. Incidental learning affected performance in concept attainment and affected both attitudes and performance in a self-instruction program.

### *Concept Mastery and Creativity Tasks*

Concept mastery and creativity tasks have been used to investigate the effects of member ability. Steiner's (1966) complementary task model assumed that each group member possessed abilities unshared by other members and that by combining these abilities groups could surpass the performance of persons working independently (see Laughlin, Branch, & Johnson, 1969r). In an investigation of this theory (Laughlin & Johnson, 1966), group members were first tested as individuals and then retested in homogeneous or heterogeneous groups. In heterogeneous groups, an individual working with a partner of greater ability seemed to perform better than an individual working alone or with a partner of lesser ability. In homogeneous groups, the unshared resources contributed by a group member seemed to increase with ability level (i.e., in high-ability groups, members had a greater number of unshared resources than did members in low-ability groups). The complementary task model, then, seemed to be increasingly accurate as the ability level of the group increased.

In a more precise test, using Part I (Syn-

onyms and Antonyms) of the Terman Concept Mastery Test (Laughlin et al., 1969r), the complementary task model was supported for high (H) levels of ability but not for medium (M) or low (L) levels. In homogeneous groups, high-ability groups (CG3) made higher scores than did high-ability coacting individuals (CI), that is,  $HHH > H$ ; but medium- and low-ability groups did not differ from medium- and low-ability individuals, respectively (i.e.,  $MMM > M$ ,  $LLL > L$ ), suggesting a large overlap in ability. In heterogeneous groups, performance was generally proportional to the sum of the represented ability levels (e.g.,  $HHM > HML$ ), but the relative contribution made by medium-ability persons was greater in groups that included a person of high ability than in groups that did not.

Similar results were found for four-person groups (Laughlin & Branch, 1972r). Scores of high- and medium-ability homogeneous groups (CG4) were significantly higher on the Terman Concept Mastery Test than scores of high- and medium-ability coacting individuals (CI), respectively (i.e.,  $HHHH > H$ ,  $MMMM > M$ ), and scores of low-ability groups did not differ from low-ability individuals (i.e.,  $LLLL \sim L$ ). In heterogeneous groups, performance of high-ability individuals seemed to be detrimentally affected by non-high-ability members. Although groups with three or four high-ability members performed significantly better than all other groups and individuals, the performance of groups with only one or two high-ability members was lower than predicted (e.g.,  $H > HLLL$ ,  $H > HHML$ ,  $HMMM > HHML$ ). High-ability individuals performed better than any group not containing a high-ability member (e.g.,  $H > MMMM$ ), but a group with only one high-ability member did not perform better than a group with no high-ability member (e.g.,  $HMMM > MMMM$ ). Because the Terman items were not "eureka-type" items, a group member who knew the correct answer may not have been able to persuade other members to accept it (Laughlin & Bitz, 1975r).

Because "division-of-ability" potential of group members may have been confounded with decision strategies in the Terman Con-

cept Mastery Test, a subsequent study (Laughlin & Bitz, 1975r) used the word association items of the Remote Associates Test (RAT), whose items were believed to be eureka tasks; that is, solutions would be readily recognized (truth-wins decision strategy). Research supported the prediction that heterogeneous ability levels of group members would be more evident from performance on the RAT: Low-, medium-, and high-ability persons contributed to the performance of low-, medium-, and high-ability partners, respectively (e.g.,  $LL > L$ ,  $MM > M$ ,  $HH > H$ ). Accuracy of a truth-wins decision model was also supported: Low- and medium-ability partners contributed to the performance of persons of medium and high ability, respectively (e.g.,  $LM > M$ ,  $MH > H$ ). These results were consistent with an earlier report (Amaria, Biran, & Leith, 1964r) that mixed-ability group members learned from each other as well as from a self-instructional program about levers. Scores of high- and low-ability coacting individuals (CI) were higher for those who had worked in mixed-ability groups (CG2) rather than in homogeneous groups or as individuals (I).

In order to investigate decision strategies, the Terman Concept Mastery Test was administered to see which of nine a priori decision schemes<sup>2</sup> were used by high- or low-ability groups (Laughlin, et al., 1975r). College students first took the test as coacting individuals to determine ability levels and then took the test again either individually (CI-CI) or in groups (CI-CG2, CI-CG3, CI-CG5). The performance of all group sizes was superior to that of coacting individuals. The best fitting models—for high-ability groups (CG3, CG5) only—were truth-supported wins and majority if correct, equiprobability otherwise. Surprisingly, groups with one previously correct member seemed to have a lower probability of submitting a correct response than did groups with no previously correct members.

When the Visualizing Relations Test (Laughlin & Adamopoulos, 1980r) was used, further evidence for the truth-supported wins model was found through model fitting and model testing (see Kerr, Stasser,

& Davis, 1979). Group performance (CI-CG6) was superior to coacting individual performance (CI-CI). Groups who had previously worked as individuals (CI-CG6) and individuals who had previously worked in a group (CI-CG6-CI) performed better than individuals who had worked only individually (CI-CI-CI). Two correct group members had a probability of .67 of persuading up to four incorrect members to accept the correct answer. Three or more correct members were "virtually certain to prevail." An initially incorrect individual who subsequently performed in a correct group, however, had a probability of .80 of being correct in the third testing (CI-CG6-CI), whereas an initially correct individual who subsequently performed in an incorrect group had a probability of .36 of being correct.

Comparison of the RAT with the Otis Quick-Scoring Mental Ability Test (Laughlin, Kerr, Munch, & Haggarty, 1976r) later showed that decision strategies were affected by task differences. Groups (CG4) were superior to individuals (I), but group performance on the RAT seemed to be influenced by a truth-wins decision strategy, whereas performance on the Otis seemed to be influenced by a more complicated strategy that was similar to truth-supported wins.

In sum, research with the Terman Concept Mastery Test indicated that there was a greater number of unshared resources among high-ability group members than among low-ability members and that the contribution of medium-ability members was greater when working with a high-ability partner than with a low-ability partner. When sharing of resources was not followed by a truth-wins decision strategy, the level of group performance did not equal the level of the best member. Heterogeneity of resources at low ability levels was seen in the Remote Associates Test, indicating that eureka tasks were more amenable to a truth-

<sup>2</sup> The nine a priori decision schemes were equiprobability, proportionality, truth-wins, truth-supported wins, majority (equiprobability otherwise), majority if correct (equiprobability otherwise), majority if incorrect (equiprobability otherwise), error-wins, and error-supported wins.

wins decision strategy and involved less hindrance from low-ability members than did noneureka tasks. Further research on decision strategies is cited in the discussion of group versus individual process.

### *Problem Solving*

*Abstract problems.* Some of the earliest evidence that groups pooled information and corrected errors was found in the study of abstract problems. On the basis of informal observations and subjective interpretation of percentages of groups solving three variations of four types of problems (the Tartaglia Problem—three versions<sup>3</sup>: a prose completion task, a sonnet completion task, and a school bus route problem), Shaw (1932r) concluded that groups (CG4) tended to make their first error at a later stage in the problem-solving process and produced a larger proportion of correct solutions than did coacting individuals (CI). Groups took more time to solution but had more correct solutions than did individuals. Incorrect suggestions were more often rejected by another member of the group than by the individual who proposed it.

Additional support for error checking in groups was reported when a Twenty Questions Problem was used (Taylor & Faust, 1952r). Participants were allowed 20 questions in which to name an object identified as either animal, vegetable, or mineral. Tetrads (CG4) made fewer failures per problem and required less time per problem than did dyads (CG2), which made fewer failures and required less time than did individuals (I), suggesting that a greater number of member contributions reduced the likelihood of persisting in a wrong questioning set. Dyads and tetrads also required fewer questions per problem than did individuals, but they did not differ significantly from each other. For tetrads there seemed to be a tendency for the member getting the correct answer to ask more questions than other members of the group (i.e., the most competent member seemed to play the largest part in solving the problem).

A reanalysis and expansion of Shaw's (1932r) research (Marquart, 1955r) provided further evidence of the influence of the

group's most competent member. Eight problems were used, four of which were "the same or closely parallel to four of those used by Shaw" (Marquart, 1955r, p. 104). Groups (CG3) produced more correct solutions than did coacting individuals (CI), but they produced about the same number of solutions as did the best member of statistical aggregates (CSB) and took approximately the same amount of time to solution. Groups benefited from the aggregation of members, which increased the probability of including at least one exceptionally competent member, indicating that groups should be compared with statistical pooling (SP) of the responses of an equal number of individuals or with the best member (SB) of a statistical aggregate. These conclusions were partially supported in a study of spatial and anagram tasks (Faust, 1959r): Groups (CG4) solved more spatial and verbal problems than did coacting individuals (CI), but groups and best members of statistical aggregates (CSB) solved a similar number of spatial problems. Groups solved significantly more anagram problems than did best member statistical aggregates in one sample of college students but not in another.

When the problem was complex or difficult, the most proficient group member seemed to draw on the resources of other members to complete the task. In a comparison of easy and difficult crossword puzzles (Shaw & Ashton, 1976r), easy puzzles were completed relatively quickly by a competent group member, and solutions were readily adopted by other members. The number of successful groups (CG3) was proportional to the number of individuals (I) in the sample who could successfully solve the problem. When the puzzle was difficult, however, the proportion of successful groups was greater than the proportion of successful individuals, implying that groups pooled their resources when no member could solve the problem alone. Group productivity

<sup>3</sup> The task was to move three Cannibals and three Missionaries from side A to side B of a river by means of a boat that can carry only two persons at a time. All of the Missionaries and one Cannibal can row. Never may the Missionaries be outnumbered by the Cannibals except when there are no Missionaries present.



seemed to be determined by the most competent group member, plus "assembly bonus effects," minus losses due to faulty group process (process loss). Assembly bonus effects were defined as an increase in group effectiveness resulting from efficient group interaction (see Collins & Guetzkow, 1964).

Two kinds of behavior seemed necessary for achieving assembly bonus effects: pooling of pieces of information and integrating these pieces to form a solution. In a study of information processing and code diagnosticity (Howell et al., 1970r), group performance was augmented when information was common to more than one member and when integration of complementary information was allowed. Individuals (I) and dispersed groups (DG) made a greater number of optimal choices and had smaller mean differences between optimal and actual choices than was found in statistical pooling of responses (SP). On both measures, performance was better in dispersed groups whose communication network was decentralized (DG2) rather than centralized (DG3), suggesting that method of information integration could be a source of process loss.

In sum, the superiority of groups over individuals in abstract tasks seemed to be due mainly to the aggregation of member resources. When the task was difficult, group members pooled and integrated their resources and corrected each other's errors. For easy tasks, performance was often determined by one competent member. The group's size increased its probability of containing at least one member who could solve the problem. For multiple stage problems, groups had a greater probability than did individuals that at least one member would be able to solve each stage. It should be noted, however, that the concept of probability implies that highly competent members would be uncommon if the distribution of abilities followed a normal curve. Most large groups would include a large proportion of medium- and low-ability members who, as we have seen in the discussion of concept mastery and creativity tasks, may hinder performance on complex tasks. Process loss may result from centralization of the communication network.

*Brainstorming.* Brainstorming tasks differed from learning, concept-mastery, and abstract tasks in that brainstorming produced more than one correct solution. Osborn (1963) believed that brainstorming groups could stimulate the production of ideas beyond the number that could have been produced by an individual. His idea was supported in a study (Buchanan & Lindgren, 1973r) of fourth-grade students: Coacting individuals who had practiced brainstorming as a group (CG-CI) made significantly more responses and demonstrated a higher level of creativity than did those who had practiced individually (CI-CI).

A number of imaginative problems have been used. For example, (a) what would happen if everyone after 1960 had an extra thumb on each hand (Thumbs Problem), (b) what different steps might be taken to ensure that schools will provide effective instruction in light of increasing enrollment (Education Problem), (c) what would be the consequences and what adjustments would be required if the average height of Americans at age 20 had increased to 80 inches and the average weight had almost doubled (People Problem), and (d) what steps can you suggest to get more European tourists to come to this country (Tourist Problem; Dunnett et al., 1963)? In several studies, type of problem affected performance. For example, (a) the People Problem elicited significantly fewer ideas than did the Thumbs Problem (for advertising personnel but not for business researchers from the same corporation; Dunnette et al., 1963); (b) a significantly smaller number of ideas was produced on socially relevant problems (overpopulation and pollution) than on the unrealistic Thumbs Problem, even though participants were told that all ideas would be used by local agencies; and (c) brainstorming was inhibited on a politically relevant problem, namely, what can you as an individual do to influence United States foreign policy (Dillon, Graham, & Aidells, 1972r). Some inconsistencies may have been caused by differences in instructions (Dillon et al., 1972r; Harari & Graham, 1975r; Osborn, 1963); for example, the Thumbs Problem asked for potential consequences of

the problem, whereas the Tourist and Education Problems asked for solutions.

Across all problems, however, scores from statistical pooling (SP, CSP) were equal to or greater than those of groups (e.g., Dillon et al., 1972r; Harari & Graham, 1975r). In order to eliminate redundancies in the group product, researchers counted the number of unique ideas produced or the number of unique ideas produced per problem instead of the total number of ideas. For the Thumbs and Tourist Problems, statistical pooling of responses (SP, CSP) produced more unique ideas than did groups (CG) and more ideas of high quality on three dimensions: effectiveness, generality, and feasibility (Dunnette et al., 1963; Milton, 1965r; Taylor, Berry, & Block, 1958r). When total number of responses (including redundancies) was statistically controlled (through analysis of covariance), however, statistical pooling was superior to group responses in number of unique ideas and in number of high-quality ideas for the Thumbs Problem (Taylor et al., 1958r) and produced a greater number of ideas of high quality on three dimensions: probability, significance, and generality. In each of these cases, statistical pooling had the benefit of simultaneous division of labor (writing), which allowed a larger response rate than did serial division of labor (verbalizing) in groups. If a form of simultaneous division of labor (e.g., writing) were used in groups, it might reduce time requirements and production blocking (member distraction due to group interaction; Lamm & Trommsdorff, 1973). Production blocking might also be reduced if members were asked to contribute within a category of thought. For example, in naming a toothpaste, the categories might be sex appeal (Close-Up), hygiene appeal (Ultrabrite), fear of decay (Aim), appetite/palatability (Pepsodent), or symptom relief (Sensodyne). A theme (e.g., historical, artistic, outer-space) introduced by any member could find application in all categories. This type of procedure would allow individuals to follow idiosyncratic lines of thought and would reduce hindrance by less productive members.

An attempt to combine the advantages of statistical pooling and group interaction was

made by using a written feedback condition (individual brainstorming plus exchange of written ideas). Dispersed groups (CI-DG4) and statistical pooling (CSP-CSP) produced significantly more solutions than did coacting groups (CG4-CG4) when they were asked to propose names for a new toothpaste (Toothpaste Problem), suggesting that it was not the pooling process but other group processes that inhibited brainstorming (Madsen & Finger, 1978r). On the Thumbs Problem, however, no differences were found between conditions. The authors suggested that the results differed because participants responded with "single unscorable generalizations" on the Thumbs Problem but with "variations on a theme" for the Toothpaste Problem.

In another programmatic approach (Van de Ven & Delbecq, 1974r), brainstorming, feedback, and decision making were combined to produce a job description for part-time student dormitory counselors. The approach was called the "nominal group technique" (NGT): Coacting individual (CI) brainstorming was followed by a group (CG7) round-robin procedure for recording ideas, group discussion for clarification and evaluation, and independent voting to arrive at a group decision. NGT was tested against the delphi technique (Dalkey, 1969) in which individuals did not meet face-to-face: A questionnaire was mailed to respondents asking them to generate ideas independently; the returned responses were summarized and sent back to the respondents with a questionnaire probing more deeply into the ideas; respondents voted independently on the priority of the summarized ideas and returned them and the questionnaire to the experimenters; a final summary and feedback report that were developed from these responses was then mailed back to the respondent groups. NGT and the delphi procedure did not differ in quantity of unique ideas produced, but both produced significantly more unique ideas than did coacting groups, again suggesting that interaction rather than information pooling was responsible for inhibition of brainstorming performance. NGT groups expressed significantly greater satisfaction with their group process

than did either delphi or coacting groups, which did not differ significantly from each other.

Two studies raised doubts about the effectiveness of programmatic approaches. In a study using the Tourist and Education Problems (Rotter & Portugal, 1969r), persons who were given instructions as an aggregate and subsequently brainstormed individually (CI-I) produced more solutions than did either groups (CI-CG4) or mixed conditions (CI-I-CG4 and CI-CG4-CI). Similar results were found in a study of executive decision making (Schoner, Rose, & Hoyt, 1974r) and a study using the Change of Work Procedure Problem (Campbell, 1968r) to be discussed with complex problem-solving tasks. These findings are inconsistent, however, with findings (Dunnette et al., 1963) that statistical pooling produced more responses when individuals had previously brainstormed as a group (CG4-SP) than when they had not (SP), that is,  $CI-I > CI-CG4-CI$ , but  $CG4-SP > SP$ .

In sum, statistical pooling of individual responses frequently produced a greater number of unique ideas than did group interaction in brainstorming because of the ability of individuals to produce a greater number of ideas when working separately. More ideas were produced on fanciful tasks than on realistic problems possibly because of the type of instructions received, consequences related to the ideas produced, or scoring procedures that counted "variations on a theme" as unique responses. In programmatic approaches to brainstorming, idea production increased when information was pooled in writing but decreased when information was pooled through discussion. Use of a nominal group technique that combined individual brainstorming, group discussion of ideas, and a group selection of the best idea resulted in a level of performance equal to that obtained from exchange of written information, but NGT members expressed greater satisfaction with task process. Neither programmatic approach, however, produced more solutions than did individual performance.

**Complex problems.** Complex problems were similar to brainstorming tasks in that

more than one correct or acceptable answer was allowed. Again, group performance tended to be superior to individual performance but inferior to statistical pooling of responses.

Researchers used complex problems to make the task as realistic as possible. For example, a Mined Road Problem was constructed in an open-country field for the training of Air Force Reserve Officers (Lorge, Tuckman, Aikman, Spiegel, & Moss, 1955r). The task was to formulate a plan for getting five men across a road embedded with supersensitive enemy mines that could be neither neutralized nor removed. No differences, however, were found between conditions that (a) presented the field problem but did not allow manipulation of objects in the problem, (b) presented the field problem and did allow manipulation short of carrying out the solution, or (c) presented the field problem and required carrying out the solution. Across all conditions, the quality of group (CG5) solutions was superior to that of individual (I) solutions.

In a subsequent study (Tuckman & Lorge, 1962r), the Mined Road Problem was used in written format only. Air Force Officers first practiced individually (I) and then resolved the problem as individuals (I) or in groups (CG5). Group re-solving performance (I-CG5) was superior to individual re-solving performance (I-I), but groups did not incorporate some of the best ideas previously produced by their members. Groups adopted solutions of their three best members but never of their poorest members: 79% of the re-solving group solutions were as good as or better than their best member's score individually (I), but 11% were poorer than their best member's score.

In a study involving the Change of Work Procedure (CWP) Problem (Campbell, 1968r), similar performance losses were seen: Statistical pooling of responses (SP) and the average coacting individual (CI) both scored higher than groups (I-CG4-CI-CG4). The CWP (Maier, Solem, & Maier, 1957) was a simulated conflict negotiation between supervisor and employees where the supervisor's proposal to change the work method is met with resistance from employ-

ees. Second- and third-line managers in an industrial setting (the subjects) wrote solutions to the problem in response to a mail request; they discussed solutions in a brainstorming format, again wrote down their individual solutions, and then participated in group selection of a solution (CI-CG4-CI-CG4). A control group (CG4) worked on the Circular Assembly Problem (CAP; Maier et al., 1957) that was also a conflict negotiation problem involving work methods and human relations. A comparison of experimental (CWP) and control (CAP) conditions indicated that practice effects were not significant. There was no significant change in the average coacting individual's (CI) solution score after participating in group discussion. Group interaction seemed to be hindered in the decision-making stage where the truth-wins decision strategy may have failed.

In order to find whether research results reflected the decision strategies inherent in statistical models, the scores of groups (CG5) and coacting individuals (CI) were compared with scores based on a plurality model (CSM), best member (CSB) of a statistical aggregate, or incidence of proficient individuals in the population (probability model, CSM; Schoner et al., 1974r). Statistical pooling (SP) was not tested. Three executive marketing decision tasks were used: (a) choosing one of four regions in which to build an assembly plant, (b) deciding whether to produce a quantity of paint that may soon be made obsolete by a competitor, and (c) deciding whether or not to pay a research firm for information on a competitor's product. Group solutions tended to be superior to solutions of coacting individuals or plurality vote groups but inferior to solutions of best-member statistical aggregates and the probability model, implying that groups were not able to use fully the expertise of group members (posttests were not reported).

In an attempt to improve performance, groups were trained in group dynamics and allowed more time for interaction (Fox & Lorge, 1962r). Students in an Air Force Field Officers' course were asked for a plan to improve the morale and operating efficiency of persons stationed at isolated weather stations in the Arctic. Before train-

ing, increasing the time available for solution resulted in a significant increase in the quality of decisions written by groups (CG6) but not by coacting individuals (CI). Individual solutions were superior to group solutions when 50 minutes were allowed but not when 100 minutes were allowed. After training in group process and problem solving, increasing the time available resulted in significant increases in the quality of decisions made by both groups and individuals, but groups were superior to individuals. On the average, group solutions before and after training were better than solutions of the worst individuals but not better than solutions of the best individual (CSB) in a statistical aggregate.

The probability that an idea would be included in a group's solution may have been a function of the commonality of the idea, that is, the number of individuals who had the same idea prior to the group meeting (Lorge, Davitz, Fox, & Harrold, Note 1; cf. Lorge et al., 1958). Lorge et al. (Note 1) found that only 10% of the ideas possessed by only one person prior to the group meeting were ultimately included in the group solution. One-third of the ideas that were included in the group solution, however, had not been evident in prior individual performance, suggesting that new ideas emerged from group interaction.

In the use of an approximation of the delphi technique (Dalkey, 1969), an attempt was made to combine individual and group performance strategies (Gustafson, Shukla, Delbecq, & Walster, 1973r). Persons were given anthropometric data (heights and weights of men and women) and were asked to make eight logarithmically calibrated likelihood estimates, for example: "The observed height of a person is 68 inches. Is the person more likely to be a man or a woman? How much more likely?" Significant differences were found among four conditions: Estimate (CI), Estimate-Talk-Estimate (CI-CG-CI), Talk-Estimate (CG-CI), and Estimate-Feedback-Estimate (CI-DG-DG). Feedback in the Estimate-Feedback-Estimate condition consisted of exchange of written estimates. The Estimate-Talk-Estimate condition produced more accurate estimates than did the Talk-Estimate condi-

tion; The Estimate and Estimate-Feedback-Estimate conditions were the least accurate. (Posttests were not reported.) These results were congruent with those found for abstract problems where group interaction was dysfunctional during the idea generation phase but was beneficial for integration of complementary information (Howell et al., 1970r) and for clarification and justification in the evaluation phase (Dunnette, 1964; Vroom, Grant, & Cotton, 1969). Discussion increased solution accuracy (error correction) more than did written feedback.

In sum, group performance was usually superior to individual performance but did not achieve the potential suggested by statistical pooling models, even though some group members were trained in group dynamics and problem solving. The result of member interaction was superior to written feedback without discussion. Groups did not always incorporate the best ideas of their members. The following pages look at some phenomena that have led to process loss and process gain.

### Process and Process Interventions

Many studies of individual versus group performance have examined the effects of group process, but few have studied the psychological or interpersonal processes themselves. The studies in this section are divided into these categories: (a) indirect study of process through manipulations such as training, practice, and feedback and (b) direct study of processes such as learning strategies or decision strategies. There is a great need for multivariate research in these areas; most studies have tested only one or two main effects. The relation between specific processes and effects has largely been neglected.

### Process Interventions

Process interventions have shown that practice, training, and task consequences have affected performance. As indicated above, the effects of practice have varied considerably across tasks: (a) Groups (CG2, CG4) benefited more than individuals (I) from training in problem solving and group dynamics (Fox & Lorge, 1962r) and from practice on a pursuit rotor task (learning;

Wegner & Zeaman, 1956r), (b) individuals (I) benefited more than groups (CG4) from practice in brainstorming (Dunnette et al., 1963), (c) individuals (I) and groups (CG2, CG4) improved equally after practice on a conceptual task (Twenty Questions Problem; Taylor & Faust, 1952r), and (d) group (CG2, CG4) practice had no effect on a complex problem-solving task (Campbell, 1968r; Tuckman & Lorge, 1962r; see also Laughlin & Sweeney, 1977r). In math education, group (CG4) scores during practice were not maintained when members were tested as coacting individuals (CI; Johnson et al., 1978r). Although researchers have used practice trials for warm-up (Milton, 1965r) or to equalize performance levels of participants before introducing the experimental conditions (Wegner & Zeaman, 1956r), the effects of practice were not verified.

Several studies indicated the need to distinguish training and practice from transfer: In concept attainment, groups (CG) of two or more members attained concepts in less time than did individuals (I) during training, but individuals took less time than did groups during transfer (Lemke, Randle, & Robertshaw, 1969r). Incidental learning of poor concept-attainment strategies (Laughlin & Jaccard, 1975r) suggested that training effects may occur through task feedback or through information obtained from observing others. In brainstorming (Dillon et al., 1972r) the inhibiting effect of training negated the positive effects of practice, possibly because training groups felt overwhelmed and intimidated after watching a videotape of a model group that violated no brainstorming rules (see also Colleros & Anderson, 1969). Members who did not view the videotape benefited from practice.

Task consequences (e.g., rewards) also affected performance, but groups and individuals were affected differently. In a circle drawing task, rewards were more motivating than fines when subjects were evaluated and sanctioned individually (I-I), but fines were more motivating than rewards when the subjects were evaluated and sanctioned as a dispersed group (DG4-DG4; Sampson, 1963r). When subjects were evaluated individually but sanctioned as a group, rewards and fines were equally motivating.

Those in the reward condition liked their sanctioner (leader) better than did those in the fine condition.

In sum, process manipulations showed that group problem-solving proficiency could be improved with training, that practice effects varied with training and transfer conditions, that transfer was greatest when training and transfer conditions were similar in social milieu, that training and practice effects can counteract each other, and that groups and individuals were not similarly influenced by task consequences (rewards were more motivating than fines when persons were sanctioned as a group).

### *Direct Study of Process*

Because the components of individual and group process were difficult to observe, some researchers attempted to identify them through statistical models (SM) that predicted solution time based on hypothesized group processes, number of persons involved, and number of subproblems or problem stages (Davis, 1969rb; Restle & Davis, 1962). Two models suggested general sources of variance: (a) A pooling-of-contributions model indicated that group members who did not solve a problem nevertheless consumed their share of group time (Restle & Davis, 1962), and (b) a parts-process model suggested that individuals did not solve subproblems in an ordered sequence, but this model was not supported for groups (Davis, 1969rb).

Several specific sources of variance were suggested. In a group context, some part of solution time was required for voice communication (Howell et al., 1970r). Some other part of solution time might have been required for task familiarization (e.g., gathering information about the task, recalling relevant facts or experience, or integrating dimensions of the problem). For example, groups (CG5) working on the Mined Road Problem (Lorge et al., 1955r) often required excessive time in laboratory settings where members had little room to gather information simultaneously, whereas individual (I) solution time was not affected by type of task presentation (verbal description, photographic representation, miniature scale

model, or a full-scale field simulation). In a subsequent study using the Mined Road Problem (Tuckman & Lorge, 1962r), resolving groups (I-CG5) took less time to solve than groups solving for the first time (CG5).

Another part of solution time might have been required for members to become familiar with each other and to coordinate member input. In Air Force Field Officers' training (Fox & Lorge, 1962r), groups (CG6) were inferior to coacting individuals (CI; when 50 minutes were allowed) before training in problem-solving and group dynamics but superior after training.

A major part of solution time seemed to be devoted to strategies for task solution. Several studies indicated that individuals and groups used different problem-solving processes, for example, different learning strategies in concept attainment (Laughlin, 1965r; Laughlin, McGlynn et al., 1968r).

Group discussion even seemed to create ad hoc norms. In a Choice Dilemma task, risk-oriented discussion led to risk taking and pessimism in groups (CG4) but not in coacting individuals (CI; Lamm, Trommsdorff, & Kogan, 1970r). For an impossible circle drawing task (Rettig, 1966r), however, discussion unrelated to risk taking was followed by risk taking in dispersed groups (DG3) but not in individuals (I). In a group setting, members seemed willing to involve others in risk taking but unwilling to assume responsibility for the other (Zaleska & Kogan, 1971r). When making a decision for another person in a gambling task, groups (I-CG) of from three to six members chose high-risk gambling, whereas individuals (I-I) tended to choose conservative gambling. In a study of "risky aggression" (Yinnon, Jaffe, & Feshbach, 1975r), where the "Other" agreed to the conditions of participation and shared in the rewards in a concept-attainment task, groups (CG3) showed higher levels of aggression than did individuals (I) by administering higher levels of electric shock for incorrect learner responses (38 out of 45 individuals and 39 out of 42 groups chose electric shock instead of a flashing light as a means of teaching the Other). Rewards were higher (for both decision maker and learner) in the electric

shock condition, and the payoff increased if the concept was learned in a small number of trials. When asked to advise a bogus learner who was subsequently unsuccessful (Mynatt & Sherman, 1975r), group (CG5) members were less likely than individuals (I) to assume responsibility for the result, to believe that the advisee often took their advice, or to believe their advice had much influence on the advisee's decisions.

This tendency to diffuse responsibility in a group may have been related to a phenomenon called "social loafing" (Latané, Williams, & Harkins, 1979r). When university students were asked to clap or shout in groups (CG2, CG4, CG6) or as coacting individuals (CI), the average sound pressure generated per person in a group was 36%–72% of the sound pressure generated as a coacting individual. This decrease of effort in groups seemed to be caused by members who (a) attempted to maintain an equitable division of labor, (b) perceived the task as an optimizing task (attempting to reach an optimal level of sound output) rather than a maximizing task (students were actually instructed to yell "as loud as you can"), or (c) felt that the contingency between their input and the outcome was lessened in the group context (loss of control over rewards). This research confirms an earlier study (Bray et al., 1978r) that concluded that the "functional size" of a group was a subset of its actual size. Groups (CG2, CG3, CG6, CG10) produced more correct solutions on easy and moderate problems than did individuals (I), but groups and individuals produced about the same proportion of correct solutions for difficult problems and did not differ in time to solution regardless of difficulty. Two statistical models (equalitarian and hierarchical; SM), based on group size, overpredicted group performance. In measures of group atmosphere, members indicated that the preferred group size was from three to six members and that satisfaction and involvement were greater in small groups (CG2, CG3) than in large groups (CG6, CG10).

Another major part of solution time seemed to be required for decision making, as seen most clearly in problem-solving tasks where only one solution could be submitted

by the group. When a task had only one solution, experimenters often assumed that any member of the group who knew the solution could convince others to accept it (truth wins; Faust, 1959r; Ryack, 1965r). This model seemed accurate for both groups (CG2) and coacting individuals (CI) for eureka problems where the correct answer was easily identified (Laughlin & Bitz, 1975r), but when the problem was complex or subject to interpretation, the correct member was sometimes overruled by an incorrect subgroup (Faust, 1959r; Laughlin & Bitz, 1975r; see also Steiner, 1972). The probability of being overruled by incorrect members was most likely in groups of low ability. For high-ability groups, the solution was usually determined by a correct member supported by at least one other member (truth-supported wins), by a majority (majority rules), or by equiprobability if there was not a majority consensus (majority rules, equiprobability otherwise). In general, the decision seemed to be a function of the probability of a correct response (i.e., the proportion of persons capable of solving), with an additional increment from the influence of more than one correct advocate (Laughlin et al., 1975r). The prevailing decision scheme, however, could also be influenced by the type of task (Laughlin et al., 1976r).

In sum, solution times of groups and individuals seemed to be determined by needs for communication, task familiarization, coordination of member input, strategies for task solution, and decision making. The extent to which these processes overlapped was not clear. Groups used a focusing strategy more than did individuals, made riskier decisions, less frequently assumed responsibility for another member, and showed signs of "social loafing." Groups usually used truth-wins and majority-rules decision strategies to select the task solution.

### Individual Differences

The comparison of groups and individuals has been affected by three types of individual differences: ability, sex, and affiliation preference. For learning and concept-attainment tasks, groups (CG) were generally superior

to individuals (I; Laughlin & Bitz, 1975r; Laughlin & Branch, 1972r; Laughlin et al., 1969r; Laughlin & Jaccard, 1975r; Morrisette et al., 1964r; Wegner & Zeaman, 1956r). In one case (Terman Concept Mastery Test), however, a high-ability individual was superior to dyads and quads (e.g.,  $H > MMMM$  and  $H > HLLL$ ). In concept attainment, member ability was inconsistent across trials (Laughlin, McGlynn et al., 1968r). Only two studies (Laughlin et al., 1976r; Lemke et al., 1969r) however, reported tests of significant differences among high, medium, and low scorers.

Several instances have shown an interaction between sex and size of group. In a study of recall in information processing, there was less improvement for women than for men as individuals (I) but more improvement for women than for men in groups (CG5; Morrisette et al., 1964r). In concept attainment (Laughlin, McGlynn et al., 1968r), male groups (CG2) made more use of focusing strategies than did either female groups (CG2) or male/female individuals (I), suggesting that men benefited more than women from working with a partner. Significant higher order interactions were found for Sex  $\times$  Number of Persons  $\times$  Problem Type and for Sex  $\times$  Memory Aids  $\times$  Number of Persons.

The effect of affiliation preference was indicated in a study (Davis, 1969rb) involving a divisible problem (five simple arithmetic problems) and an indivisible (modified water jar) problem. On the average, groups (CG5) reached a solution significantly faster than did coacting individuals (CI). For the divisible problem, however, groups whose members preferred to work in groups also achieved a greater proportion of correct solutions than did groups whose members preferred to work individually. Preference to work alone may have been related to "self-orientation" as observed in brainstorming tasks (Campbell, 1968r). No significant interaction was found between orientation levels (self-orientation, interaction orientation, or task orientation) and group versus individual brainstorming performance on a human relations problem (Change of Work Procedure), but statistical pooling (SP) scores were positively related

to self-orientation and negatively related to interaction orientation. High self-orientation seemed to contribute to the superiority of statistical pooling (SP) over groups (CG4).

In summary, the comparison of groups and individuals may interact with individual differences in ability level, sex, memory, and affiliation preferences. High-ability individuals performed better than some mixed-ability groups. Men worked better with a partner on a concept-attainment task than did women, but the reverse was true for an information-processing task. Groups whose members preferred to work in a group performed better than groups whose members preferred to work as individuals.

#### Discussion: Four Types of Group-Individual Comparisons

Before proceeding, it should be noted that the above research may have been affected by several methodological or procedural variables. These are (a) the presence of the experimenter or experimenter-appointed group leader(s) (Bouchard, 1969; Bouchard & Hare, 1970; Kerr & Sullaway, in press), (b) the manner of recording group solutions (written versus tape recording; Bouchard, 1969; Horowitz & Newman, 1964; Laughlin, McGlynn et al., 1968r; Van de Ven & Delbecq, 1974r), (c) the amount of time allowed for solution (Davis, 1969a; Fox & Lorge, 1962r), (d) the type of instructions received by the subject (Dillon et al., 1972r; Weisskopf-Joelson & Eliseo, 1961r), (e) time of day (Bouchard, 1969), (f) performance criteria (Lamm & Trommsdorff, 1973), or (g) method of computing performance scores (Lamm & Trommsdorff, 1973). No study reported controlled cross-cultural comparisons, but a few implied cross-cultural replicability (Kanekar & Neelakantan, 1976; Kanekar & Rosenbaum, 1972; Lindgren & Lindgren, 1965; Zaleska & Kogan, 1971r). These points should be kept in mind as we examine four questions that underlie research comparing groups and individuals: (a) How does the performance of a group differ from that of an individual? (b) How does the performance of a group differ from that of the most



competent member of a statistical aggregate? (c) How does the performance of a group differ from statistical pooling of responses? (d) How accurate are math models in describing group processes?

*Group (DG or CG) Versus Individual (I or CI)*

Research in this area has focused largely on productivity comparisons. Group performance was often quantitatively superior to the performance of individuals, for example, number of correct solutions (Marquart, 1955r; Shaw, 1932r) or card choices to solution (Laughlin & Jaccard, 1975r), insofar as groups benefited from pooling of information, opportunities for one member to correct another's errors, and statistical cancellation of errors in the computation of average member performance. Groups were also qualitatively superior, for example, in complex problem solving (Schoner et al., 1974r; Tuckman & Lorge, 1962r), but group members contributed less when they preferred to work as individuals (Davis, 1969rb) and when their abilities were low (Laughlin et al., 1969r). Group superiority declined with practice, for example, in concept attainment (Laughlin, McGlynn et al., 1968r) and when group learning was transferred to individual performance (Johnson et al., 1978r).

Groups benefited from member aggregation in that the probability of including an exceptionally competent member increased with group size. The best member's contribution to the group product, however, was obscure.

*Group (DG or CG) Versus the Most Competent Member (SB or CSB) of a Statistical Aggregate*

In order to detect the effect of the most competent member, groups were compared with the best member of a statistical aggregate. Although group performance was often quantitatively similar to individual performance, for example, number completing crossword puzzles (Shaw & Ashton, 1976r), and qualitatively similar, for example, optimal solutions in an executive decision-making task (Schoner et al., 1974r), group per-

formance was sometimes better than a best member's performance, for example, number of correct solutions on an anagram task (Faust, 1959r), and sometimes worse, for example, scores on weather station morale problem (Fox & Lorge, 1962r). Interproblem correlations in a concept-attainment task showed that individual performance was not consistent within a class of problems (i.e., most groups did not contain a member who was consistently superior to the others). In some cases, the best member was hindered by working with less capable partners, for example, in problem solving (Laughlin & Bitz, 1975r; Laughlin & Branch, 1972r; Laughlin et al., 1969r), but hindrance was low when the solution was readily apparent, for example, eureka tasks (Laughlin & Bitz, 1975r). The group's performance was similar to that of its best member when working on an indivisible task.

*Group (DG or CG) Versus Statistically Pooled Responses (SP or CSP)*

For learning tasks and abstract problems, for example, syllable recall (Ryack, 1965r) and code diagnosticity (Howell et al., 1970r), group performance was similar to that of statistical pooling, supporting the pooling-of-information hypothesis. In brainstorming (Dillon et al., 1972r) and complex problem solving (Tuckman & Lorge, 1962r), however, group performance was inferior to statistical pooling. Process loss seemed to occur in one or more stages of group process: (a) aggregation of information (Lorge et al., 1955r; Tuckman & Lorge, 1962r), (b) integration of information (Howell et al., 1970r), (c) error checking or decision making, for example, failure of the truth-wins decision strategy (Laughlin & Branch, 1972r; Laughlin et al., 1969r; Schoner et al., 1974r), or (d) division of labor, for example, production blocking (Lamm & Trommsdorff, 1973) or nonproductive (self-) allocation of subtasks (Steiner, 1972).

In general, groups needed more process time than did statistical aggregates, for example, in number recall (Morrisette et al., 1964r) and in complex problem solving (Fox & Lorge, 1962r), insofar as groups contrib-

uted serially (verbally) rather than simultaneously (writing).

### *Group (DG or CG) Versus Math Models (SM or CSM)*

The complex models discussed in this review can be divided into two main categories: resource models and process models. One resource model (i.e., statistical pooling) showed that groups benefited from aggregation of resources (Shaw, 1932r) and division of labor (Marquart, 1955r) but that they often did not fully use member resources. A second model (Model A, Lorge & Solomon, 1955; Probability Model, Lorge & Solomon, 1955; Marquart, 1955r; Schoner et al., 1974r; Shaw & Ashton, 1976r) showed that one of the group's aggregated resources might be a highly competent person (i.e., its best member).

Process models were used to hypothesize the means by which individual efforts were combined. Research indicated (a) that group members who could not solve the problem nevertheless seemed to consume their share of group time (Equalitarian Model; Davis, 1969rb; Restle & Davis, 1962) rather than (b) that subjects who were "off the track" were nonfunctioning in their groups (Hierarchical Model; Davis, 1969rb; Restle & Davis, 1962), (c) that group superiority over individuals on a problem that involved two or more separate stages was a function of the pooling of abilities of group members across stages (Model B; Lorge & Solomon, 1955), (d) that the functional size of a group was smaller than the actual size (Bray et al., 1978r; Steiner & Rajaratnam, 1961), (e) that subproblems (parts of a task) were not necessarily solved in an ordered sequence (Parts Model; Davis, 1969rb) rather than (f) that group members each worked on the whole problem with solutions arising freely and independently (Parts Process Model; Davis, 1969rb), (g) that a person working with a partner of greater or comparable ability improved relative to her or his performance alone, whereas a person working with a partner of less ability did not (Complementary Task Model; Laughlin et al., 1969r; Laughlin & Johnson, 1966; Steiner, 1966), and (h) that a correct answer was adopted

by the group if and only if a member advocated it and it was supported by at least one other member (truth-supported wins and eight additional a priori social decision schemes; Laughlin et al., 1975r; see Laughlin, in press).

Other models that combine these processes may involve networks of variables (Cartwright & Zander, 1968) that may be statistically analyzed by maps of variables (March & Simon, 1958), structural path equations or path analysis (Werts & Linn, 1970), cross-lagged panel analysis (Kenny, 1975), and/or cluster analysis (Tryon, 1963; Tryon & Bailey, 1970). General categories of variables that may make up networks of variables have been suggested in Steiner's (1972) theory of group productivity and process loss. For further discussion of math models of group performance the reader is referred to Davis (1969rb, 1973, 1980), Davis et al. (1977), Davis and Restle (1963), Einhorn, Hogarth, and Klempner (1977), Feinberg and Larntz (1971), Johnson and Davis (1972), Laughlin (1980), Laughlin et al. (1975r), Lorge and Solomon (1955), Penrod and Hastie (1979), Restle and Davis (1962), Smoke and Zajonc (1962), Steiner (1966), Steiner and Rajaratnam (1961), Stone (1963), Thomas & Fink (1961), and Zajonc and Smoke (1959).

### Theoretical Implications: Productivity Loss or Gain

Much of the present review has supported the concept of process loss in groups as described in Steiner's (1972) theory of group productivity. Potential group productivity was defined as "the maximum level of productivity that can occur when an individual or group employs its fund of resources to meet the task demands of a work situation" (p. 8). Actual productivity was defined as potential productivity minus losses due to faulty process. Both levels of productivity were believed to vary as a function of task demands, member resources, and group process.

These definitions assumed, however, that group resources were static. A proficient member who increased another member's motivation or understanding of the task was

believed to be making the best use of the group's or best member's resources (Steiner, 1972; see also Kerr & Sullaway, in press). This description does not account for the finding that dyads used a focusing strategy in concept attainment (Laughlin, 1965r; Laughlin & Jaccard, 1975r) more often than did individuals.

Several authors (Argyris & Schon, 1974; Hackman & Morris, 1976; Hoffman, 1965; Lamm & Trommsdorff, 1973; Osborn, 1963; Zagana et al., 1966r) suggested that group process could lead to process gain (i.e., that new ideas, solutions, or efforts could be generated through group interaction). Two potential sources of process gain were suggested: (a) member capacity to learn and (b) cognitive stimulation. In the present review, evidence for member capacity to learn was presented in studies of observational learning (Davis, 1969rb), incidental learning (Laughlin & Jaccard, 1975r), social facilitation (Zajonc, 1965r), and implicit/explicit coercion (Foot, 1973). Evidence that groups benefited from training in group process and problem solving was seen in complex problem solving of Air Force Field Officers (Fox & Lorge, 1962r) and in improvement in individual performance after group performance (Laughlin & Adamopoulos, 1980r).

Less evidence indicated that cognitive stimulation could lead to process gain. A study by Maier (1970), however, suggested that cognitive stimulation in groups may produce novel ideas, a unique combination of subideas, or a complex solution whose total value is "greater than the sum of its parts." The group product might be improved if groups were encouraged to be "problem-minded" rather than "solution-minded" (Maier & Solem, 1962), that is, if the leader encouraged the group to question its current approach or to consider other aspects of the problem (Maier, 1950, 1970), if the group analyzed problem facets as subtasks (Maier, 1952; Maier & Hoffman, 1960b; Maier & Maier, 1957), if members separated and recombined problem-solving strategies (Maier, 1960), or if groups were encouraged to produce two different solutions to a problem so that the better of the two might be adopted (Maier & Hoffman, 1960a). Whether groups using these pro-

cesses can surpass the potential suggested by statistical aggregates remains to be seen.

This review has shown that group performance was generally qualitatively and quantitatively superior to the performance of the average individual. Group performance, however, was often inferior to that of the best individual in a statistical aggregate and often inferior to the potential suggested in a statistical pooling model. This research confirms the belief that the performance of one exceptional individual can be superior to that of a committee (Davis, 1969rb), especially if the committee is trying to solve a complex problem and if the committee contains a number of low-ability members. Further research is needed to describe group process, to examine the variables that affect group process, to examine the relation between group process and the group's product, and to compare group process and productivity with their potential.

### Reference Note

1. Lorge, I., Davitz, J., Fox, D., & Harrold, K. *Evaluation of instruction in staff action and decision-making* (Tech. Rep. No. 16). U.S. Air Force Human Resource Research Institute, 1953.

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Received August 24, 1981 ■