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Re-conceptualizing the past: Historical data in vocational interest research

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Abstract

Noteworthy progress has been made in the development of statistical models for evaluating the structure of vocational interests over the past three decades. It is proposed that historically significant interest datasets, when combined with modern structural methods of data analysis, provide an opportunity to re-examine the underlying assumptions of J.L. Holland's [Holland, J. L. (1959). A theory of vocational choice. *Journal of Counseling Psychology, 6,* 35–45; Holland, J. L. (1997). *Making vocational choices* (3rd ed.). Odessa, FL: Psychological Assessment Resources] RIASEC model. To illustrate this potential, data obtained from J. P. Guilford's study of interest structure were re-analyzed using modern circumplex and hierarchical clustering techniques to evaluate Holland's and I. Gati's [Gati, I. (1979). A hierarchical model for the structure of interests. *Journal of Vocational Behavior, 15*, 90–106; Gati, I. (1991). The structure of vocational interests. *Psychological Bulletin, 109,* 309–324] interest structures. Obtained results indicate that a circumplex model can be used to effectively represent the structure underlying Guilford's interest measures. However, hierarchical clustering results suggest that Holland's RIASEC types may not be the most effective categories for grouping specific interest measures into broader interest areas. The current findings provide support for the continued investigation of alternatives to Holland's interest categories using modern measures of basic interests.

Keywords: Historical data; Circumplex models; Hierarchical clustering; Vocational interests; Holland's RIASEC model

1. Introduction

Over the past three decades a substantial body of research has emerged investigating the structure of interests, primarily at the general factor level, with the focus of this attention on Holland's (1959, 1997) RIASEC interest types. Despite the substantial empirical support for Holland's model (Rounds & Tracey, 1996; Tracey & Rounds, 1993), other research summarized in Rounds (1995) suggests some limitations for using the Hol-

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land model to represent the interest domain. In particular, the research supporting Holland's model almost invariably uses interest measures designed to reproduce the six RIASEC types, raising the possibility that the Holland structure identified in this research is an artifact of using Holland-based measures (Shivy, Rounds, & Jones, 1999). When combined with modern advances in statistical methods, the use of historical data may provide an opportunity to re-examine support for the Holland model using non-RIASEC measures.

In 1953, J. P. Guilford and his colleagues (Guilford, Christensen, Bond, & Sutton, 1953) published an obscure US Air Force technical report outlining an investigation of the factor structure of human interests in two samples of Air Force personnel. In this study they identified seven interest factors related to occupational choices and vocational development: Mechanical, Scientific, Aesthetic Expression, Social Welfare, Business, and Outdoor Work. An edited version of this technical report was subsequently published in Psychological Monographs (Guilford, Christensen, Bond, & Sutton, 1954). Although Holland did not cite this study in the initial formulation of his RIASEC interest types and work environments (Holland, 1959), subsequent theoretical statements (Holland, 1997) have acknowledged the significance of Guilford et al.'s work in providing empirical support for the six types. In the time since the Guilford study, a number of advances have been made in the statistical methods used to test the structural hypotheses for Holland's model. The present study used the techniques of Circular Unidimensional Scaling (CUS, Hubert, Arabie, & Meulman, 1997) and hierarchical clustering (Hubert & Arabie, 1995) to evaluate Holland's model by re-analyzing Guilford's data.

Precedent for revisiting empirical studies from the history of individual differences research can be found in the literature on the five-factor model of personality. In particular, re-interpretation of previous research findings and historical datasets is a notable component of the empirical support for this model. Deary (1996) demonstrates the utility of re-analyzing historical data by applying modern factor-analytic techniques to data published by Webb (1915) and finding support for a five-factor model of personality. Goldberg (1993) has identified a number of significant studies that represent precursors to the five-factor model, including factor-analytic work by Fiske (1949) and Tupes and Crystal (1961/1992) in which personality factors were identified with characteristics similar to current definitions. The work by Tupes and Christal is also notable for its shared characteristics with the Guilford et al. (1953, 1954) research. In both cases the studies were originally obscure US Air Force technical reports with findings that serve as a template for the development of subsequent models (i.e., the five-factor model and RIASEC) that are now dominant in the fields of personality and interest research.

1.1. The Holland RIASEC types

Holland (1959, 1997) has proposed a set of vocational personality types and working environments with six broad categories: Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising, and Conventional (C). These six categories, collectively referred to by the first letters acronym RIASEC, can be used to classify an individual's interests, have influenced the development of interest measures (Campbell & Borgen, 1999), and can also be used to classify occupations (Gottfredson & Richards, 1999; Muchinsky, 1999). By matching an individual's interests to occupational characteristics by Holland category, it is possible to identify potential career choices for career counseling (McDaniel & Snell, 1999). A spatial model of the types was proposed by Holland, Whitney, Cole, and Richards (1969), using a hexagon to represent the inter-relations between the types ordered clockwise R-I-A-S-E-C. As illustrated in Fig. 1, the degree of similarity between any two of

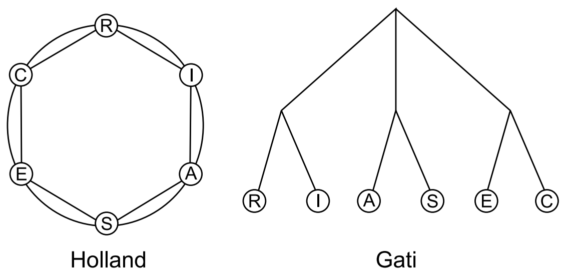

Fig. 1. Holland's (1997) circumplex and Gati's (1991) hierarchical model of interests.

the types is inversely proportional to the distances between them in the hexagon. An alternative hierarchical model proposed by Gati (1979, 1991) is also illustrated in Fig. 1.

1.2. A role for historical data

Historical datasets represent an important and often overlooked opportunity to test Holland's (1959, 1997) model of interests. Although Holland first proposed his model in 1959, it did not emerge as the dominant model of interests until the 1970s (Campbell & Borgen, 1999; Rounds, 1995), long after the initial development of vocational interest measures in the 1920s (see Fryer, 1931). Whereas modern interest measures clearly display a Holland influence, as evidenced by the routine reporting of Holland type scores, interest measures that predate the dominance of Holland's model appear to offer a more independent picture of the world of work. Arguably one of the most important of these historical datasets is the landmark Guilford et al. (1954) factor analysis of interests, the results of which predate the development of Holland's theory. A re-analysis of this data is potentially very interesting and may have important repercussions for the RIASEC model because Holland (1997) cites the original Guilford et al. results as support for the types.

The historical dataset used in the present study was obtained from interest assessment research program conducted by the US Air Force during the 1950s that provides access to data collected under rigorous conditions with large samples selected to control for demographic characteristics. Guilford et al. (1954) surveyed the empirical and theoretical literature on human motivation to identify lists of interests, needs, drives, and other motivational determinants of behavior to develop their measures. A total of 100 ten-item scales were developed by the researchers representing 33 content areas of individual differences in motivation. The scales were then administered to two large samples of Air Force personnel, and the resulting correlation matrices of interest scales were factor analyzed using the now obsolete methods of centroid factor extraction and the Zimmerman graphic method of orthogonal rotation (see Guilford et al., 1953, pp. 16–17). The factor analyses produced 28 identifiable factors, including six that corresponded to what Guilford et al. referred to well-known vocational interest factors. These six factors are now viewed as reflecting the RIASEC model: Mechanical, Scientific, Aesthetic Expression, Social Welfare, Business, and Clerical. A seventh factor, Outdoor Work, was also cited as being relevant to vocational interests. The Guilford et al. study remained the most comprehensive investigation of vocational interest factors until the late 1970s (Rounds, 1995).

1.3. Circumplex and hierarchical models of interests

Tracey and Rounds (1995) have proposed that the six RIASEC types represent a more general circumplex structure of interests. Holland refers to the structure described by the calculus assumption as a hexagon; the proper statistical term, however, for a model with a circular arrangement and distances indicating degree of similarity is a circumplex (Guttman, 1954; Rounds, Tracey, & Hubert, 1992). The circumplex is a potentially effective strategy for creating a parsimonious visual representation of the inter-relations among a set of variables, if the underlying structure coincides with a circular order. Circumplex structures have been identified in a number of areas of psychological research, including personality (Gurtman, 1997), emotions (Russell & Barrett, 1999), interpersonal behavior (Wiggins, 1996), and psychopathology (Widiger & Hagemoser, 1997). Tracey and Rounds (1995) have demonstrated that a circumplex model can be used to describe interest structure, and have suggested that Holland's types are an arbitrary set of six groups representing a more general circular ordering of interests they referred to as the concentric-circles model.

When Gati (1979, 1991) proposed a hierarchical model of interests, he claimed that this structure would be more effective than a hexagon or circumplex to represent the inter-relations among types. This claim of hierarchical model superiority has received mixed support in large scale meta-analyses of RIASEC correlation matrices. Tracey and Rounds (1993) analyzed data from 104 published matrices and found the fit of Holland's circumplex model to be superior to Gati's hierarchical model. However, in a second meta analysis of RIASEC data taken from data collected in the US and 18 different countries, Rounds and Tracey (1996) found the fit of Gati's model to be superior to Holland's for US ethnic group and international samples. Gati (1991) also maintains that the benefits of the hierarchical model was more apparent when examining the structure of interests with a larger number of more specific interest measures, as opposed to general interest measures of the

RIASEC types. Therefore, fitting a larger set of non-RIASEC interest measures to a hierarchical model, and then comparing the fit to a circumplex model for the same data, will provide a test of Gati's claim that a hierarchical model will be more effective for representing interest structure when moving beyond the six Holland types.

1.4. The present study

In the present study, data obtained from Guilford et al. (1953) will be re-analyzed using the technique of Circular Undimensional Scaling (CUS, Hubert et al., 1997) to evaluate the fit of a circumplex model. To the extent that Guilford's data coincides with the structural model proposed by Holland (Holland, 1997; Holland et al., 1969), it was predicted that the circular arrangement of interest measures obtained using CUS will be consistent with a RIASEC-based ordering. The data will also be analyzed using the technique of least-squares hierarchical clustering (Hubert & Arabie, 1995) to evaluate the fit of a hierarchical model. To the extent that the structure underlying Guilford's data coincides with Gati's (1979, 1991) hierarchical interpretation of Holland's model, it is predicted that the clustering of the Guilford interest scales should be consistent with the RIASEC categories.

2. Methods

2.1. The Guilford data

The Guilford et al. (1954) monograph does not include correlation matrices of the interest measures that were factor analyzed. However, the correlation matrices were obtained from the Air Force technical report of the same research project (Guilford et al., 1953). Using the results of the Guilford et al. factor analyses, the review of the results by Rounds (1995) and Holland's (1997) type definitions, 25 scales were selected for inclusion in the current study. Table 1 outlines the proposed variables for use in the present study arranged by RIASEC type. The correlations for the 25 Guilford interest scales selected for analysis are presented in Table 2 for both the enlisted personnel and officer samples.

2.2. Sample characteristics

A sample of 600 male Air Force enlisted personnel was obtained from thirteen training flights ($n = 898$) between November and December 1951. Guilford et al. (1953) report that the sample was restricted to White

Table 1
Selected Guilford et al. (1954) scales by Holland type

Holland type	Scale	Holland type	Scale
Realistic	Agriculture Manual Construction Mechanical Design Mechanical Manipulation Outdoor Work Precision—Detail	Social	Civics Elucidation Personal Services Social Science Welfare of Others
Investigative	Logical Processes Mathematical Concepts Science—Investigation Science—Laboratory Science—Theory	Enterprising	Business—Administration Business—Contact Business—Selling
Artistic	Drama Graphic Arts Literature Music	Conventional	Office—Clerical Office—Numerical

Table 2
Correlations of 25 Guilford interest scales for enlisted personnel and officer samples

Scale	1	2	3	4	5	6	7	8	9	10	11	12
1. Drama	—	0.388	0.607	0.614	0.432	0.388	0.349	0.315	0.402	0.536	0.014	0.057
2. Graphic Arts	0.459	—	0.600	0.513	0.259	0.170	0.364	0.214	0.288	0.291	0.188	0.373
3. Literature	0.571	0.608	—	0.641	0.174	0.347	0.366	0.205	0.329	0.587	−0.152	0.083
4. Music	0.650	0.504	0.596	—	0.234	0.247	0.232	0.100	0.270	0.324	0.014	0.144
5. Personal Services	0.523	0.230	0.377	0.405	—	0.481	0.416	0.516	0.395	0.334	0.187	−0.009
6. Welfare of Others	0.364	0.377	0.430	0.352	0.536	—	0.505	0.667	0.470	0.592	−0.130	−0.066
7. Business—Admin.	0.467	0.484	0.560	0.413	0.437	0.607	—	0.745	0.683	0.593	−0.188	−0.058
8. Business—Contact	0.355	0.453	0.504	0.384	0.523	0.764	0.803	—	0.633	0.507	−0.100	−0.091
9. Business—Selling	0.486	0.456	0.498	0.502	0.496	0.465	0.664	0.678	—	0.458	−0.061	0.038
10. Civics	0.494	0.398	0.620	0.481	0.455	0.640	0.662	0.678	0.529	—	−0.100	−0.029
11. Manual Construction	0.082	0.316	0.022	0.082	0.230	0.101	−0.052	−0.012	0.142	0.067	—	0.528
12. Mech. Design	0.155	0.404	0.188	0.105	0.000	0.173	0.075	0.060	0.192	0.128	0.394	—
13. Mech. Manipulation	−0.098	0.061	−0.193	−0.069	0.077	−0.042	−0.195	−0.169	−0.005	−0.163	0.754	0.453
14. Office—Clerical	0.215	0.338	0.333	0.317	0.544	0.553	0.685	0.668	0.432	0.525	0.177	0.029
15. Office—Numerical	0.165	0.225	0.281	0.197	0.412	0.489	0.623	0.640	0.428	0.530	0.120	0.090
16. Agriculture	0.022	0.087	−0.032	−0.061	0.246	0.098	−0.010	0.022	0.133	0.091	0.546	0.078
17. Outdoor Work	0.163	0.288	0.150	0.110	0.362	0.248	0.129	0.185	0.233	0.213	0.690	0.207
18. Precision—Detail	0.186	0.439	0.171	0.162	0.200	0.280	0.248	0.264	0.226	0.246	0.533	0.489
19. Science—Investigation	0.380	0.549	0.472	0.391	0.234	0.313	0.389	0.332	0.359	0.511	0.356	0.551
20. Science—Laboratory	0.313	0.528	0.254	0.257	0.201	0.309	0.318	0.360	0.255	0.285	0.252	0.372
21. Science—Theory	0.298	0.324	0.279	0.192	0.262	0.264	0.120	0.213	0.348	0.318	0.248	0.455
22. Social Science	0.486	0.509	0.649	0.341	0.411	0.604	0.671	0.588	0.512	0.776	0.163	0.265
23. Logical Processes	0.391	0.512	0.507	0.393	0.205	0.457	0.489	0.450	0.353	0.543	0.000	0.370
24. Mathematical Concepts	0.338	0.478	0.436	0.332	0.174	0.315	0.485	0.423	0.391	0.541	0.144	0.396
25. Elucidation	0.579	0.588	0.719	0.501	0.556	0.605	0.662	0.612	0.594	0.821	0.209	0.340

Scale	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Drama	−0.077	0.079	0.066	0.024	0.055	0.061	0.180	0.045	0.052	0.294	0.301	0.088	0.481
2. Graphic Arts	0.100	0.105	0.093	0.219	0.160	0.218	0.390	0.204	0.130	0.269	0.265	0.184	0.426
3. Literature	−0.225	−0.043	−0.144	0.024	0.029	−0.088	0.184	−0.025	−0.009	0.440	0.495	0.054	0.673
4. Music	−0.069	0.027	−0.040	0.112	0.002	−0.001	0.163	−0.035	0.166	0.226	0.259	0.001	0.312
5. Personal Services	0.043	0.446	0.234	0.175	0.296	0.229	0.174	0.131	0.118	0.246	0.036	−0.048	0.411
6. Welfare of Others	−0.179	0.305	0.126	0.048	0.096	−0.079	0.013	−0.014	−0.026	0.478	0.273	−0.157	0.493
7. Business—Admin.	−0.221	0.342	0.212	−0.106	0.041	−0.123	0.011	−0.099	−0.025	0.562	0.264	0.060	0.545
8. Business—Contact	−0.188	0.408	0.299	−0.061	0.082	−0.087	−0.019	−0.041	−0.098	0.510	0.170	−0.068	0.449
9. Business—Selling	−0.068	0.288	−0.186	0.072	0.139	−0.063	0.108	−0.077	0.045	0.446	0.215	0.016	0.454
10. Civics	−0.170	0.251	0.015	0.091	0.117	−0.060	0.060	0.057	0.094	0.672	0.436	−0.032	0.716
11. Manual Construction	0.762	0.169	0.273	0.535	0.609	0.672	0.505	0.430	0.301	−0.034	−0.032	0.310	0.088
12. Mech. Design	0.558	0.062	0.197	0.229	0.354	0.583	0.713	0.521	0.494	−0.042	0.214	0.510	0.177
13. Mech. Manipulation	—	0.097	0.247	0.352	0.534	0.690	0.522	0.534	0.303	−0.123	−0.099	0.344	−0.007
14. Office—Clerical	0.039	—	0.531	0.045	0.212	0.273	0.035	0.184	0.048	0.314	−0.009	0.144	0.403
15. Office—Numerical	−0.022	0.757	—	0.186	0.271	0.328	0.206	0.247	0.182	0.132	0.004	0.464	0.159
16. Agriculture	0.447	0.095	0.153	—	0.652	0.240	0.232	0.241	0.206	0.094	0.074	0.051	0.106
17. Outdoor Work	0.471	0.286	0.219	0.773	—	0.422	0.386	0.338	0.319	0.121	0.015	0.138	0.224
18. Precision—Detail	0.573	0.328	0.353	0.222	0.318	—	0.710	0.638	0.460	0.023	0.088	0.521	0.155
19. Science—Investigation	0.272	0.321	0.255	0.110	0.281	0.715	—	0.777	0.623	0.228	0.237	0.632	0.312
20. Science—Laboratory	0.127	0.371	0.342	0.143	0.291	0.612	0.730	—	0.506	0.043	0.131	0.533	0.124
21. Science—Theory	0.182	0.183	0.218	0.168	0.265	0.523	0.656	0.458	—	0.194	0.344	0.519	0.210
22. Social Science	−0.021	0.473	0.489	0.150	0.289	0.466	0.697	0.509	0.531	—	0.511	0.249	0.701
23. Logical Processes	−0.070	0.254	0.360	0.000	0.078	0.455	0.601	0.535	0.514	0.695	—	0.285	0.439
24. Mathematical Concepts	0.027	0.405	0.604	0.097	0.164	0.599	0.719	0.583	0.579	0.650	0.703	—	0.173
25. Elucidation	0.028	0.498	0.514	0.136	0.365	0.467	0.664	0.495	0.479	0.840	0.614	0.622	—

Note. Correlations above the diagonal are for officers ($n = 720$); correlations below are for enlisted personnel ($n = 600$).
Mech., Mechanical; Admin., Administration.

male enlisted personnel who scored at least 4.00 on the Technical Specialty Aptitude Indexes to ensure that "significantly differing environmental backgrounds in the sample might tend to blur factor structure" (p. 11). Demographic information reported suggests that this sample is comparable in education and age to the larger population of White male enlisted Air Force personnel of that era.

A second sample of 720 Air Force officers was obtained from three groups of Air Force officers: AFROTC candidates ($n = 257$), air cadets and student officers in flight training ($n = 187$), and officer candidates in OCS training ($n = 276$). Similarly to the enlisted personnel sample, this group was restricted to White males to control for potential concerns about between group variability in interest factor structure. Reported demographic information suggests that this sample is comparable in education and age to the larger population of White male Air Force officers of that era.

2.3. Scale development

Guilford et al. (1953) developed a list of 33 hypothesized interest constructs by surveying the extant interest literature and available interest measures. From this list of 33 general interest constructs they developed operational definitions for 100 interest measures (referred to as sub-hypotheses). Three general types of items were included in the instrument: Activity items, self-descriptions, and attitude and belief items. A three-point response format ("Yes," "?," and "No") was used for all questions. Several thousand items were initially developed from the hypothesized constructs and 15 items were selected to represent each scale in preliminary testing of the measures. The interest survey was pilot tested on a sample of 400 airmen, after which the inventory was revised and shortened, resulting in 10 items for each scale. Reliability estimates for the scales were obtained from random samples of 200 answer sheets from each sample using the Rulon formula (Guilford, 1950). For the 25 scales used in the present study, the mean scale reliability for the enlisted personnel sample was .85, with a range of .68–.92, and the mean scale reliability for the officer sample was .86 with a range from.77 to.92.

2.4. Data analysis

The data analysis in the current study were performed using statistical programs presented in a monograph by Hubert, Arabie, and Meulman (2007). These programs were developed for implementation in the MATLAB programming environment based on algorithms initially presented in Hubert et al. (1997) and Hubert and Arabie (1995). The MATLAB m-files used in the current analyses are available for download through the website associated with Hubert et al.'s (2007) monograph (http://cda.psych.uiuc.edu/srpm_mfiles/).

2.4.1. Circular unidimensional scaling

The fit of the Guilford data to a circumplex model of interests was assessed using CUS (Hubert et al., 1997). CUS directly evaluates the two essential elements of a circumplex structure, the ordering and spacing of objects (in this case basic interest scales) around a circle. In comparison, previous circumplex techniques represent "indirect attacks on the CUS task through the fitting of (transformed) proximities by nonlinear monotonic functions of the minimum distances calculated around a circular structure" (Hubert et al., 1997, p. 257). An additional advantage of the CUS technique is the use of an easily interpreted Variance-Accounted-For (VAF) measure of model fit, a statistic that offers an interpretation similar to an R^2 value in a regression analysis.

There are three steps in the CUS data analysis procedure. First, a good ordering of types is determined using quadratic assignment, a heuristic technique for identifying the optimal ordering of types according to a set of structural constraints specified by a target matrix (see Hubert & Schultz, 1976). The CUS data analysis begins with a random permutation of the data matrix and a target matrix that specifies a circular structure. From the random starting permutation, a baseline estimate of fit, the Cross Product Index (CPI), is calculated, and then a series of local operations are used to make changes to the ordering of types in the data matrix with the objective of improving the fit of the data to the specified structure, as measured by changes in the CPI. The entire data matrix is reordered in a series of iterations until no improvements can be made to the CPI value, producing a final ordering of the types.

The second step in the CUS analysis is the estimation of inflection points in the circular structure using an iterative projection strategy presented in Hubert and Arabie (1995). The determination of inflection points is essential when estimating minimum distances between types in a circular structure, because for each pair of types there are two possible connecting paths (i.e., distances can be generated for both clockwise and counterclockwise directions), one of which is shorter unless the two types are exactly opposite in the circular structure. The final step in the process is the estimation of distances between types in the circular structure. Iterative projection is used to minimize a least-squares loss function that accounts for the presence of inflection points and minimizes the squared discrepancies between the original data and the distances between objects in a circular structure. The data analysis occurs in a series of iterations, during which different sets of distances between the types are evaluated and a series of incremental improvements are obtained for the fit of the data to a circular model. When no additional improvements can be made to the fit of the model, a final set of distances between types in the circular structure is produced. An additive constant is included in the model for the calculation of a VAF statistic.

2.4.2. Least-squares hierarchical clustering

The fit of the Guilford data to a Gati-based hierarchical model will be assessed using a least-squares iterative projection-based hierarchical clustering method developed by Hubert and Arabie (1995). This results in an ultrametric structure, the hierarchical clustering of a set of objects where the steps in the sequence of partitions connecting the objects together in clusters satisfy what is called the triangle ultrametric inequality. In a sequence of partitions that satisfies the ultrametric inequality, at each threshold level where objects from two disjoint subsets are joined together, the distances between all objects across the two united subsets will be equal to this threshold, and all other intra-cluster distances are smaller. The Hubert and Arabie technique uses iterative projection as a heuristic search strategy to identify a hierarchical structure that minimizes the squared discrepancies between the original data values and the fit distances between objects in the obtained hierarchical structure. This procedure is similar to the iterative projection method used in the CUS technique, with the primary difference being in the types of constraints specified for evaluating potential hierarchical solutions.

The data analysis occurs in a series of iterations during which different sets of distances between objects are evaluated and a series of incremental improvements are obtained for the fit of the data to an ultrametric model. When no additional improvements can be made, the final set of distances between objects is produced. The primary advantage of this technique over other hierarchical clustering methods is that the iterative projection search method increases the probability of identifying a very good fitting ultrametric solution. An additional advantage of this technique, shared with CUS, is the use of a VAF statistic to assess model fit by comparing original data and fit distances.

3. Results

3.1. Guilford airmen sample results

The results for the CUS analysis are presented in Fig. 2. There appears to be a group of basic interest scales associated with working with things that are separated somewhat from the remaining scales. The VAF for the unconstrained CUS model is.75. Overall the distribution of Guilford scales around the circumplex is unequal, with four R scales, Outdoor Work, Agriculture, Manual Construction, and Mechanical Manipulation, effectively isolated on one half of the structure. When examining the circular ordering of the scales, the R and I scales are ordered consistently with Holland’s theory. The ordering of the Graphic Arts and Logical Processes scale (reversing the I–A ordering), is the first deviation from the Holland model, and this is followed by the jumbled ordering of A, S, E and C scales. Deviations from the Holland ordering appear to primarily be an issue with the location of S scales, with two (Social Sciences and Verbal Elucidation) falling between the I and A scales, with Welfare of Others falling between the E and C scales and Personal Services falling between the C and R scales. From the perspective of Holland’s theory, the only S scale to be properly located between the A and E scales is Civics.

The results of the hierarchical clustering analysis with the Guilford airmen are presented in Fig. 3. This solution has a VAF of .65. A visual inspection suggests that either six or seven distinct clusters can be iden-

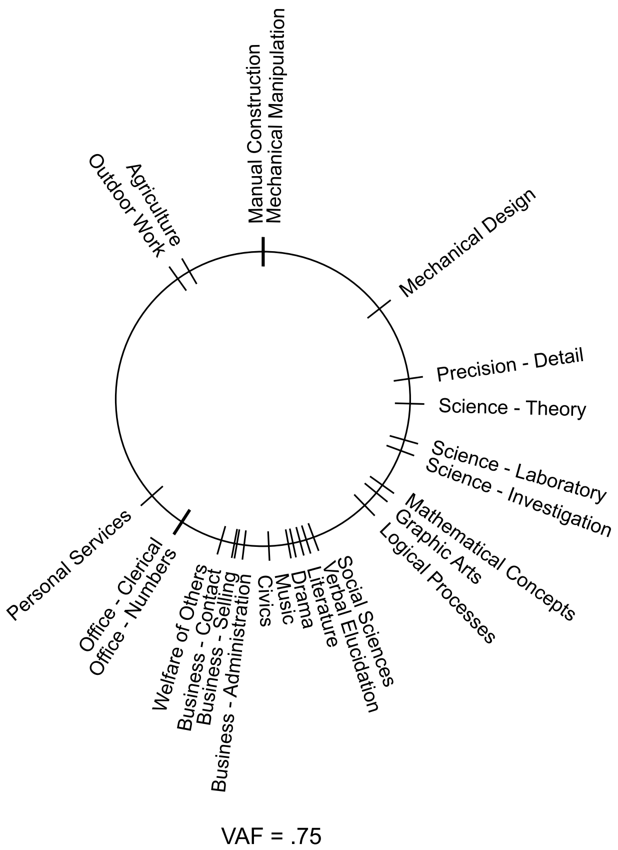

Fig. 2. Circular unidimensional scaling results for Guilford airmen sample.

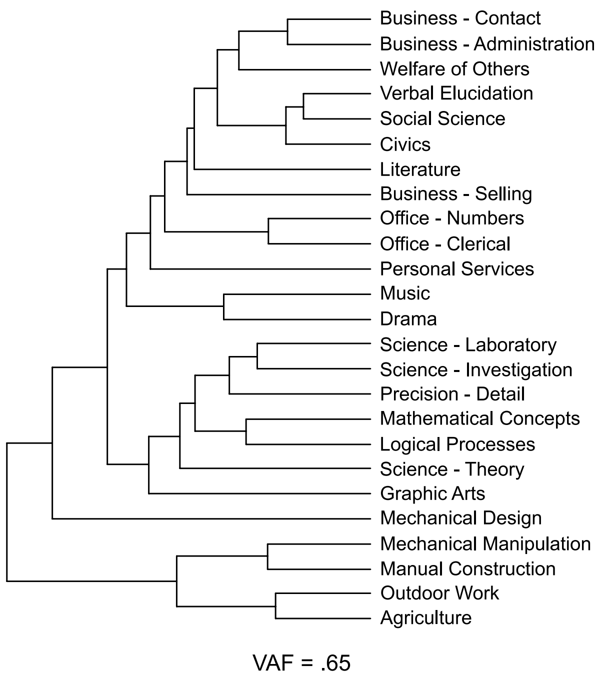

Fig. 3. Hierarchical clustering results for Guilford airmen sample.

tified depending on the point used as a cutoff for determining cluster groups. This solution includes a number of scales that do not become connected to the overall structure until distinct clusters have already started to join together to form larger categories. For example the cluster containing the Business—Contact, Business—Administration, and Welfare of Others is connected to a cluster of three S scales (Verbal Elucidation, Social Science, and Civics). This joining of two clusters creates a more general cluster of working with people, to which the scales measuring interest in Literature and Business—Selling become attached, followed by a separate cluster of two C scales (Office—Numbers and Office—Clerical), the Personal Services scale, and a cluster of two A scales (Music and Drama). Although there are four clusters of scales corresponding approximately to the E, S, C, and A types, in this structure there are also three scales (Literature, Business—Selling, and Personal Services) that do not join their expected clusters, instead becoming joined with other clusters at distinct junctions that defy classification into one of the emerging clusters.

The position of the Graphic Arts scale connects this measure with a group of I scales The Mechanical Design scale, which joins the clustering solution after the primarily I scale cluster, joins the grouping of E, S, A, and C scales. In a separate branch there are four R scales that create two distinct pairings, one being a cluster of the two outdoor work scales (Outdoor Work and Agriculture), and the other consisting of Mechanical Manipulation and Manual Construction. The grouping of the four scales is consistent with Holland's definition of the R type, and provide some support for joining the outdoor work with other R scales, unlike the results that will be presented for Guilford's officer sample. Of the five scales that do not fall into a tight cluster, Holland-consistent or otherwise, two are A scales (Literature and Graphic Arts), one is E (Business—Selling), and one is R (Mechanical Design). In addition to the scales that do not cleanly join a cluster of scales representing a Holland type, there are several scales that appear to be misclassified. The Welfare of Others scale appears to be more strongly associated with the cluster of E scales than with its own S scales, and the Precision—Detail scale is in league with the I scales instead of its own R scales.

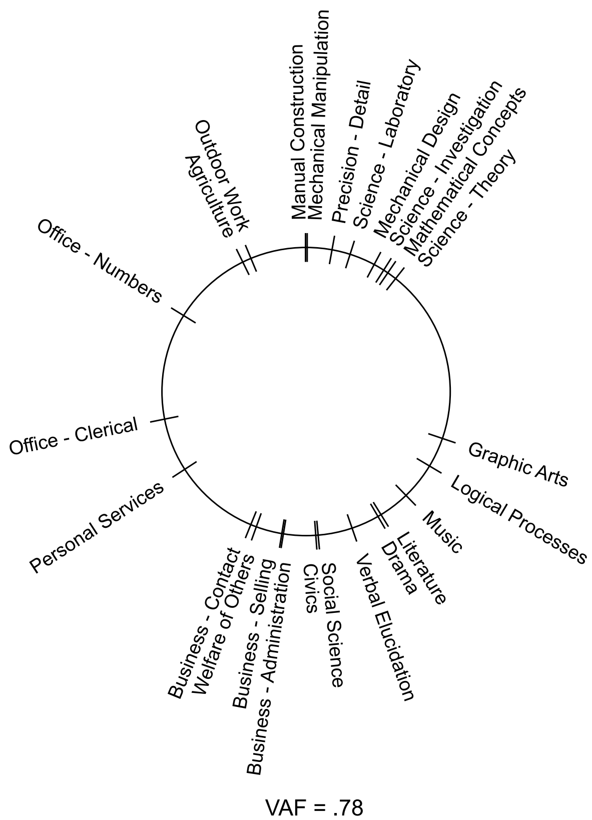

Fig. 4. Circular unidimensional scaling results for Guilford officer sample.

3.2. Guilford officer sample results

The results of the CUS analysis of the Guilford Officer data are presented in Fig. 4. The VAF for the unconstrained CUS model is .78. When compared to the Airmen sample results, the scaling of the officer data results in a more even distribution of scales around the circumplex. However, there remains a large gap between the I and A scales, and the distance between the two C scales is large when compared to distances between many of the other scales in this structure. There are four deviations from the Holland model in the ordering of the scales. The Science—Laboratory (I) and Mechanical Design (R) are out of sequence, as are the Graphical Arts (A) and Logical Process (I). The Welfare of Others (C) scale is embedded in the middle of the E scales instead of with the other S scales, and the Personal Services (S) scale falls between the E and C scales. It is also worth noting that although the two C scales appear adjacent to each other in the CUS model, they appear in different clusters in the hierarchical analysis discussed below.

The results for the hierarchical clustering of the Guilford Officer data are presented in Fig. 5. The clustering solution obtained with this sample has a VAF of .72. The primary split in the clustering analysis appears to be the R and I scales associated with working with things, and the E, S, and A scales. Similar to the results obtained with the Guilford airmen sample, there are a number of scales that do not clearly fit into one of the clusters of scales obtained in the analysis. These scales include Personal Services, the Logical Processes, and the two C scales, Office—Clerical and Office—Numbers. Unlike the Guilford airmen sample results, where the Outdoor Work and Agriculture scales joined early with other R scales, in the officer sample they form a distinct cluster that does not join the other R scales until after the I scales are also combined into a single larger cluster of working with things. Three of the R scales, Mechanical Manipulation, Manual Construction, and Precision—Detail form a distinct cluster, and the I scales appear to form two groupings. The first I grouping includes both the Science—Laboratory and Science—Investigation scales with an R scale, Mechanical Design, and the second I grouping is of the Mathematical Concepts and Science—Theory scales. This split may reflect a distinction between the applied and theoretical aspects of the I type.

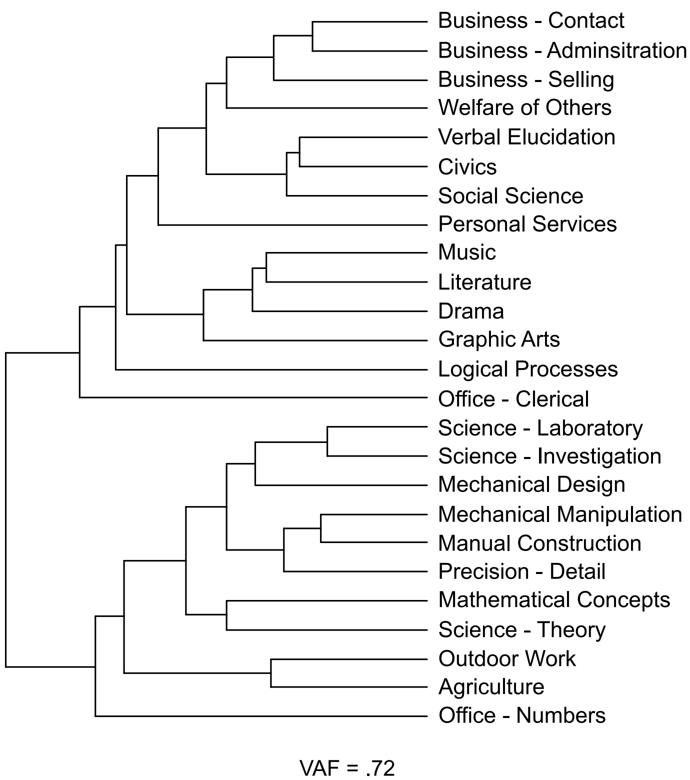

Fig. 5. Hierarchical clustering results for Guilford officer sample.

In the second major cluster of the Guilford Office sample, containing the A, S, and E scales there appear to be clusters corresponding to each of these types. The four A scales (Music, Literature, Drama, and Graphic Arts) form a tight cluster, as do the three E scales (Business—Contact, Business—Administration, and Business—Selling). Three of the S scales (Verbal Elucidation, Civics, and Social Science) also form a tight cluster, but the other two S scales are not as clearly connected. The Welfare of Others scale joins the cluster of E scales, and Personal Services does not join until the other S and E scales are all joined into a large working with people cluster. The most conspicuous absence in this analysis, however, is the lack of a cluster consistent with Holland's C type. One of the two C scales, Office—Clerical, is the last scale to join the large group of primarily A, S, and E scales, whereas the other C scale, Office—Numbers, is the last scale to join the large cluster of R and I scales.

4. Discussion

Guilford's (Guilford et al., 1953, 1954) factor-analytic study of interest structure has been cited by Holland (1997) as providing evidence for the RIASEC type definitions. Although the factors identified by Guilford bear some resemblance to Holland's constructs, the original analyses conducted in 1953 did not include formal evaluations of the circumplex (Holland et al., 1969) and hierarchical (Gati, 1979, 1991) structural models proposed for representing the inter-relations among types in the Holland model. In the time since Holland (1959) first proposed his theory, advances have been made in the statistical methods used for evaluating structural hypotheses (Rounds, 1995). The primary objective of this study was to re-examine the Guilford data using current statistical techniques to evaluate support for Holland-based structural models of interests. Although the obtained results provide partial support for Holland's structural hypotheses, they could also be interpreted as providing support for the continued development of alternative models based on basic interests.

Holland's RIASEC types can be arranged in a circular order, forming a circumplex model of interests. Based on the concentric-circles model of interests proposed by Tracey and Rounds (1995), it was predicted that the ordering of Guilford's interest scales in a circumplex model would be consistent with the Holland (1959, 1997) model. According to the concentric-circles hypothesis, when the RIASEC structure is extended to include measures of more specific interests, the ordering of the scales around the circumplex should preserve the RIASEC ordering. To evaluate this hypothesis, scales representing each of the RIASEC-like interest factors identified in the original Guilford factor analyses were re-analyzed using the CUS technique. With the airmen sample, the ordering of A, S, E, and C around a circumplex displayed some deviations from the predicted Holland ordering. In comparison, the officer sample results appeared to be closer to representing the Holland model, with a smaller number of deviations from the RIASEC order predictions.

It should be noted that the mean number of years of education for the airmen sample was 11.6 years, which suggests that this group was primarily educated at the high school level. In comparison, the mean number of years of education for the officer sample was 15.8 years, which suggested that this group was primarily educated to the college level. Observed differences between the airmen and officer samples may reflect the differing educational backgrounds and range of career options open to high school and college educated students in the 1950s. Because college-level education has become more ubiquitous in the 50 years since the Guilford data were collected, this difference between the two samples may be less relevant today than it would have been at that time. However, it should also be noted that Holland's theory was primarily developed on samples of gifted college and college-bound high school students (see Holland, 1997, pp. 74–77). Thus, the present findings provide some support for continued investigation of the role of educational attainment in the development of interests.

Gati (1979, 1991) proposed using a hierarchical model to represent interest structure as an alternative to Holland's circumplex. Similarly to the concentric-circles model, Gati proposed that a hierarchical model of interests could be extended beyond the RIASEC types, with each type sub-divided into more specific interest measures, and claimed that this method would be superior to using a circumplex model. This hypothesis can be evaluated by comparing results obtained using the CUS and clustering techniques presented in Figs. 2–5. Based on previous research using Holland-based measures, it is reasonable to predict that the fit of the competing hierarchical and circumplex models would be similar. However, with the added complexity of having 25 interest measures instead of 6 RIASEC scales, it was conceivable that a statistical difference between the two models could have emerged. Obtained results with the Guilford interest scales do not support Gati's hypothesis that a hierarchical model will provide a better fit. In fact, VAFs for the circumplex models were higher than for the corresponding hierarchical clustering solutions. A more detailed comparison of the solutions, however, finds many points of agreement between these different methods for representing interest structure.

Although Gati's (1979, 1991) hypothesis that a hierarchical model would provide a more effective representation of interest structure than a circumplex was not supported in the current analyses of basic interest measures; the similar mean VAFs obtained for both models suggest that each may offer insights into the underlying structure of interests. In previous studies comparing the Holland circumplex and Gati's hierarchical variation, such as the RIASEC-based meta-analyses of US (Tracey & Rounds, 1993) and international samples (Rounds & Tracey, 1996), the results have been mixed, with US sample results supporting the Holland model and international sample results supporting the Gati model. The discussion of these results often hinges upon a speculative discussion of which structural approach would be more useful in career counseling. The potentially more interesting issue that emerges in the current analysis of basic interests is the degree of similarity across the two models, both in terms of VAF and interpretive agreements about the relative similarity of different basic interest scales. With a few notable exceptions, the scales that occupy similar positions in the circumplex model are joined together at the earliest points in the hierarchical tree structure, and vice versa. Points where there are clear separation among the types are often the same across solutions, and in other instances, such as the overlap of Realistic and Investigative scales these overlaps are also found across the two structures. Ultimately the best solution may be to integrate these models instead of trying to develop a rationale for choosing one over the other.

In addition to raising questions about the limits of the Holland framework, the results obtained when evaluating the first two hypotheses also raise a potential question about the effectiveness of using either a hierarchical or circumplex structure to represent the structure of basic interests. As previously discussed, the fit of both models was similar and appear to be compatible, which would support the development of an integrated model combining the information from both solutions into a concentric-circles model, but without the inclusion of the six RIASEC categories. However, that the average model fit of 73% VAF obtained for both models suggests that additional improvements may be obtained by fitting a more complex model to basic interests. The challenge with fitting a more complex model is to justify the incremental improvements obtained in model fit against the loss of parsimony and ease of use in applied settings. It should be noted, however, that the developers of CUS (Hubert et al., 1997, 2007) have proposed an alternative strategy for fitting more complex structures to data based on the analysis of residual matrices obtained when fitting a circumplex, hierarchical, or dimensional structure. Given the potential utility of circumplex and hierarchical models for representing the structure of interests, it may be worthwhile to explore the Hubert et al. model in future investigations.

The obtained results provide support for the suggestion that using modern techniques of data analysis to reinterpret historical datasets may shed new light on long-standing issues associated with the models used to represent individual differences measures in vocational psychology. There are, however, some important limitations to using historical data, including potentially limited generalizability to current environments. Additionally, the samples obtained from the Guilford data represent White males, and although there is strong evidence for the equivalence of the RIASEC model by gender (e.g., Rounds & Tracey, 1993), concerns remain about its generalizability to diverse racial-ethnic groups (Armstrong, Hubert, & Rounds, 2003). Therefore, the demographic characteristics of historical samples are a potential concern, but this is not a reason in and of itself to avoid re-examining historical datasets. With Holland's theory in particular, the Guilford data represents the time period during which the RIASEC model was first being conceptualized. The finding that the RIASEC model is not entirely supported by the Guilford data adds extra weight to current issues being raised about the limits of the Holland model for representing the full range of vocational interests.

Despite potential reservations regarding the extent to which the RIASEC types effectively capture the entire individual differences domain of interests, the suggestion that the Holland model is dominant in vocational psychology is not a debatable point (see, Campbell & Borgen, 1999; Rayman & Atanasoff, 1999). As noted by Rounds and Day (1999), the dominance of Holland's theory effectively mandates its inclusion in any investigation of interest structure. In fact, it could be argued that the dominance of Holland's model in the interest measurement literature, and more generally in vocational psychology and applied settings such as career counseling, is somewhat of a liability for the advancement of the science of interest assessment. The intractability of the Holland types can be seen not only in the process by which new measures such as the Interest Profiler are developed (see Lewis & Rivkin, 1999), but also in terms of how alternative models are presented. Current findings support a potential shift in research focus away from Holland-based RIASEC measures towards more general issues of interest structure using measures, such as basic interests, that represent a wider range of interest constructs.

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