Journal of Applied Psychology
1977, Vol. 62, No. 1, 70–75

Matching Roommates by an Optimal Indirect Technique

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The general problem of optimally matching two-person teams to maximize total group compatibility was discussed. It was argued that an indirect self-selection-type questionnaire can form a good basis on which to match such teams. Dwyer's method of "local regions" was used to optimally match roommates. The questionnaire on which the matches were based consists of items where the respondents first describe themselves and then indicate the characteristics of their most and least preferred roommate choices and the intensity of their preferences. The resultant matched groups (63 pairs) were found in a follow-up questionnaire to express more satisfaction and showed a greater tendency to stay together as compared with two control groups. For the two control groups, roommate assignments were determined on either a random basis (26 pairs) or on the basis established by the dean's office (13 pairs).

The problem of matching persons who are to work or live together is an important problem in applied psychology. Familiar situations in which this problem arises include the matching or assembling of work partners, dating and marriage partners, roommates, and athletic teams. Of course, it cannot be assumed that the same factors are involved in all cases, but it seems likely that the same general principles and research techniques may apply. In fact, the antecedent work to the present study on matching roommates was a series of investigations conducted at the Combat Crew Research Laboratory in San Antonio, Texas. That research focused on the problem of assembling about 60 aircrews, each composed of 11 specialized members who had no earlier opportunity to interact. Consequently, the present study is in many respects a prototypic solution of the optimal-matching problem.

An earlier paper (Roby, Note 1) discussed the general problem of assembly, considered as a two-stage process. The first stage is to obtain compatibility-score functions, that is, some way of relating the measures on two or more potential teammates that would predict their later success as a team. Various possible functions were suggested a priori; for example, complementarity, similarity, and set addition (for such individual characteristics as role aptitude). The second step is to assemble *all* individuals into teams in such a way as to maximize the sum of predicted team scores. It was pointed out that it is really ducking the problem if the only thing accomplished is to match up the people who are "most acceptable" as individuals. For example, a marriage service that arranges successful matches one at a time may just skim off all of the most eligible people of both sexes, leaving a residual of sour spinsters and bitter bachelors. To obtain optimization, it was pointed out that existing linear programming techniques (Dwyer, 1954; Votaw, 1952; Votaw & Dailey, 1952) could be used for two-person matches, and a program was initiated to develop programming techniques for larger groups (Dwyer, 1956; Dwyer & Galler, 1957).

A second theoretical paper (Roby, 1954b)

We gratefully acknowledge the able assistance of Stephen Chiumente, Donald Isaacs, Karen Maitland, and Janice De Verber. Associate dean of Jackson College, Elizabeth Toupin, served as liaison between the research group and the dean's office.

Support for this study was in part provided by the Faculty Research Fund of Tufts University and by grants from NIMH MH 12672-06 and MH 13952.

Despite the untimely death of Professor T. B. Roby, the other authors of the paper wish to preserve the order of authorship in honor of Dr. Roby's work and memory.

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considered the properties of compatibility predictor scores that would permit maximization of assembly sums. It was demonstrated that the variance of assembly sums (i.e., the degree to which rational assembly potentially makes a difference) is a direct function of three properties: (a) the interaction or uniqueness variance of compatibility scores between pairs of persons, (b) the symmetry of directional compatibility scores, and (c) the "transitivity" of compatibility scores—that is, if A is compatible with B and B compatible with C, is A compatible with C? (The last property is not relevant to the two-person matching problem investigated here.)

An initial search for useful types of compatibility scores failed to extract much promise from either biographical similarity or personality traits as measured by the Cattell 16 Personality Factor (PF) scales (Roby, Note 1, Note 2). This finding is also supported by Miller, Campbell, Twedt, and O'Connell (1966), who tested the hypothesis that personal relationships are affected not only by the similarity of self-descriptions but also by the extent to which persons are viewed as similar by others. Residents in fraternity groups were requested to evaluate themselves and each of the people with whom they had resided. They were then asked to indicate their closest friends. Examination of these data revealed a stable relationship between the *reputations* of friends; for example, if one member of a friendship pair is viewed as conceited, his friend is likely to be viewed in the same way. This contrasted with the fact that the compatible people did not seem to view themselves similarly. Taken together, these findings raise the suspicion that the correlational results that have been obtained relating similarity or complementarity of traits or attitudes to compatibility may simply reflect after-the-fact adjustments or perceptual distortions. As a consequence, such techniques form a questionable basis on which to obtain successful matching.

Roby (1953) developed a self-selection procedure that could be adapted to large-scale use. The technique that emerged was to have potential team members write out answers to certain critical questions and to reproduce these answers so that other team members could evaluate them. Several studies (Roby, 1954a, 1954b; Rosenberg & Roby, 1956) using this technique demonstrated the presence of the prerequisite properties (i.e., large uniqueness variance and symmetry of compatibility scores) and obtained some validation for the success of the overall assembly.

The present larger study concerns the matching of roommates in the freshman class of Jackson College, Tufts University. We did not feel that the correlational results mentioned above provided any firm grounds for matching on the basis of trait similarity, complementarity, or similar obvious relations. Accordingly, we elected to let the women make their own choices by a self-selection indirect method.

Problem of Group Optimization

The technique of group optimization that was employed for the present study is the method of "local regions" (Dwyer, 1954). A mini-problem that illustrates the method and some of the difficulties in finding an optimal assignment for the group is displayed in Table 1. For this problem the group of 12 subjects are randomly split into two subgroups of 6 each. The problem now is to find the most compatible arrangement of 6 dyads where only one member of the dyad can come from either subgroup. Of course the subdivision of the total group into two random halves cuts down on the total range for the optimization, but there is no practical and systematic algorithm for optimization without this procedure.

The basis for the matches are the compatibility scores between Subjects i and j (C_{ij}), which are computed from a questionnaire. In the procedure that follows, we are optimally matching Subjects i to Subjects j. In Table 1, the row labeled v_j represents the maximum score for that column. The column labeled J_0 indicates the "best" initial assignment using the rule that $v_{J_0} - C_{iJ_0} \leq v_j - C_{ij}$. For example, Subject 10 has been assigned to Subject 3 (i.e., $J_0 = 3$) since $v_3 - C_{10,3} = 0$ is smaller than any other $v_J - C_{10j}$ (e.g., $v_1 - C_{10,1} = 1$; $v_2 - C_{10,2} = 19$; $v_4 - C_{10,4} = 3$;

Table 1
Hypothetical Compatibility Scores Between Subjects i and j to Illustrate the Method of Local Regions

	Subjects j							
Subjects i	1	2	3	4	5	6	J_0	J_1
7	30	49	25	26	33	27	1, 2	2
8	25	37	33	38	24	26	3, 4	4
9	25	33	20	22	23	27	1	1
10	29	30	36	38	24	34	3	3
11	29	27	20	12	30	28	5	5
12	28	25	30	41	39	43	4, 5, 6	6
v_j	30	49	36	41	39	43		

Note. Abbreviations: J_0 = "best" initial assignment; J_1 = next assignment; v_j = maximum score for any subject j.

$v_5 - C_{10,5} = 15$; $v_6 - C_{10,6} = 9$). Thus in this procedure we are comparing all Subjects j for each Subject i. Where there were ties for the initial assignment, all of the J values have been listed. Notice that Subjects 7, 8, and 12 received more than one (i.e., tied) initial assignments. Besides ties, there are occasions when a given subject is best matched with more than one other subject. For example, Subject 1 is best assigned both to Subjects 9 and 11 in the sense that $v_1 - C_{9,1} = 5$ is a minimum for Subject 9, and $v_1 - C_{11,1} = 1$ is a minimum for Subject 11. However, Subject 1 can only be assigned to one subject. Examination of the second "best" choices shows that Subject 9 could be matched with Subjects 2, 3, 5, or 6 with $v_J - C_{9,J} = 16$, whereas Subject 11 could be matched with Subject 5 with $v_J - C_{11,5} = 9$. The loss of not assigning Subject 1 to Subject 9 is relatively more severe; hence it is better to assign Subject 1 to Subject 9 and to assign Subject 5 to Subject 11. The column labeled J_1 indicates the next assignment where an effort is made to resolve ties. For Subject 7 the tie is resolved in favor of assigning Subjects 7 and 2 together, since Subject 1 has been previously assigned to Subject 9. In a similar fashion, the ties for Subjects 8 and 12 are resolved. No other iterations are necessary, since the assignments shown in column J_1 uniquely match each subject. Thus the method of local regions finds the group optimal assignment in two steps for a problem that would require (N/2)! or 720 steps in an exhaustive search. In fact if all 12 subjects were optimized without splitting the group into random halves, then an exhausted search would require (N − 1) (N − 3) (N − 5) . . . 1, or 10,395 steps. Clearly, then, the method of local regions is a practical and efficient solution to the applied problem of group optimization, and it is ideally suited to the problem of optimizing roommate assignments. Without the method of local regions an exhaustive search would render the group optimization of the present study virtually impossible, even with high-speed computers, since it would require about 2×10^{8T} individual computations.

Method

Questionnaire

A questionnaire for predicting roommate compatibility for female college freshmen was developed. A number of undergraduate women were interviewed to determine what personal characteristics, attitudes, habits, or biographical factors they felt had been important in relations with their roommates. A pool of approximately 60 items was obtained in this way and was edited by the experimenters. Certain questions were deleted because of policy considerations; for example, it was felt that race should not be considered. Also, questions that would negatively affect parental attitudes toward the college were omitted. The questions were phrased in a multiple-choice format. For each item the respondents were asked first to describe themselves, then on a separate form, to indicate the most preferred choice, the least preferred choice, and the intensity of their preference on that item on a 5-point scale (basic parts of the test items are displayed in Table 4 below).

Design and Procedure

The questionnaire was mailed to all 294 female members of the incoming freshmen class, and 289 were returned. A computer program calculated the predictive compatibility scores for the potential roommates. These scores were derived by taking the number of "most preferred" hits (i.e., instances where a rater's preference and a ratee's self-description coincided) multiplied by the intensity rating for each item, and subtracting from that the number of hits on "least preferred" alternatives, again weighing for intensity rating.

The noncommuting part of the class (272 students) was divided at random into three groups: an experimental group of 68 pairs to be assembled into roommate pairs using the compatibility scores, and two control groups. The 34 roommate pairs in the first

control group were assembled entirely at random; a second control group of 34 pairs was reserved to be assembled by the dean's office. After the original assignments were completed, it became necessary to break up a number of roommates in order to fill unanticipated dormitory openings. It was decided to take most of these pairs from the original group assembled by the dean's office. The comparison between this group and the experimental group is further compromised by the fact that many of the roommates in the dean's office group were given special dormitory assignments, and their overall dormitory satisfaction appeared to be rather higher than that of the experimental and random groups. We have, nevertheless, retained this group in subsequent analysis. The resulting number of pairs in the experimental, random, and dean's office groups was 63, 26, and 13, respectively. In the experimental group a computer program using the method of local regions was used to maximize the total compatibility scores across the entire set of assembled roommates. None of the subjects were informed as to how they were matched, and all believed that they were matched on the basis of the questionnaire.

A first-impression follow-up questionnaire was administered about 6 weeks after the roommates started living together. The questionnaire consisted of five questions to be rated on a 5-point scale. The first four questions were rather redundant but were intended to assess different aspects of the roommates' attitude toward each other and to add variance and reliability. The fifth question referred only to the student's general satisfaction with dormitory conditions and was not included in subsequent analyses. A second follow-up questionnaire, nearly identical, was administered after the roommates had been together for about 5 months.

Results

An analysis of the overall compatibility scores from the questionnaire indicated that about 32% of the variance was due to the uniqueness effect between particular subjects (i.e., an interaction effect between subjects), and the remainder of the variance was due to subject effects. This uniqueness effect was taken as large enough to permit an appreciable gain due to assembly and to provide a suitable basis for purposes of matching roommates.

Table 2
Original Matching Scores and Rates of Return of Follow-up Questionnaires for Experimental and Control Groups

Group	No. pairs	Mean matching scores	Questionnaires returned	
			No.	%
Control (random)	26	92.8	12	46
Experimental	63	126.0	45	71
Control (dean's office)	13	90.5	5	38

The next result concerns the actual means of the compatibility scores for roommates who were assigned to one another in the experimental and control conditions. These data are shown in Table 2. It will be seen that the mean for the experimental assembly group is approximately 35 points higher than the means for either of the two control groups. Thus these data attest to the utility of the method of local regions for group optimization.

Validating Results

The follow-up surveys were sent out to all persons in each of the three groups, and arrangements were made for completing and returning them to the house supervisor. In fact, there was a very slow return rate despite attempts to obtain the follow-up surveys as soon as possible. As the results of Table 2 show, the proportions of returned questionnaires were different among the various treatment groups, considerably higher in the experimental group than in either of the control groups. In fact, the mean rate of return was 71% in the experimental group and only 44% in the two control groups, a highly significant difference. We take this difference to be somewhat indicative of the success of the matching study; that is, it is assumed that the roommates who were getting along well and thus benefiting from being matched on the questionnaire would be more likely to return the follow-up rating scales than those who were not so well matched.

Table 3 summarizes analyses of variance of the sociometric scores between the three treatment groups for both the first and the second follow-ups. The first three columns of data indicate the respective means for each of the three groups on the first four sociometric questions and on the sum of those four questions. In general, the means are highest for the experimental group, only slightly lower for the small dean's office group, and markedly lower for the random control group. The variances within groups are very small (in

Table 3
Means and Analyses of Variance of Follow-up Scores

Question	Control (random)	Experimental	Control (dean's office)	F
		First follow-up		
1	4.92	5.50	5.10	4.11*
2	4.79	5.58	5.60	13.36**
3	4.62	5.33	5.30	8.15**
4	3.62	4.83	4.50	10.04**
Total	17.96	21.2	20.5	11.29**
No./group	23	89	9	
		Second follow-up		
1	5.31	5.57	5.12	1.71
2	5.00	5.63	5.62	8.50**
3	4.75	5.38	5.25	4.68*
4	3.81	4.91	4.87	7.45**
Total	18.88	21.50	20.87	6.96**
No./group	15	81	7	

Note. Questions were as follows: 1. How do you like your assigned roommate as a friend? 2. After this short time, how are you and your roommate getting along in sharing a room? 3. How do you think you and your roommate will get along in the same room for the rest of the year? 4. How close is your roommate to the preferred one you indicated on your roommate matching questionnaire?
* $p < .05$.
** $p < .01$.

fact, most subjects tended to use only the two highest scoring categories), and the F ratios are generally significant for all questions and for the total differences. Obviously, the significant differences between individual means concern only those between the random control group and the experimental and dean's office groups. The results are stable between the two testing sessions. It may also be observed that the means are higher for the second follow-up in spite of the fact that a particular request was made for the subjects to use all ratings on the scale. This result might be attributed to the fact that the data were derived entirely from those roommates who stayed together.

There were differences between the movers and the stayers (roommates who remained matched and those who changed roommates) in the three treatment groups. The proportion of the persons who stayed together is significantly higher for the experimental group than for the combined controls: 82% as compared with 64%, $\chi^2(1) = 6$, $p < .05$. Furthermore, the compatibility scores of the roommates who stayed together is higher than that of the roommates who broke up, $F(1, 91) = 6.30$; $p < .05$.

Finally, an attempt was made to select the most effective items to both improve the test for subsequent use and to help understand this particular social-interaction process. Table 4 contains a listing of the items (abbreviated) and the mean intensity or importance that the subjects had assigned to the items. Clearly,

Table 4
Intensity Scores on Items in the Compatibility Scale

Item	Intensity	Item	Intensity
Section of country	2.36	Predicted grades	3.06
Socioeconomic	2.47	Going steady	2.45
Community size	1.95	Study plans	3.60
Financial-aid status	1.74	Study vs. dates	3.52
Preferred community	1.69	Dating plans	3.02
Family size	2.39	Student activism	3.53
Hobby 1	2.37	Introversion–extroversion	3.42
Smoking	3.61	Close to roommate	3.90
Sharing personal items	3.54	Work during year	2.09
Study conditions	3.98	Political interest	2.91
Neatness	3.54	Friendship pattern	3.23
Sleep habits	3.29	Sex attitudes	3.47
Rock music	3.23	Accustomed freedom	2.77
Classical music	2.82	Lived away from home	2.59
Political stand	3.24	Grade attitude	3.31
Postgrad plans	1.92	Leadership	3.14
Intended major	2.23	Settling quarrels	4.08
Hobby 2	2.22	Drug attitude	3.92
Sports	2.39	Personal discussion	3.33
Social services	2.56	Spending money	2.45

the respondents are mostly concerned about those characteristics of a roommate that may have a direct effect on the relationship—for example, method of settling quarrels, preferred study conditions, and attitudes toward drugs—whereas they are less interested in the potential roommate's past history.

Chi-square values (not shown here) between the compatibility rating on each item, trichotomized into "most preferred," "least preferred," or "miss," and the first sociometric rating of the roommate, dichotomized at the median, were calculated. Individual item prediction was low, and only two chi-square values reached the .05 significance level. Also the chi-square analysis did not identify any superfluous items that could be removed from the questionnaire. Thus while particular items were not strongly related to the success of the matching, when taken together, the entire set of items were related to matching success. It is important to note, however, that these chi-square values did not reflect the intensity scores, and this may be the reason why the individual items did not more strongly relate to the matching success.

Discussion

One of the principal results of this study is that a self-selection-type questionnaire forms a good basis from which to make team (or, in this particular case, roommate) matches. The self-selection questionnaire does not assume that similar personalities or complementary personalities will automatically be good matches but only assumes that subjects can accurately describe the characteristics of their preferred roommates.

The computational efficiency of the local regions method makes possible group optimal teams for large-size groups. In fact, Tufts University now uses this technique to match roommates for the entire freshman class (separately for males and females). Surely other applied naturalistic settings (such as work teams in a factory) can employ these same procedures. Of course the questionnaire on which the compatibility scores are based must have sufficient uniqueness variance to have an appreciable gain due to assembly. Given this condition, the validity data of the present controlled study suggests that the optimization technique can be used even when reverification is either not feasible or too expensive.

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Received February 9, 1976 ■