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ABSTRACT

This paper illustrates a procedure for using the interest scores of occupational group members to locate occupations on Holland's hexagon. The procedure locates occupations throughout the hexagon--not just at the six points. The Holland types are Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C). Score profiles for Holland's six types and current occupations were obtained from a sample of 3,612 4-year college alumni. The hexagon locations of 51 occupations pursued by these alumni were determined through the application of hexagon-based weights to their score profiles. The weights convert the profiles to scores on the data/ideas and things/people work task dimensions that underlie Holland's hexagon. Several applications of hexagon locations are described, including a Hexagon Congruence Index (HCI) that reports person-occupation congruence on a scale anchored to the hexagon. The HCI can be used with six-score profiles of Holland's types, three-letter codes, two-letter codes, high-point codes, or any combination of these reporting procedures. Four tables, 3 figures, 35 references, and an appendix describing statistical analysis procedures used in the study are included. (Author/NLA)

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PLACING OCCUPATIONS ON HOLLAND'S HEXAGON VIA SCORES FOR HOLLAND TYPES.

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Running Head: Hexagon

ABSTRACT

This paper illustrates a procedure for using the interest scores of occupational group members to locate (map) occupations on Holland's hexagon. The procedure locates occupations throughout the hexagon--not just at six points (R, I, A, S, E, and C). Score profiles for Holland's six types were obtained approximately 8 years prior to determining the occupations of 3,612 4-year college alumni. The hexagon locations of 51 occupations pursued by these alumni were determined through the application of hexagon-based weights to their score profiles. The weights convert the profiles to scores on the data/ideas and things/people work task dimensions that underlie Holland's hexagon. Several applications of hexagon locations are described, including a Hexagon Congruence Index (HCI) that reports person-occupation (etc.) congruence on a scale anchored to the hexagon. The HCI can be used with 6-score profiles of Holland's types, 3-letter codes, 2-letter codes, high-point codes, or any combination of these reporting procedures.

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Depicting the locations of occupations on charts or "maps" has a long tradition in vocational psychology. Strong (1945) provided a 34-occupation Interest Global Chart as an aid in interpreting Strong Vocational Interest Blank results. Tiedeman, Bryan, and Rulon (1951) used a comprehensive battery of ability tests and biographical scales to map the locations of eight occupations on two dimensions (discriminant functions). Thorndike and Hagen (1962) and Cooley and Lohnes (1968) also mapped occupations (22 and 34, respectively) on two discriminant functions. Cole, Whitney, and Holland (1971) used a "configural analysis" of Vocational Preference Inventory (VPI) scale intercorrelations to represent the scales "in a 'best-fitting' plane" (p. 1). Via the configural analysis, 40 occupational choice groups were located (mapped) on the plane. Cole et al. proposed a number of counseling and research applications for the resulting "two-dimensional map of occupations" (p. 3)--e.g., a person-occupation congruence measure based on distance between map locations.

Although each of the charts and maps cited above had an empirical basis, neither the identification nor the interpretation of their underlying dimensions was guided by hypotheses regarding the structure of the trait domain under investigation. Holland and his colleagues (Cole et al., 1971), for example, did not speculate about the nature of the dimensions underlying their two-dimensional map--this despite their earlier discovery of a hexagonal (two-dimensional) arrangement of six occupational groups (Holland, Whitney, Cole, & Richards, 1969). The six groups (also called "types") and their abbreviations are shown in Figure 1. The proximities of the six groups indicate their relative similarity.

Insert Figure 1 about here.

Subsequent studies in the Vocational Research Program at American College Testing (ACT) led to the identification of two bipolar dimensions--working with data/ideas (D/I) and things/people (T/P)--that are compatible with Holland's (1985) hexagon (see Figure 1). These two work-task dimensions are also compatible with the two dimensions that Roe and Klos (1969) proposed for Roe's circular arrangement of eight occupational groups. Prediger (1976) summarized early research supporting the D/I and T/P dimensions and introduced an empirically based "World-of-Work Map" (WWM) showing the locations of 25 job families on the dimensions. The WWM (described later) was revised (ACT, 1988) when a substantial amount of additional occupational data had accumulated.

Prediger (1981a) showed that U.S. Department of Labor (DOL) job analysis data (DOL, 1972) for occupations in the Dictionary of Occupational Titles (DOT; DOL, 1977) supported the D/I and T/P dimensions. In targeted, principal components analyses of 27 sets of intercorrelations, Prediger (1982) found that the D/I and T/P dimensions efficiently summarized the scores provided by each of five instruments assessing Holland's types (e.g., the VPI). Rounds (in press) obtained similar results in a structural analysis of 60 sets of intercorrelations based on six instruments assessing Holland's types.

Formulas for obtaining D/I and T/P scores from any inventory assessing Holland's types were provided by Prediger (1981b). In an informal article addressed to practitioners, Prediger (1985) described how the formulas could be used to "flesh-out" Holland's hexagon--that is, to depict the hexagon locations of occupations on the basis of their 3-letter codes (their three predominant types). Locations based on 3-letter codes are scattered throughout the hexagon. In contrast, Holland's hexagon locates the 12,000 DOL-recognized occupations (DOL, 1977) at only six points (R, I, A, S, E, and C--see Figure 1). For example, occupations with RIA, RSE, REC, etc. 3-letter codes are all located at Point R on the hexagon; occupations with ERC, ESA, ECI, etc. codes are all located at Point E; and so on. The D/I and T/P formulas cited above provide unique locations for such occupations.

Mau, Swaney, and Prediger (1990) showed how 725 adults in 9 occupational groups and 1,078 12th graders in 18 occupational preference groups could be located on the hexagon through the use of 3-letter codes for group member . The codes were based on scores for Holland's types obtained from the Unisex Edition of the ACT Interest Inventory (UNIACT). Generally, the hexagon locations of the 27 groups made good sense when compared with the hexagon locations of Holland's types and the underlying D/I and T/P dimensions.

Study Objectives

The study reported here is an extension of previous research in that it is the first to map occupations on the hexagon by using all six scores for Holland's types. Hexagon locations were determined for workers in each of 51 occupations. In addition, this is the first study to use longitudinal data to locate occupations on the hexagon. The workers' scores were obtained through the administration of UNIACT when they were still in high school--approximately 8 years prior to determining their occupations.

Study objectives were as follows:

1. To illustrate a procedure for using the interest scores of occupational group members to locate (map) occupations on Holland's hexagon. The procedure locates occupations throughout the hexagon--not just at six points (R, I, A, S, E, and C).

2. To illustrate how hexagon locations provide the basis for a new index of agreement or congruence between two sets of scores for Holland's types (e.g., between the scores for two occupations, the scores for a person and an occupation, the scores for a person tested at two different times). This index, called the Hexagon Congruence Index (HCI), can be used with 6-score profiles of Holland's types, 3-letter codes, 2-letter codes, high-point codes, or any combination of these reporting procedures.

3. To show how hexagon locations can be used to evaluate the

reasonableness (i.e., construct validity) of an occupation's score profile for Holland's six types. The results for this objective provide evidence relevant to assessing the construct validity of UNIACT.

Despite the widespread use of interest inventories such as the "Strong" over the past 60 years, there have been few longitudinal validity studies. For example, the latest manual for the Strong-Campbell Interest Inventory (Hansen & Campbell, 1985) cited only six longitudinal studies involving independent samples (total of 1,757 cases across the studies) and more than one or two occupations. The study with the longest time span (18 years) was initiated in 1928. The two most recent studies (published in 1979 and 1983) spanned less than 4 years. All of the studies were based on college attendees, usually graduates, from a single institution (e.g., Stanford, Harvard, Minnesota). The 8-year longitudinal study reported here was based on 3,612 alumni from 71 institutions nationwide.

Variables and Sample

Interest Measure

As in the Mau et al. (1990) study cited above, UNIACT was used to assess interests. UNIACT contains 90 items arranged in six, 15-item scales that parallel Holland's types. Results are reported as T-scores (mean of 50 and SD of 10). The UNIACT norms used in this study were based on a nationally representative sample of 3,585 12th graders. Internal consistency reliability coefficients for UNIACT scales range from .83 to .93 (median of .86) for the 12th grade norm group. Validity data include interest profile summaries for more than 40,000 persons in 352 career groups. Additional information regarding UNIACT's psychometric characteristics (e.g., summaries of 30 longitudinal and cross-sectional validity studies) is provided in the UNIACT Technical Report (Lamb & Prediger, 1981) and its 1988 supplement. Each year, UNIACT is completed by more than 1.5 million college-bound students as part of the ACT Assessment Program (AAP) and P-ACT+.

Sample

Selection. The study sample was drawn from a pool of former 4-year college students who completed ACT's Alumni Survey (ACT, 1989) between 1986 and 1990. This pool consisted of 19,932 alumni who reported their current occupation at the request of their college and who indicated that they were employed full-time, self-employed (full-time), or serving in the armed forces. Persons who were unemployed or employed part-time were excluded from the study. Sample members completed the Alumni Survey 2-4 years after leaving college. Since nearly all (94%) had graduated, sample members can appropriately be described as 4-year college graduates.

The study's longitudinal design required that information on occupation be matched with UNIACT scores obtained when Alumni Survey respondents had completed the AAP as high school juniors or seniors. AAP records dating from 1977 (when UNIACT was introduced) were included in the study. To facilitate the match, a subset of 71 Alumni Survey institutions which made substantial use of the AAP (as indicated by participation in AAP research services) was identified. A Social Security number match of the alumni records and the AAP records for these 71 institutions identified 4,595 persons who had completed both the Alumni Survey and the AAP. Of these, 3,612 had completed all UNIACT scales. Therefore, the final sample consisted of 3,612 4-year college graduates who were employed, full-time, 2-4 years after graduation, and who had completed UNIACT while they were in high school.

The time interval between UNIACT administration and Alumni Survey administration (when occupation was reported) ranged from 6-13 years; the mean was 8.1 years (SD = 1.2). Persons with a 6-year interval fit the following description: (a) took the AAP as high school seniors; (b) went to college immediately after high-school; (c) graduated from college in 4 years; and (d) completed the Alumni Survey 2 years after college graduation. For others, the time interval could range up to 13 years (1990 minus 1977, the earliest administration of UNIACT). Occupational status was determined 2, 3, and 4 years after college graduation for 35%, 41%, and 24% of the final sample, respectively.

The Alumni Survey contained a list of 199 occupational fields (see Table 1 for examples). Sample members were asked to use the list to indicate their current occupation. There were 42 fields (hereafter called occupational groups) with 20 or more members, the cutoff used to identify occupational groups for the purpose of analysis. Nine additional occupational groups were formed by combining closely related occupations. For example, chemical/petroleum engineering (n = 24) was created by combining chemical engineering (n = 12) and petroleum engineering (n = 12). Thus, 51 occupational groups (N = 2,911) were represented in the analyses addressing the three study objectives. (Additional cases were included in the preliminary analyses described in the next section.)

Characteristics. The final sample (63% female) was 95% Caucasian, 3% Black, and 2% "other" or "prefer not to respond." Mean age was 25.5 years (SD = 2.0). The regional distribution of the 71 institutions attended by sample members was as follows: Southwest (11%), West (7%), Mountain/Plains (7%), Midwest (38%), East (0%), and Southeast (37%)--a distribution that approximates AAP usage across the nation. Educational degrees were distributed as follows: Associate (6%), Bachelors (86%), Masters (6%), and Doctoral or professional (2%). Almost all sample members (96%) indicated that they were employed full-time; the remainder were self-employed (full-time) or in the armed forces.

UNIACT means for the final sample ranged from 50 (for the R Scale) to 53 (for the I and C Scales). UNIACT means for 70,616 12th graders, a representative sample of those taking the AAP, ranged from 48 (for R) to 54 (for E). Differences between the two samples averaged less than 0.1 SD units across the six UNIACT scales. Thus, the interests of final sample members, as assessed while they were still in high school, were highly similar to the interests of a representative sample of AAP-tested college-bound students.

While still in high school, final sample members obtained a mean AAP Composite score of 20 (SD = 5). (The AAP Composite is a summary of performance on the four AAP Ability Tests.) The representative sample cited above obtained a mean AAP Composite score of 19 (SD = 6). Thus, final sample members were slightly more able, a difference that would be expected for college entrants vs. college graduates, all of whom were tested while still in high school.

Preliminary Analyses

Procedures. Three related statistical procedures--multivariate analysis of variance (MANOVA), discriminant analysis (DISANL), and hit rate analysis--were used to determine whether there were statistically significant differences in UNIACT profiles across occupational groups. (Statistical significance is a prerequisite for analyses related to the study's third objective.) The nature of the three statistical procedures and their relevance to the study are described in Appendix A. Analyses were conducted via the SPSS-X DISCRIMINANT routines (SPSS Inc., 1988).

In the preliminary analyses, members of the final sample were assigned, on the basis of occupation, to six job clusters (ACT, 1988) that parallel UNIACT's six scales and Holland's six types. Job cluster sizes were as follows: R (111), I (766), A (265), S (1,020), E (839), and C (351). The total, 3,352, excludes sample members in occupations too general to be assigned to a job cluster (e.g., health professions, general; military). The effect of grouping sample members into six job clusters (rather than 51 occupations) is conservative in that it increases within-group (within-cluster) variance relative to total-group variance. Because Wilks's lambda (used in the MANOVA test of statistical significance) is based on the ratio of within-group to total-group variance, its value is increased. As noted in Appendix A, higher lambdas indicate poorer group differentiation.

Approximately two-thirds of the cases in each job cluster (2,235 cases across the clusters) were randomly assigned to an analysis sample. The remaining cases (1,117) were assigned to a cross-validation sample. Two types of analyses were conducted: weighted and unweighted. In the former analyses, the job clusters were weighted to have equal size and influence. Thus, the R Cluster (for example) would not be overwhelmed by the S Cluster, which is nearly 10 times larger. All descriptive statistics are based on weighted analyses. Tests of statistical significance, however, are based on unweighted analyses--i.e., actual cluster sizes.

Results. Results of the preliminary analyses are presented in Table A1 of Appendix A. Given that Wilks's lambda (.71) is statistically significant at the .0001 level, the results indicate that differences among job clusters cannot reasonably be attributed to chance (i.e., the differences can be thought of as real).

Another way to report degree of job cluster differentiation is by determining the percentage of cluster members who are assigned to their own cluster through use of UNIACT scores. This percentage is commonly called a "hit rate." The overall cross-validated hit rate for job cluster predictions was 3: %. The 95% confidence limits for the overall hit rate range from 30% to 36%. These limits do not approach the chance hit rate (17%). Hit rates for individual clusters ranged from 9% for E to 45% for R. The hit rate for the E cluster suggests that there is substantial interpersonal variation in the vocational interests of future members of enterprising occupations.

As shown in Table A1, univariate F values for each of the six UNIACT scales are statistically significant at the .0001 level. The DISANL results confirm that job cluster differentiation is multi-dimensional. Although four discriminant functions were statistically significant, the first two accounted for 75% of among-group variance. These results, together with the results of the targeted principal components analysis presented in the next section, support the use of two dimensions to summarize occupational group differences.

Locating Occupations on the Hexagon

The study's first objective was to illustrate a procedure for using the interest scores of occupational group members to locate occupations on Holland's hexagon. As noted above, two bipolar work task dimensions underlie Holland's hexagon: (a) working with data (e.g., facts, records) vs. ideas (theories, insights) and (b) working with things (materials, machines) vs. people (care, services). In this study, formulas for computing D/I and T/P scores (Prediger, 1981b) were applied to scores for Holland's six types. The six UNIACT scores for each member of the final sample were entered into the formulas in order to obtain the member's D/I score and T/P score. These scores were then used to locate occupations on the hexagon. Specifics are provided below.

Calculating D/I and T/P Scores for Sample Members

The following formulas were used to calculate D/I and T/P scores:

$$D/I\ score = (0.00 \times R) + (-1.73 \times I) + (-1.73 \times A) + (0.00 \times S) + (1.73 \times E) + (1.73 \times C)$$

$$T/P\ score = (2.00 \times R) + (1.00 \times I) + (-1.00 \times A) + (-2.00 \times S) + (-1.00 \times E) + (1.00 \times C)$$

Scores for Holland's types are represented by the upper case letters. The weights applied to these scores are the Cartesian coordinates for Holland's types arranged as a hexagon (Figure 1). The C type, for example, is located at 60° in Figure 1. On a unit circle, the X-axis and Y-axis coordinates of 60° are 1/2 and the squareroot of 3/2, respectively. When multiplied by 2 in order to eliminate denominators, the coordinates are 1 and the squareroot of 3. Thus, the weight for C in the T/P (X-axis) formula is 1, and the weight for C in the D/I (Y-axis) formula is the squareroot of 3 (approximately 1.73). The R type, on the other hand, is located at 0° in Figure 1 and has X and Y coordinates of 1 and 0, respectively, on a unit circle. When multiplied by two, the coordinates are 2 and 0. Thus, R's weight in the T/P formula is 2; its weight in the D/I formula is 0. Weights for the other four Holland types were derived in the same way.

To compute D/I and T/P scores for a person, one simply replaces the letters in the formulas with the person's scores for Holland's types. Assume, for example, that a person obtains the following T-scores on the six UNIACT scales: R (56), I (54), A (45), S (41), E (48), and C (52). Then,

D/I = (0.00 x 56) + (-1.73 x 54) + (-1.73 x 45) +

(0.00 x 41) + (1.73 x 48) + (1.73 x 52)

The result is a score of 1.73. The formula for T/P yields a score of 43. Although the formulas do not require the use of T-scores, the use of some type of normed score is recommended. Raw scores can be used if there is research-based evidence that a given raw score (e.g., 20) indicates the same standing or amount of interest for each of Holland's types.

In general, positive values for the D/I (or T/P) dimension indicate a preference for working with data (or things). Negative values for the D/I (or T/P) dimension indicate a preference for working with ideas (or people). The range of values for D/I and T/P is dependent on the type of score (e.g., T-score, stanine, etc.) entered into the formulas.

Calculating D/I and T/P Scores for Occupational Groups

D/I means for each of the 51 occupational groups were obtained by averaging the D/I scores of members of each group. The mean and SD of the 51 D/I means were then obtained. These values were used to compute D/I z-scores for each of the 51 occupational groups. The same procedure was followed with

T/P scores. Although a z-score transformation is not necessary for mapping, z-scores provide a convenient way to determine an occupation's standing (in SD units) among all occupations in the study. Table 1 provides D/I and T/P means and UNIACT means for the 51 occupational groups. (Standard deviations are available on request.)

Insert Table 1 about here

Finding Hexagon Locations

Occupational groups were mapped on the hexagon through use of the D/I and T/P means described above. For example, natural resources management has a T/P mean score of 0.62 and a D/I mean score of 2.08. To map this occupation on the hexagon, one would find and the T/P value on the horizontal axis and the D/I value on the vertical axis. The coordinate point (0.62, 2.08) represents the group's hexagon location (see upper right of Figure 2).

Insert Figure 2 about here.

The locations of all 51 occupational groups are presented in Figure 2. The ID numbers enable the reader to cross reference group locations with the D/I and T/P z-scores in Table 1. A discussion of whether groups are located as one would expect is provided in the section addressing Objective 3.

Explanatory Power of the D/I and T/P Dimensions

As noted in the introduction, Prediger (1982) used targeted, principal components analyses (PRINCOs) of 27 sets of correlations to show that the D/I and T/P dimensions efficiently summarize the scores provided by instruments assessing Holland's types. Three of the analyses were based on the intercorrelations of interest scale means for three sets of career groups--78 occupational groups, 72 occupational preference groups, and 78 college major groups. In these analyses, the D/I and T/P dimensions "explained" (accounted for) about 63% of the total variance in each of the three sets of career groups. The maximum amount of variance that could be explained by two dimensions was about 66%, as determined by standard PRINCOs.

The procedures used by Prediger (1982) were applied to intercorrelations of UNIACT means for the 51 occupational groups. As before, the hexagon coordinates served as PRINCO "targets" for UNIACT loadings on the two dimensions. The D/I and T/P dimensions explained 64% of total variance among the occupational groups. The maximum possible amount for two dimensions was 65%. Thus, the D/I and T/P dimensions once again provided an efficient summary of occupational group differences. (The third principal component explained only 14% of total variance.) UNIACT scale loadings for the D/I and T/P dimensions were as follows--D/I: R (-.08), I (-.49), A (-.43), S (-.10), E (.65), C (.78); T/P:

R (.73), I (.54), A (-.66), S (-.84), E (-.50), C (.38). The loadings approximate a hexagon when plotted on the D/I and T/P dimensions.

Taken together, these results confirm that the two work task dimensions have substantial explanatory power. They appear to provide a convenient, theory-based, empirically confirmed structure for summarizing similarities and differences among occupations.

Using Hexagon Locations to Measure Congruence

The study's second objective was to illustrate how hexagon locations provide the basis for a new index of congruence (the HCI). Swaney and Prediger (1985) and Mau et al. (1990) used a precursor of the HCI to assess UNIACT validity. Here, the HCI is defined as the absolute difference between the angles of any two locations on the hexagon (e.g., the locations of occupations, persons, theory-based Holland types, or any combination of these). The angle for a hexagon location can be determined by computing the arc tangent of the location's D/I score divided by the location's T/P score. Since the arc tangent function is readily available on hand calculators and in computer software, angles can be easily computed once D/I and T/P scores are obtained. As defined by the geometry of the hexagon (Figure 1), the angles for Holland's types are as follows (in geometric sequence): R (0°), C (60°), E (120°), S (180°), A (240°), and I (300°).

Hexagon angles for the 51 occupational groups are presented in Table 1. The standard error of the mean angle (SEMA) for each occupational group was calculated in order to obtain perspective on the extent to which study results might generalize to other samples. Across the 51 occupational groups, SEMAs ranged from 2.7 for accounting (n = 232) to 12.4 for physical sciences (n = 23). The 95% confidence limits (+ or - 1.96 SEMA) for accounting (mean angle of 89°) are 84° and 94°. For physical sciences (mean angle of 295°), the 95% confidence limits are 271° to 319°. Across the 51 occupations (mean sample size of 57), the mean range for the 95% confidence limits is 30°. Thus, for samples of 20 or more cases, hexagon angles have a relatively small sampling error when judged in the context of the angular distance between adjacent Holland types (60°).

Calculating the HCI

Suppose that occupation X has an angle of 85° and occupation Y has an angle of 30°. Then the HCI for the two occupations would be 55° (85° - 30°). If, on the other hand, occupation Y had an angle of 355° (equivalent to -5°), then the HCI for occupations X and Y would be 90°--the absolute (unsigned) difference between the two angles. Note that this is also the minimum difference: That is, one would not subtract 355° from 85° to obtain 270°.

The HCI for an occupation and a Holland type can be determined by subtracting the angle for the Holland type from the angle for the occupation. Thus, the HCI for occupation X (85°) and Type C (60°) is 25°. The HCI for a person and an occupation or a person and a Holland type can be determined in a similar manner.

The HCI ranges from 0° (maximum congruence) to 180° (maximum incongruence). The HCI for Holland types that are adjacent on the hexagon (e.g., R and I) is 60°. Opposite types (e.g., R and S) have an HCI of 180°. The mean HCI for randomly determined hexagon locations is 90°, a value which defines "chance" for the HCI.

Comparing the HCI to Alternatives

Measures of congruence are not new (e.g., see Assouline & Meir, 1987, for an overview of various measures). The measures recently recommended by Holland (1987) were developed by Iachan (1984) and Zener and Schnuelle (1976). However, there are several problems with these measures. First, they use 3-letter codes rather than scores. Because 3-letter codes are based on ranks, score differences are ignored. Consider, for example, the following two sets of RIASEC T-scores: Set 1 (70, 69, 30, 68, 30, 30); Set 2 (70, 50, 30, 40, 30, 30). Despite substantial differences, the two sets of scores have the same 3-letter code (RIS). Hence, congruence appears to be perfect. The HCI, on the other hand, uses scores rather than ranks for Holland's types. The hexagon angle for Set 1 is 302°; for Set 2, it is 336°. The HCI of 34° (more than half the distance between adjacent Holland types) reflects differences in the two score sets that are obscured by 3-letter codes.

A related problem with the Iachan and Zener-Schnuelle congruence measures is that they are based on 3-letter codes and only 3-letter codes. The Set

2 scores above have a code of RIS, even though R and S differ by 3 SDs. Should the code be RI (difference of 2 SDs) or just R? Why must 3-letter codes always be used, regardless of actual scores? The HCI can be applied to anything between 6-score profiles and high-point codes--or any combination of these reporting procedures.

A third problem with the Iachan and Zener-Schnuelle congruence measures is that they make no use of Holland's hexagon. Instead, they focus on the extent of letter matches in 3-letter codes, regardless of the hexagon proximity of the letters. For these measures, the RIASEC hexagon sequence could just as well be IERSAC. The HCI takes hexagon proximities into account.

Finally, the Iachan and Zener-Schnuelle congruence measures have arbitrary score scales with no inherent meaning. The HCI reports scores on a universal scale that has intuitive meaning when considered in conjunction with hexagon benchmarks (e.g., an HCI of 60° for adjacent Holland types). The HCI scale also has a visual counterpart--e.g., Figure 2. The Iachan and Zener-Schnuelle measures do not. (For a discussion of other problems with 3-letter code congruence measures, see Gati, 1985).

Cole et al. (1971) proposed a linear measure of congruence based on the distance between two points on their "two-dimensional map." Point locations on a map (or hexagon) are a function of (a) type of interest (angle) and (b) consistency of interests (distance from the center of the hexagon). Inconsistent score profiles (e.g., a profile with a 3-letter code of RSE) are located closer to the center of the hexagon than consistent scores (e.g., CRI). Thus, a linear measure of distance between two hexagon locations confounds congruence of interest type with interest consistency. The HCI avoids this problem by focusing on the angular difference between two hexagon locations. Only congruence of interest type is assessed by the HCI.

Evaluating Hexagon Locations of Occupations

The study's third objective was to show how hexagon locations can be used to evaluate the reasonableness (i.e., construct validity) of an occupation's score profile for Holland's six types. A common way to approach this task is to identify the Holland types which have profile peaks for a given occupation. These Holland types are then compared with expectations for the occupation--e.g., the occupation's 3-letter code (Holland, 1985). Although this profile analysis procedure is useful, it does not directly address questions regarding the amount of agreement (congruence) between a profile and expectations. Also, the evaluation of expectations regarding similarities and differences among occupations is difficult when more than a few profiles (or 3-letter codes) are available.

Figure 2 illustrates a different approach to profiling--an approach that provides visual and numerical assessments of amount of congruence between a profile and expectations and that facilitates profile comparisons across numerous occupational groups. As already noted, the hexagon locations of the occupations shown in the figure take into account scores for all six Holland types. Although there are 51 occupations, a quick scan of Figure 2 provides a preliminary assessment of degree of congruence with expectations (e.g., whether the occupations are near appropriate Holland types). The assessment of similarities and differences among occupations is also facilitated. Making such assessments by scanning 51 6-score profiles (or 51 3-letter codes) would be difficult, at best. See, for example, Figure 3, which provides 6-score profiles for 6 of the 51 occupational groups.

Insert Figures 2 and 3 about here

The D/I and T/P dimensions also contribute to the evaluation of an occupation's score profile. With few exceptions, the work tasks (and Holland types) associated with the locations of occupations (e.g., accounting, aerospace engineering, fine and applied arts, communications) appear to be reasonable. Detailed analysis of Figure 2 is left to the reader.

Table 2 illustrates a way to use the HCI to evaluate the reasonableness of an occupation's score profile. Capsule definitions of Holland's six types are provided at the left. Work tasks characterizing each type are also shown. The right-hand column identifies the three occupational groups with HCI scores most congruent with each Holland type. In this case, one is interested in whether the descriptions in the left-hand column are appropriate to the groups, given the nature of the sample (i.e., college graduates).

Insert Table 2 anout here

The HCI can also be used to assess the congruence of an occupation's score profile with a target profile--e.g., a theory-based ideal or a 3-letter code. Further, the HCI can be used to compare the results obtained in a specific study with the results of previous research. For example, the World-of-Work Map (WWM; ACT, 1988) shows the locations of 23 job families on the D/I and T/P dimensions underlying Holland's hexagon. Job analysis data for the 12,099 occupations in the 4th edition DOT and the interest scores of persons in 991 occupational groups were used to assign occupations to job families and to determine job family locations on the map (ACT, 1988). Through use of D/I and T/P scores, each job family's location can be expressed as an angle on Holland's hexagon. Hence, the HCI can be used to determine congruence between a WWM job family and any other occupational group.

The occupations reported by alumni in the final sample were assigned to job families through use of the ACT Occupational Classification System (ACT, 1988). The 16 job families with at least 20 members are listed in Table 3. Their D/I scores, T/P scores, and hexagon angles were computed using the procedures described above. Hexagon angles for WWM job families are also shown in Table 3. The HCIs for job family pairs ranged from 3° to 53°; the mean was 20°--one-third of the distance between adjacent Holland types (60°), and about one-fifth of the chance value (90°). This high level of congruence is especially noteworthy because the hexagon locations for the final sample were based on longitudinal data for college graduates, whereas the WWM locations summarize interest score profiles and job analyses for a wide range of occupations at all levels of education.

Insert Table 3 about here.

Discussion

This paper illustrates how occupations can be mapped on Holland's hexagon through the application of hexagon-based weights to score profiles for Holland's six types. Although the illustration used interest scores, the hexagon mapping procedure can be applied to any assessment of Holland's types (e.g., the three Self-Directed Search ability components; frequencies for Holland's types based on the majors of students at various colleges). By converting 6-score profiles into hexagon locations, the hexagon mapping procedure efficiently summarizes information contained in the profiles. As a result, numerous occupational groups can be presented on the same hexagon without loss of interpretability; trends in the data are easy to see; and results for one occupational group can be easily compared with results for other occupational groups. In contrast, 6-score profiles and 3-letter codes are difficult to comprehend and compare when more than a few appear together.

Several existing data bases can be used to map occupations on Holland's hexagon. For example, Hansen and Campbell (1985) provided mean scores for Holland's six types for 207 occupational groups. Johansson (1986) provided mean scores for 111 occupational groups. Gottfredson and Holland (1989) provided 3-letter codes for all 12,860 occupations in the DOT and its supplements. These data bases can be used for a variety of research purposes. Some examples of possible studies (and expectations based on Holland's, 1985, theory of careers) follow: (a) occupations are grouped according to similarity (e.g., welders, cooks, foresters, and opticians should have similar hexagon locations--all are RIS occupations); (b) the raw-score-based locations of males and females in the same occupation are compared (the locations should be the same--Holland's Occupations Finder is genderless); (c) an occupation's locations, determined from interests and abilities, are compared (the locations should be the same); and (d) the locations of satisfied and dissatisfied workers in the same occupation are contrasted (the locations should be different). The hexagon provides a theory-based context for visualizing the results of each of these studies.

Holland and his colleagues (Cole et al., 1971) suggested additional applications of a "visual occupational map" (p. 8). For example, they suggested using such a map "to show an individual where his interest profile falls and what occupational groups show similar interests" (p. 8). Their visual occupational map provides a link between a counselee's characteristics and occupational options thus meeting "the need . . . for a method of suggesting potential careers related to a client's expressed interests" (p. 1).

The mapping procedure described in this paper can be used to locate counselees on Holland's hexagon. Counselees can then identify and explore occupations near their locations. This "method of suggesting potential careers" is based on a visual occupational map (as suggested by Holland and his colleagues) rather than matches between 3-letter codes--the procedure currently recommended by Holland (1985). When counselees with an RIE code (angle = 349°) use a visual occupational map, they will include RIC occupations (angle = 351°; HCI = 2°) among those they consider, although the RIE and RIC codes do not "match" (Holland, 1985). They will exclude EIR occupations (angle = 90°; HCI = 101°) from those they consider. According to Holland's current procedure, RIE and EIR are permutations that "match"--even if a counselee's R and E scores are several SDs apart. By observing hexagon locations, counselees can easily determine which occupations actually do match their profile for Holland's types. Arbitrary permutation rules and a look-up-list of codes (e.g., the Occupations Finder) are not needed.

Another advantage of hexagon mapping is that it addresses inconsistencies in the Holland types characterizing certain occupational groups. Math education, for example, is located toward the data side of the hexagon's center (see Figure 2). UNIACT means for future math educators were as follows: R (49), I (53), A (49), S (56), E (48), and C (55). When the all-or-none, 3-letter code system is used, math educators are Ss with C and I tendencies. In fact, the 3-letter code for math educators (SCI) is the epitome of inconsistency. The two highest means are separated by 0.1 SD units. The three highest means, which are separated by 0.3 SD units, are on opposing points of the hexagon. The hexagon location of math educators reflects these inconsistencies. Math educators are not called Ss, or Cs, or Is.

The systems analysis group provides another example of how hexagon mapping addresses inconsistencies in score profiles for Holland's types. UNIACT means for this occupational group were as follows: R (52), I (54), A (52), S (49), E (51), and C (55). Although the 2-letter code for the group is CI (R and A are tied for third), only 0.3 SD units separate the top four means. The C and I means differ by 0.1 SD units. On the D/I dimension of the hexagon, C opposes I and A. On the T/P dimension, both C and I are supported by R. (The relatively low mean for S is also supportive.) The hexagon location of the systems analysis group reflects these features of its score profile. One way to emphasize the inconsistency of the profile for this occupational group would be to supplement the hexagon location with arrows that point toward C and I.

Holland and his colleagues (Cole et al., 1971) expressed concern "when occupations have divergent interest patterns" (p. 5), even though they found "few cases of this kind" (p. 5). The hexagon mapping procedure described in this paper appears to address their concern. A hexagon location provides a synthesis of divergent interest patterns--a common way of addressing inconsistencies in counseling and research.

The hexagon mapping procedure described in this paper can, no doubt, be improved. Given the centrality of the hexagon in Holland's theory of careers, the ease with which occupations can be located on the hexagon, and the many applications of the HCI, we believe that hexagon mapping has considerable promise as a way to extend Holland's hexagon beyond its RIASEC roots.

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Table 1

UNIACT, D/I, and T/P Mean Scores for 51 Occupational Groups

JOB CLUSTER and Occupations	n	UNIACT Scale[a] R	I	A	S	E	C	Hexagon location[b] D/I	T/P	Angle
TECHNICAL (R)[c]										
1 Natural Resources Management	42	51.9	50.3	49.7	49.4	55.8	58.9	2.08	0.62	73°
2 Construction & Related Trades	20	54.2	49.3	45.4	46.1	49.3	51.8	1.02	1.43	35°
SCIENCE (I)										
3 Computer Programming	90	52.5	54.2	51.3	51.1	51.3	57.3	0.57	0.79	36°
4 Medical & Laboratory Technology	82	48.8	61.8	50.2	51.5	45.1	52.2	-1.75	0.89	297°
5 Electrical & Electronics Engineering	57	57.4	58.5	51.1	49.8	50.7	53.7	-0.50	1.60	342°
6 Computer & Information Sciences	38	53.3	53.6	51.8	50.4	53.6	57.2	0.87	0.76	49°
7 Mechanical Engineering	35	56.8	59.8	49.6	46.7	49.6	52.0	-0.85	2.01	337°
8 Pharmacy	34	47.7	62.8	50.4	52.4	49.2	51.8	-1.43	0.44	287°
9 Systems Analysis	31	51.6	54.5	52.2	49.2	50.8	55.3	0.10	0.79	7°
10 Information Systems & Sciences	29	49.7	51.0	47.9	53.1	52.3	54.3	1.19	0.01	89°
11 Industrial &/or Management Engineering	28	55.0	56.6	49.0	48.8	51.6	53.0	0.06	1.37	3°
12 X-ray Technology	27	47.0	55.4	50.7	48.7	48.8	48.9	-0.94	0.19	281°
13 Civil Engineering & Technology	26	55.7	55.8	50.4	44.2	46.0	53.8	-0.64	2.23	344°

Table 1 (continued)

JOB CLUSTER and Occupations	n	UNIACT Scale[a]						Hexagon location[b]		
		R	I	A	S	E	C	D/I	T/P	Angle
14 Aerospace & Aeronautical Engineering & Technology	25	54.8	56.4	45.9	45.6	47.6	51.2	-0.29	2.00	352°
15 Engineering Technology--Industrial/Manufacturing	24	57.9	57.7	51.4	51.0	53.1	56.0	0.18	1.45	7°
16 Chemical/Petroleum Engineering	24	50.7	60.2	45.6	48.8	51.5	54.5	0.20	1.34	9°
17 Engineering, general	23	54.4	57.6	52.7	53.2	50.9	55.3	-0.36	0.80	336°
18 Physical Sciences (e.g. Chemistry)	23	50.1	61.1	48.7	51.2	48.4	48.5	-1.51	0.71	295°
ARTS (A)										
19 Law & Prelaw	42	48.1	52.5	56.6	54.7	56.6	53.6	0.31	-1.06	164°
20 Radio/Television Broadcasting	31	50.5	52.9	56.7	51.3	51.8	48.0	-1.11	-0.41	250°
21 Advertising	31	48.3	49.7	58.4	54.1	55.6	51.7	-0.07	-1.30	177°
22 Communications, general	30	45.1	51.3	56.3	55.2	56.6	49.1	-0.09	-1.79	183°
23 Journalism	25	48.1	48.7	56.4	55.8	53.0	47.4	-0.44	-1.55	196°
24 Clothing & Textiles	24	47.3	49.5	54.1	54.0	54.7	52.4	0.62	-1.06	150°
25 Fine & Applied Arts	22	55.5	52.3	61.6	51.6	47.2	46.6	-2.44	-0.01	270°
SOCIAL SERVICE (S)										
26 Nursing (RN)	256	48.4	57.3	51.4	54.4	49.8	51.4	-0.81	-0.14	260°
27 Elementary Education	196	49.2	50.5	54.1	56.6	53.0	51.3	0.14	-1.06	173°

38

Table 1 (continued)

JOB CLUSTER and Occupations	n	UNIACT Scale[a]						Hexagon location[b]		
		R	I	A	S	E	C	D/I	T/P	Angle
28 Special Education	72	49.1	50.1	49.9	55.6	51.6	50.2	0.40	-0.72	151°
29 Social Work	62	50.5	49.5	53.1	56.1	53.8	51.0	0.46	-0.92	153°
30 Occupational Therapy	49	48.3	55.9	56.1	59.1	50.5	49.2	-1.43	-1.22	229°
31 Criminal Justice & Law Enforcement	40	53.6	53.7	52.8	55.6	53.6	48.8	-0.35	-0.35	225°
32 Education, general	39	52.1	51.5	52.0	57.4	51.0	50.3	-0.11	-0.57	191°
33 Social Sciences (e.g., Psychology)	33	48.7	53.1	57.6	59.8	55.0	51.0	-0.44	-1.69	195°
34 English & Speech Education	31	47.5	47.4	55.9	56.1	50.7	47.7	-0.47	-1.56	197°
35 Medical Assistant	26	46.2	53.8	52.2	51.0	51.8	53.7	-0.11	0.24	155°
36 Mathematics Education	26	48.5	53.4	48.7	55.7	48.2	55.4	0.36	-0.04	97°
37 Physical Therapy	25	49.8	57.2	51.4	58.0	51.4	51.8	-0.52	-0.49	227°
38 Foods & Nutrition	25	47.6	57.7	52.6	50.8	55.5	52.2	-0.17	-0.15	230°
39 Family Relations	25	50.6	53.5	53.9	51.6	51.0	51.2	-0.51	-0.01	269°
40 Music Education	24	49.8	48.9	58.6	53.6	46.8	47.9	-1.49	-0.84	241°
41 Physical Education	23	52.3	50.5	52.2	54.9	51.5	49.6	-0.04	-0.40	186°
42 Dental Hygiene/Assistant	23	49.1	54.4	51.3	52.9	50.8	50.3	-0.42	-0.18	246°

Table 1 (continued)

JOB CLUSTER and Occupations	n	UNIACT Scale[a] R	I	A	S	E	C	Hexagon location[b] D/I	T/P	Angle
BUSINESS CONTACT (E)										
43 Marketing & Purchasing	250	50.1	51.1	52.0	53.4	55.2	53.0	0.84	-0.44	118°
44 Business Management/Administration	193	50.2	50.7	49.9	51.7	55.5	54.3	1.37	-0.09	94°
45 Banking & Finance	135	49.8	49.9	50.9	51.9	54.8	56.3	1.53	-0.10	94°
46 Real Estate & Insurance	72	50.9	54.2	51.7	52.2	54.2	53.4	0.38	0.05	82°
47 Office Management	51	50.3	48.5	51.3	53.1	54.3	56.0	1.54	-0.28	100°
48 Public Administration	21	51.2	56.4	54.2	59.5	56.3	50.8	-0.28	-1.04	195°
BUSINESS OPERATIONS (C)										
49 Accounting	232	48.4	48.4	48.8	51.7	55.4	61.3	2.70	0.04	89°
50 Secretarial Studies	94	46.4	49.0	50.2	51.1	51.9	57.0	1.43	-0.21	99°
51 Computer Operating	25	52.1	53.3	50.9	52.0	53.5	55.8	0.84	0.40	64°

[a]Holland types are shown as scale titled (see Footnote c); T-scores are reported (mean = 50, SD = 10).
[b]D/I = data versus ideas; T/P = things versus people; D/I and T/P scores are reported as z-scores.
[c]Corresponding Holland types are in parenthesis: R = Realistic, I = Investigative, A = Artistic, S = Social, E = Enterprising, and C=Conventional.

Table 2

Occupations Most Congruent with Each Holland Type, as Determined by the Hexagon Congruence Index (HCI)

Holland type[a] (and primary work tasks[b])	Angle for type	Occupational group[c] (and HCI)
Realistic: "Preference for activities that entail the explicit, ordered, or systematic manipulation of objects, tools, machines, and animals" (p. 19). (Things)	0°	Industrial &/or Management Engineering (3°) Engineering Technology--Ind./Manufacturing (7°) Systems Analysis (7°)
Investigative: "Preference for activities that entail the observational, symbolic, systematic, and creative investigation of physical, biological and cultural phenomena" (p. 19). (Ideas/things)	300°	Med. & Lab. Tech. (3°) Physical Science (e.g., Chemistry) (5°) Pharmacy (13°)
Artistic: "Preference for the ambiguous, free, unsystematized activities that entail the manipulation of physical, verbal, or human materials to create art forms or products" (p. 20). (Ideas/people)	240°	Music Education (1°) Radio/TV Broadcasting (10°) Occupational Therapy (10°)
Social: "Preference for activities that entail the manipulation of others to inform, train develop, cure, or enlighten" (p. 21). People	180°	Communications, general (3°) Advertising (3°) Education, general (11°)
Enterprising: "Preference for activities that entail the manipulation of others to attain organizational goals or economic gain" (p. 21). (Data/people)	120°	Marketing & Purchasing (2°) Office Management (20°) Secretarial Studies (22°)
Conventional: "Preference for activities that entail the explicit, ordered, systematic manipulation of data, such as keeping records, . . . organizing written and numerical data, . . . operating business machines and data processing machines to attain organizational or economic goals" (p. 22). (Data/things)	60°	Computer Operating (4°) Computer & Information Sciences (11°) Natural Resources Management (13°)

Note. Seven occupations that have data/ideas and things/people z-scores with absolute values less than 0.50 were not considered for table.
[a]Capsule descriptions are drawn from Holland (1985). [b]Work tasks are those which typify each of Holland's six types. [c]The three occupational groups with the smallest HCI are listed for each Holland type.

TABLE 3

Comparison of Job Family Locations Based on Sample Members and World-of-Work Map

JOB CLUSTER and job family	n	Location[a] D/I	T/P	Angle Sample	WWM[b]	HCI[c]
TECHNICAL (R)[d]						
Crafts & Industrial Technologies	47	0.10	0.96	6	9	3
Agriculture & Natural Resources	63	1.17	1.10	47	6	41
SCIENCE (I)						
Engineering & Related Technologies	474	0.09	1.21	4	330	34
Medical Specialties & Technologies	187	-1.38	0.50	290	336	46
Natural Sciences & Mathematics	56	-1.19	0.69	300	295	5
ARTS (A)						
Applied Arts, Visual	66	-0.28	-0.06	258	270	12
Creative/Performing Arts	22	-2.44	-0.01	270	242	28
Applied Arts, Written & Spoken	177	-0.27	-1.17	193	216	23
SOCIAL SERVICE (S)						
General Health Care	401	-0.72	-0.29	248	195	53
Education & Related Services	4	0.02	-0.79	179	172	7
Social & Government Services	127	0.01	-0.56	179	160	19
BUSINESS CONTACT (E)						
Marketing & Sales	340	0.69	-0.35	117	122	5
Management & Planning	499	1.07	-0.14	97	113	16
BUSINESS OPERATIONS (C)						
Records & Communications	94	1.43	-0.21	99	96	3
Financial Transactions	232	2.70	0.04	89	71	18
Business Machine/Computer Operation	25	0.84	0.40	64	45	19

[a]D/I (data/ideas) and T/P (things/people) z-scores for sample members. [b]WWM = World-of-Work Map. [c]HCI = Hexagon Congruence Index. [d]Related Holland type.

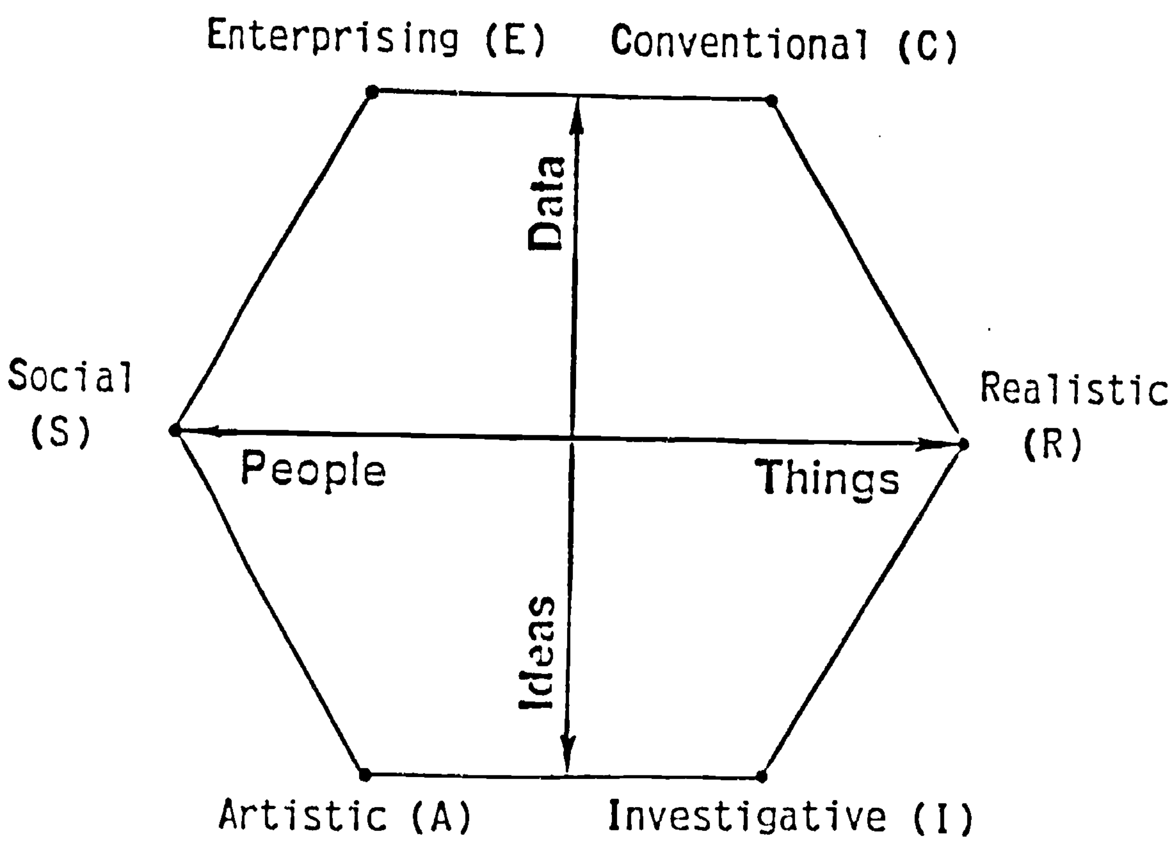

Figure 1. Holland's hexagon and underlying dimensions.

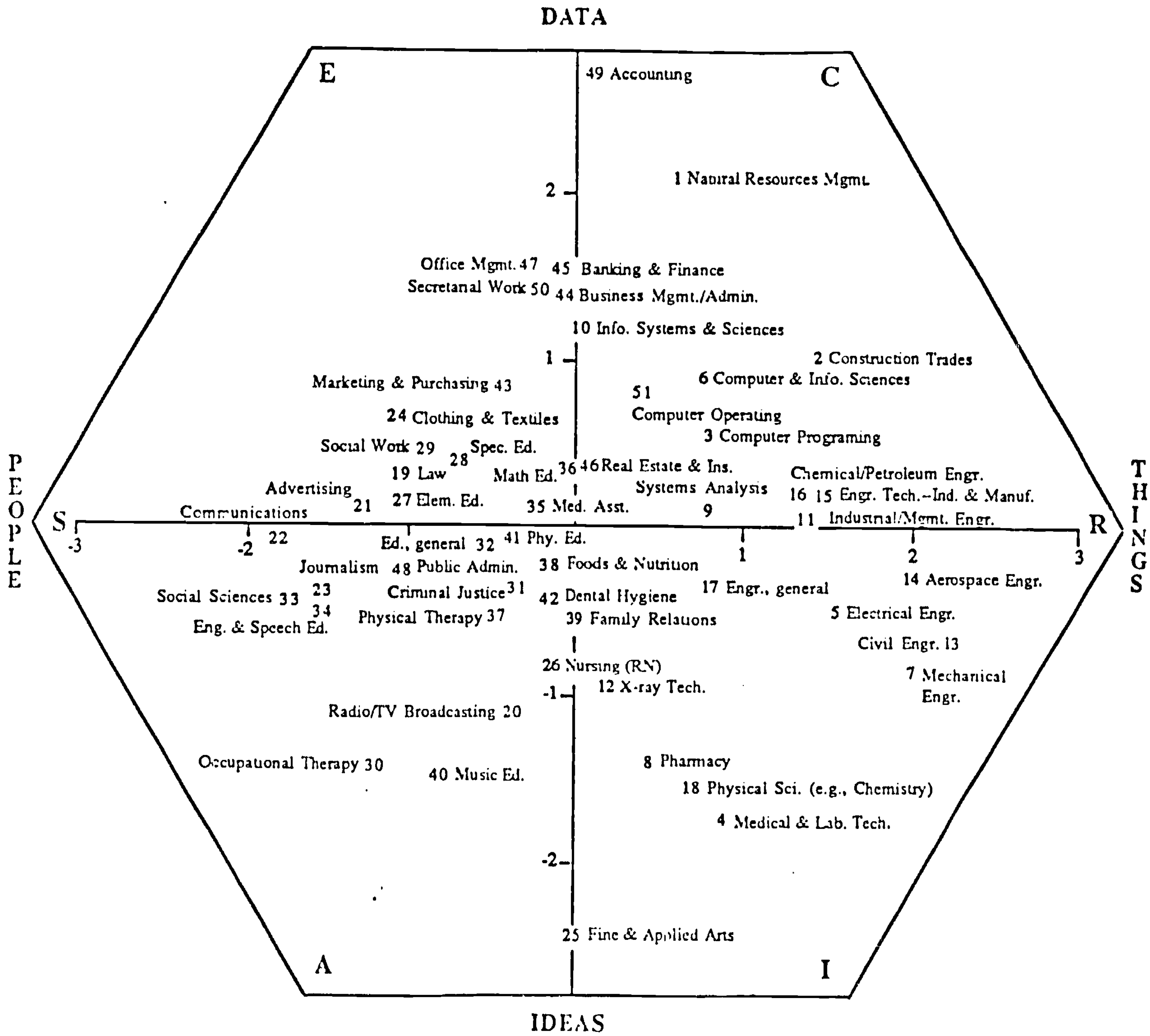

Figure 2. Hexagon locations for 51 occupational groups. (Holland's types are abbreviated as follows: R = Realistic, I = Investigative, A = Artistic, S = Social, E = Enterprising, and C = Conventional. Plots are based on z-scores for D/I and T/P.)

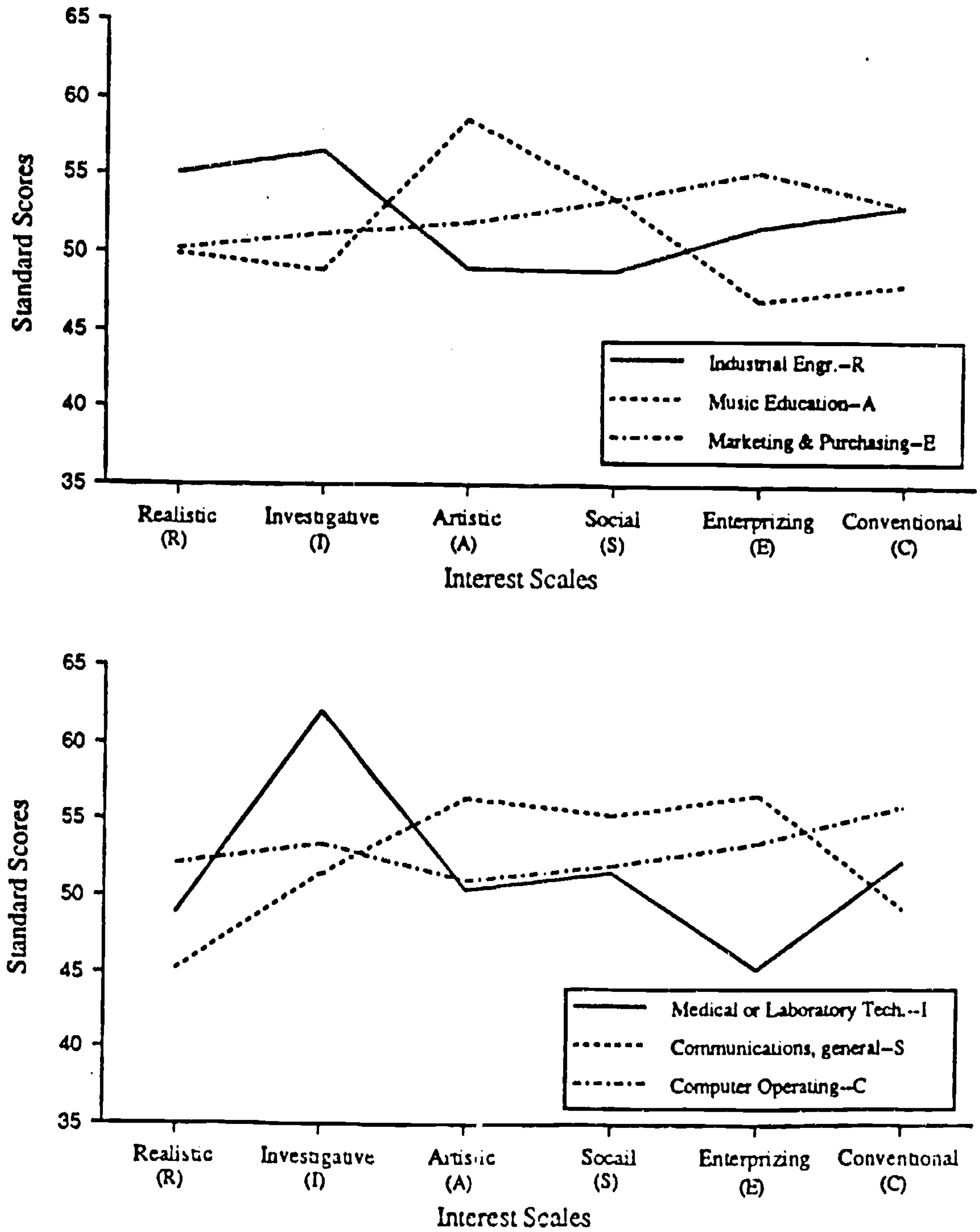

Figure 3. Interest profiles for occupations most congruent with Holland's types. (Top: R, A, and E occupations; Bottom: I, S, and C occupations).

APPENDIX A

DESCRIPTION OF PROCEDURES USED TO ANALYZE STATISTICAL SIGNIFICANCE OF OCCUPATIONAL DIFFERENCES

Multivariate Analysis of Variance (MANOVA)

MANOVA, a multivariate generalization of analysis of variance, can be used to determine the extent to which two or more groups, considered simultaneously, differ on a set of two or more measures, considered simultaneously. When there are only two groups (e.g., criterion groups), MANOVA procedures (and the discriminant analysis procedures described below) have a number of similarities with point-biserial multiple regression analysis. When there are more than two groups, MANOVA procedures and results are unique.

The Wilks's lambda statistic is typically used as an index of group differentiation in MANOVA. This statistic reflects the ratio of within-group variance to total-group variance, as determined from multivariate estimates of variance. The value of lambda can range from zero to one. When there are no group differences on a set of measures (i.e., when among-group variance is zero), lambda will equal one. Lambda approaches zero as group differences increase.

Although lambda ranges from zero to one, it does not directly provide an index of explained variance analogous to R^2 in regression analysis. In MANOVA, one would prefer to have an index that provides the proportion of total variance in a set of measures (among-group plus within-group variance, across all measures) that is attributable to criterion group differences. Huberty (1983) cites seven indices proposed for this task. Four of the seven provide similar results when sample sizes are "large" (p. 710) relative to the number of measures. One of these, the "Wilks index," is simply one minus Wilks's lambda.

Since there does not appear to be a single, best index of explained variance in MANOVA (Huberty, 1983, p. 712), the Wilks index is used here. The index estimates the proportion of total variance in individual differences across a set of measures that is attributable to inter-group differences. More briefly, the Wilks index "is a variance-explained index" (Huberty & Smith, 1982, p. 419). Because lambda is commonly available in MANOVA, the Wilks index can be easily obtained and compared across studies with comparable criterion groups.

An F value based on Wilks's lambda is used for tests of statistical significance in MANOVA. If Wilks's lambda is significant at the chosen significance level, it is common to examine univariate Fs to determine the extent to which each measure in the analysis differentiates the groups. If the measures have overlapping variance, a different approach is needed to determine the unique contribution of each measure to group differentiation. One possibility, suggested by Huberty (1984), is to note the change in lambda when a measure is removed from the set. Thus, if there are six measures in a set, the overall lambda is compared with lambdas obtained for six sets of five measures, a different measure being omitted from each set. Degree of change in lambda can then be used to rank the measures with respect to their unique contribution to group differentiation.

Discriminant Analysis (DISANL)

If MANOVA indicates that criterion groups differ significantly on a set of variables, the dimensionality of the differences can be examined through DISANL. Although a number of statistical procedures are sometimes grouped under the term, DISANL might best be thought of as a statistical technique for finding uncorrelated combinations of measures (discriminant functions) which best differentiate among a set of criterion groups. A discriminant function is defined as a linear combination of measures which maximizes the ratio of among-group variance to within-group variance, with variances represented by multivariate estimates. After each discriminant function is obtained, variance associated with it is removed and successive uncorrelated functions are obtained until residual among-group variance is exhausted.

The eigenvalue associated with a discriminant function can be used to estimate the proportion of overall group differentiation (among-group variance) that is accounted for by the function. Successive functions will account for successively smaller proportions of variance.

Although there is no generally accepted test of statistical significance for a specific discriminant function, it is possible to determine, through a chi-square transformation, whether significant group differences remain after the function is extracted. Thus, one may find that criterion group differences remaining after the first (or second, etc.) function is extracted can be reasonably attributed to chance. (The .0001 level of statistical significance was required to reject the null hypothesis of no group differences in the study reported here.) Together, the chi-square test and the "variance-explained" estimate for each function provide a basis for deciding whether criterion group differences can be adequately represented by a given number of dimensions.

Two types of data are typically used to determine the nature of the dimensions (discriminant functions) on which groups differ. First, correlations of the measures with the functions can be examined, much as in factor analysis. Second, group means and standard deviations can be obtained for the functions. (These data are available from the authors of the study reported here.)

Hit Rate Analysis

Another indicator of group differentiation is the proportion of group members who are assigned to their own groups through use of a set of measures. If the measures fail to differentiate criterion groups, the proportion of correct assignments (the "hit rate") will approximate chance. On the other hand, if there is no overlap among the criterion groups, all group members will be assigned to their own group and a hit rate of 100% will be obtained. Thus, hit rate and discrimination power co-vary. (Sampling anomalies result in less than a perfect correlation, however.)

Although frequently associated with DISANL, hit rate analyses can be conducted for any set of scores--e.g., original test scores, factor scores, discriminant function scores. In the study reported here, the overall hit rate was based on scores for all available discriminant functions. Hit rates determined from all discriminant functions generally approximate those obtained directly from the original variables.

In order to determine hit rates, indices of group similarity are needed for each member of a sample. Thus, if there are six criterion groups in a study, six indices of group similarity are needed. Each person in the study can then be assigned to the group for which he or she has the highest similarity index. In the study reported here, similarity indices were based on Bayes' rule, as described by Norusis (1985). The pooled within-group covariance matrix was used, and group sizes were considered to be equal.

Although hit rates can generally be improved by taking <u>relative</u> group size into account, this was not done in the analyses reported here. Instead, criterion group assignments were based solely on similarity indices derived from the discriminant functions. This approach to validation is compatible with the use of test scores in career counseling. Few counselors, for example, would reason as follows: "Mary scores like persons in Occupation A.
But there are few persons in Occupation A. So I will suggest something else."

Most counselors would not hesitate to tell a counselee that he or she has scores similar to persons in Occupation A, even though its size might be quite small in comparison to other occupations. Job opportunities could then be considered, separately, as part of counseling.

Although hit rates have concrete meaning, their evaluation (are the hit rates "high" or "low"?) is not straightforward. Among the factors to be considered are the following.

1. What is the chance hit rate and to what extent does the observed hit rate improve upon chance? Brennan and Prediger (1981) discuss various indices of agreement beyond chance. They show that when there are no restrictions on the number of persons assigned to a given criterion group in a classification study, chance should be defined as 1/n, where n is the number of criterion groups.

2. How many groups are in the analysis? This question is important because the number of groups directly influences the chance hit rate (1/n). Thus, if there are two groups, a hit rate of 51% would not be impressive.

3. What is the nature of the criterion groups in the analysis? They may differ, for example, from comprehensive categories covering all recognized occupations (e.g., job clusters) to highly diverse, specific occupations. Greater criterion group differentiation (hence, higher hit rates) can be expected for specific occupations because comprehensive groups, by their very nature, shade into each other. If only a few, selected occupations are included in an analysis,

however, the generalizability of results would be in doubt.

4. Are the hit rates statistically significant? This question is addressed in this study by providing confidence limits for the overall hit rate and comparing the limits with the chance hit rate. Also, it is related to the question of group differentiation. The latter question, as noted in the discussion of MANOVA, is addressed by an F test based on the Wilks's lambda.

Table A1

Differentiation of Job Clusters by UNIACT

Statistics (see Appendix A description)	Weighted-sample results	
MANOVA		
Wilks's lambda[a]	.71	
Wilks's variance-explained index	29%	
Univariate F[b] (and rank for unique contribution)		
R Scale	15.7	(5th)
I Scale	30.4	(3rd)
A Scale	32.8	(2nd)
S Scale	22.8	(4th)
E Scale	12.1	(6th)
C Scale	37.5	(1st)
DISANL		
No. of functions warranted by significance tests[c]	4	

Among-group variance for all 5 functions: 42%, 33%, 20%, 3%, 2%

Hit rate[d]: R (45%), I (37%), A (38%), S (24%), E (9%), C (44%); Total (33%).

[a]p < .0001, based on analysis of unweighted data. [b]p < .0001 for each scale, based on analysis of unweighted data. [c]p < .0001, based on analysis of unweighted data. A chi-square test for remaining functions was used. [d]Hit rate for job clusters (R, I, etc.) is cross-validated. Chance hit rate for total sample is 17%.