

## FROM CIRCUMPLEX TO SPHERE: PERCEPTIONS OF VOCATIONAL ACTIVITIES, EXPLORED AND APPLIED

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### Abstract

*Schematic maps of the world of work are often used in vocational guidance. Arguably a map is most effective if it coincides with the cognitive representation already internalized by job-seekers. Here, multidimensional scaling was used to extract a consensus representation from judgements about similarities among a set of vocational-aptitude descriptors. To exclude artefacts confined to a single procedure for eliciting similarity judgements, or a single form of analysis, three different procedures were used, and multiple groups of informants. The results converged on a 'vocational space' with at least three dimensions. Its axes were interpreted as 'people / things', 'indoor / outdoor', and 'creative / routine' aspects of work – though the map is rotationally indeterminate, so other frames of reference are valid. This map is shown to accommodate individuals' preference rankings of the descriptors, by representing them as vectors.*

**Key words:** interests; aptitudes; multidimensional scaling

### Introduction

Job-seekers confront a bewildering plethora of occupational titles and descriptions. They must make sense of information impinging on them from a variety of sources. At the same time, they must make sense of their own preferences and aptitudes: their enjoyment or lack of it for various facets of work, job-related activities, and rewards (reinforcers) provided by jobs. There is evidence that job-seekers who set out with clear career intentions achieve higher satisfaction and performance in their jobs than those who find work by accident or default. Clarity of intentions, and awareness of the range of available alternatives, are associated with job satisfaction. According to Shivy, Phillips and Koehly (1996), what counselors can offer to job-seekers is a tool for thinking

about occupational opportunities; a schema or 'map' of the world of work. Once internalized, it provides a framework for organizing both sets of information (and becoming aware of both ranges of choices).

A number of such schemata have been proposed. Holland introduced a classification of occupations into six divisions (occupations may also have secondary and tertiary tags), and parallel classifications of work interests and 'vocational personalities' (1973). Prediger (1982) interpreted these six categories as regions within a two-dimensional continuum, shifting the emphasis to the pair of bipolar axes that underlie this continuum. These axes provide a co-ordinate system, in which a given occupation can be located and its attributes can be specified. Prediger identified them as the oppositions 'People / things' and 'Ideas / data'. However, Tracey and Rounds pointed out equally valid alternative axes or oppositions for spanning the continuum (1996), and other ways of dividing it into categories (1995). Seven and eight categories characterize the systems of Athanasou (2002) and Roe (1956).

Given the long history and widespread use of tools based on Holland's system, it

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might seem otiose to re-address this issue. Nevertheless, we argue that if job-seekers benefit from vocational counseling by acquiring a schema – a framework for organizing information, clarifying their aspirations and options, and facilitating communication with advisers – then any pre-existing consensus about occupational structure, shared across the culture, is probably most easily acquired (if not present already, in nascent form). Holland's categorical system and the subsequent dimensionalized schemata grew out of theory, and are not necessarily the way that an informant (or a consensus of informants) would spontaneously think about the world of work. A number of studies have explored the 'cultural consensus' about occupations, not always finding the structure predicted by these theoretical schemata (Shivy *et al.*, 1996; Shivy, Rounds & Jones, 1999). Note also that occupational titles are not necessarily the best items to investigate occupational cognition – the best landmarks within the underlying structure, as it were. We argue below in favor of a finer-grained item set of job activities or aspects.

There is a long research tradition of representing vocational cognition with maps reconstructed from direct judgements of similarity, or from similarity estimates derived indirectly from preference rankings (reviewed by Rounds & Zevon, 1983; Davison, Richards & Rounds, 1986). The mathematical procedures for this 'cognitive cartography' are known as multidimensional scaling or MDS (Jones & Koehly, 1993).

Individual items (titles, etc.) are represented as points within a spatial map of two or three dimensions (or more), arranged so that the distance between any pair of points reflects the (dis-)similarity between the corresponding items. Adjacent items are the most similar, and the most interchangeable. Most distant items are most dissimilar: the choice or opposition between them is most clear-cut. This explicitly geometrical metaphor is a natural way of approaching the vocational domains. Crucially, judgements of occupational similarity can be used as judgements of 'transferability' (how well a candidate will be suited to one job if he is known to be ideally suited to a second). Reeb (1971) demonstrated that the two are highly correlated and yield equivalent MDS solutions.

MDS played a central part in the research reported here. Subjects indicated their relative preferences among a set of 99

vocational activities. A three-dimensional map of the items, depicting their interconnections and underlying structure, was instrumental in analyzing the subjects' responses. But the item set is the culmination of an empirical process of progressive refinement, with MDS applied at each iteration to indicate any absences within the set (where items needed to be generated) and any redundancies (where highly similar items could be rationalized). In geometrical terms, these correspond to regions of the map where too few items were distributed, or too many, respectively.

When a MDS solution is properly aligned, each of its dimensions (axes) is interpretable as a particular distinction drawn by the informants; in other words, as a particular attribute on which items can vary, such that the difference between two items' values on the attribute contribute to the overall impression of inter-item dissimilarity (and eventually to inter-item distance). Thus specific attention was paid to ensuring that item-points were present at the extremes of the three dimensions, since such items convey in pure form the vocational attribute or quality represented by that axis, positively or negatively depending on the pole. When a subject's preferences are elicited, such items sample his or her attitudes to that attribute most directly. New items were generated if necessary.

### **Alternative domains and dimensions**

Existing tools for vocational assessment tend to assume that the different domains within the broader ambit of 'vocation' – titles, aptitudes or skills, interests, 'predicates' (Coxon & Jones, 1979) – are all homologous ways of referring to the same structure, with homologous axes underlying them. One might describe these different item sets as different sets of landmarks that all occupy the same landscape, and are all equally good for navigating within it. But the empirical evidence suggests that these domains do differ in the salience of specific dimensions. Dawis (1992, p. 177) concluded that "The RIASEC structure fits only interest data, and an occupations map based on interest data will not correspond to [...] an occupations map based on other vocational variables". For reinforcers (the extrinsic, motivating attributes of jobs), some can be accommodated within occupation-title space,

but not all (Shubsachs & Davison, 1979). MDS treatment of *reinforcers* revealed additional dimensions (Ronen *et al.*, 1979).

Most MDS analyses of the subjective dissimilarities among a list of occupation titles find a 'Prestige' or 'Status' dimension emerging as a prominent quality of occupations, used by informants to discriminate them (e.g. Burton, 1972; Kraus, Schild & Hodge, 1978; Shivy *et al.*, 1996). Alternatively a dimension is given a label such as 'level of educational requirement' (Coxon & Jones, 1979) or simply 'Level' (Reeb, 1971), diverging from Status, but highly correlated with it. There are also studies where status varied little among the items available – these were restricted to a narrow band of status levels – so the quality failed to distinguish them as a dimension in the MDS solution (Coxon, 1971; Johnson, 1992).

Status level is clearly a useful variable to know about occupations, and about an individual's vocational aspiration; to omit it from discussion brings to mind the performance reported by Walter Scott, of "[...] the tragedy of Hamlet, the character of the Prince of Denmark being left out". But at the same time, it is an irrelevant and confounding factor for the purpose of determining which tasks and activities job-seekers like to do, and where they excel. When we assess the overall dissimilarity between two items, there are only so many dimensions we can consider concurrently, i.e. only so many independent qualities on which inter-item differences will contribute. This is a cognitive limitation of the human mind (additional to the celebrated "7±2" limit of short-term memory). The high salience of Status may mean that some other form of variation is thrust into the background; some variation that might gain in importance if the salience of Status were reduced.

For this reason, the present study moves away from job titles as the landmarks of choice for examining the structure of occupational cognition. Titles do have other disadvantages. As a practical tool for eliciting a job-seeker's preferences, they allow idiosyncratic factors to contribute significantly. A school-age client who has not previously mulled over the relative appeal of different careers might opt for one above others for any number of trivial or irrational reasons: because he has heard of it, or because she has a relative in that line of work, or because a recent TV series has glamorized the occupation.

For less familiar items that have not entered the cultural consensus, informants' judgements of similarity will be no more than guesswork, with no preconceived niche readily accessible within our mental filing systems. Conversely, clarity in our minds about the connotations of a given occupational title implies that it is conspicuous within the consensus. But a title that is familiar enough to evoke instant associations and a concrete mental image may not correspond to a single specific combination of activities. 'Scientist', for instance, evokes a single image (someone in a white lab coat) but covers a diffuse, heterogeneous range of actual jobs. Coxon (1971) was careful to work with "a list of occupations that avoided those titles with heterogeneous connotations."

Note also that judgements of similarity among job titles are likely to be based on stereotypes as much as on accurate knowledge of the various jobs' requirements, especially if the number of titles is large enough to map the terrain to a useful degree of detail. The cultural consensus is not an infallible guide to the true nature of a given occupation; distorted and oversimplified perceptions of the occupational domain are shared as easily as veridical ones (creating another rôle for vocational counseling – to correct a job-seeker's misconceptions if they would lead to later dissatisfaction with a chosen career). Even experts may disagree. Schwartz (1992) documents the discordance among vocational analysts on the correct coding for 'Dentistry'. Fortunately, possible distortions in the cultural consensus – that is, the possible inaccuracy of locations within the 'map' of points representing specific jobs – do not detract from its value as a schema.

Some studies have worked around issues of misconception and ignorance by providing informants with a gloss on each title – an explanation of the duties and activities it involves. In fact, one could dispense with the titles altogether by unpacking them and asking informants to judge similarities among the component activities. That approach was taken here.

Which is not to say that the present items capture all the information of interest, if used for vocational assessment. It may be that for a complete characterization of a job-seeker's vocational profile, "activity" items such as these should be combined with others drawn from complementary domains, to sample complementary axes such as Status.

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### The 'VOC-99' items

Ninety-nine items were developed and fine-tuned over a series of iterations, to explore the multidimensional semantic space they occupied and to sample it comprehensively and evenly. Rather than vocational titles, items were worded in terms of vocational activities and objects of activity (i.e. verbs and nouns), after verbs and nouns were found in a pilot study to be interchangeable. The iterations involved rewording items, winnowing items out when they led to duplication or redundancy, and generating new ones to fill any voids or under-represented regions in the space. Three key dimensions or axes of the map were tentatively identified, and attention was paid to ensure that there were items sampling these dimensions in relatively pure form (and located at the axial extremes). Instances are listed in Figure 1. They are numbered from 1 to 106 (with some numbers skipped).

Items were printed on 35-by-75 mm. slips of card for the data-collection tasks. This allowed informants to physically manipulate them, sorting them into piles according to various criteria. Three sets of data are considered here. In the first two, informants indicated the similarities among the meanings of the items, considered *qua* general concepts. In the third, the items were applied in specific cases: informants ranked these features of jobs in order of personal preference.

#### (1) Method of Triads (MoT)

Here the informant is presented with three items at a time and asked to identify the "odd-one-out" or "one least like the remaining two" in each triad (Coxon & Jones, 1979). This is equivalent to identifying the most similar pair of items. The triads are created randomly, by shuffling the 'deck' of item-cards and dealing them out in groups of three.

The triadic method was applied to an earlier selection of 78 items. For convenience these were split into two subsets of 21 and 57 items for the MoT process. Although six of the items were later winnowed out, 72 were retained in the final version. Thus these data are useful here as a way of validating the final three-dimensional 'map'.

For the 21-item subset, seven triads were generated by each cycle of shuffling and dealing. Thirty Massey University students were recruited as subjects (genders not recorded) and paid for a one-hour session. Most of them provided six cycles, for a total of 1162 triads.

For the 57-item subset, 19 triads were generated by each cycle of shuffling and dealing. Fifty-three students were recruited through Massey University, most of them providing three cycles, for a total of 2831 triads.

#### (2) GOPA-sorting

This is the familiar process of 'sorting by similarity' (Coxon, 1999), with additional phases to extract further information from the participants (Bimler & Kirkland, 2003). The acronym stands for Group-, Opposite-, Partition- and Additive-sorting phases. In Group- or G-sorting, informants arrange the items in groups according to similarity (as in Burton, 1972; Krause *et al.*, 1978), then proceed to refine those groupings in the P- and A-sorting phases. The resulting judgements of similarity are complemented by dissimilarity judgements elicited by O-sorting. Here the informants look for pairs of groups that are collectively most dissimilar, i.e. groups that are antinomial in their content, or closest to a polar opposition.

The penultimate selection of items contained only 78 items. This selection was GOPA-sorted by 30 students at Massey university (14 F, 16 M). Twenty-one items were added, creating the final set of 99 items. These were GOPA-sorted by a different 50 students (36 F, 14 M).

#### (3) Method of Successive Sorts (MOSS)

This is a variant of Q-sorting (Block, 1961). Informants sort items into five rank-ordered piles, ranging from most appealing, congenial or preferred items (which go into the pile at one extreme) to those least preferred (which go into the pile at the other extreme). The sorting is a two-step process. The informant first creates three piles containing items that are more preferred, neutral, and less preferred. Second, the first pile is subdivided into piles containing most and more preferred items, while the third pile is subdivided into piles of least and less preferred. Items can be shifted between piles if the informant reconsiders. Often a researcher using Q-sorting sets the number of items in each pile, but a forced distribution was not thought necessary here.

MOSS data came from 137 students from classes in four New Zealand secondary schools. Ages ranged from 15 to 18, with a roughly equal gender mix.

## Analysis

(1) Triadic data lend themselves to a direct form of MDS, using a 'Maximum Likelihood' algorithm (Bimler & Kirkland, 2001). A given triad, consisting of the items  $E_i, E_j, E_k$ , is represented in the MDS solution by three points ( $\mathbf{x}_i, \mathbf{x}_j, \mathbf{x}_k$ ) that form the corners of a triangle. Analysis consists of iteratively relocating the points within the geometrical model until they conform with as many judgements as possible. A judgement from one of the informants that  $E_i$  is the odd-one-out in the example – that is, that  $E_j$  and  $E_k$  is the most-similar pair – is an indication that in geometrical terms,  $\mathbf{x}_i$  should be the acute corner of that triangle. This can be restated as a pair of implied distance comparisons:  $d_{jk}$  (the length of the side of the triangle between  $\mathbf{x}_j$  and  $\mathbf{x}_k$ ) should be less than both the other distances  $d_{ij}$  and  $d_{ik}$ , where these distances naturally depend on the positions of  $\mathbf{x}_i, \mathbf{x}_j, \mathbf{x}_k$ . A goodness-of-fit criterion is defined to measure how well all those comparisons are met by the reconstructed distances, and points are adjusted to maximize the criterion (Takane, 1978).

(2) Estimates of inter-item similarity were extracted from the GOPA data, and analyzed with Kruskal's algorithm for non-metric least-squares MDS (Jones & Koehly, 1993).

One similarity estimate comes from the proportion of times that a given pair of items are grouped in a pile together (co-occurrence). We write this as  $d_{ij}^S$ ; together these elements comprise a 99-by-99 matrix  $\mathbf{D}^S$ . A second estimate of association between two items is their 'antinomality', which we write as  $d_{ij}^O$ , with  $\mathbf{D}^O$  as the matrix of these estimates. This is the proportion of O-sorting decisions in the GOPA data, in which  $E_i$  and  $E_j$  are found in piles that are chosen as 'most opposite' (for details see Bimler & Kirkland, 2003).

(3) MOSS data from the  $q$ -th informant can be written as 99 values: each item receives a value according to the pile it is assigned to, from +2 (most preferred) down to -2 (least preferred). These are rescaled (ipsatized) to a mean of 0 and a standard deviation of 1. We write  $\mathbf{v}_q$  to denote the  $q$ -th array of 99 normalized values, and  $v_{qi}$  for individual values in  $\mathbf{v}_q$ .

The correlation  $r_{ij}$  between the  $v_{qi}$  and  $v_{qj}$  assigned to a given pair of items  $E_i$  and  $E_j$ ,

when  $q$  varies over all 137 informants, is a further index of association between that pair. The correlations for all the pairs, written as a matrix  $\mathbf{D}^M$ , are grist for the mill of MDS.

Following Johnson (1995), Canonical Correlation or CANCELL was used to check the independently-obtained MDS solutions for similarity. CANCELL compares two sets of coordinates by extracting a linear combination from each, such that the correlation between them  $R_c$  is maximal. It goes on to extract further pairs of linear combinations (each new combination being orthogonal to those previously extracted from its respective coordinate set), providing correlations  $R_2, R_3$ .

To foreshadow the Results section, a three-dimensional solution was preferred. Thus each item is represented by the coordinates  $\{x_{i1}, x_{i2}, x_{i3}\}$ , or  $\mathbf{x}_i$  for short. The solution as a whole can be written as a 99-by-3 matrix  $\mathbf{X}$  (in which  $\mathbf{x}_i$  is the  $i$ -th row).

We can use this solution to summarize the preference rankings from the  $q$ -th informant,  $\mathbf{v}_q$ , by way of multivariate regression (Jones & Koehly, 1993). The value  $v_{qi}$  assigned to the  $i$ -th item is the dependent variable, and there are three independent variables, the coordinates that represent that item in  $\mathbf{X}$ . Regression provides the approximation:

$$v_{qi} \approx b_{q0} + b_{q1} x_{i1} + b_{q2} x_{i2} + b_{q3} x_{i3}$$
 (where the offset  $b_{q0}$  is usually close to 0)

and a multivariate correlation  $R_q$  that measures the compatibility between  $\mathbf{X}$  and  $\mathbf{v}_q$ .  $R_q$  ranges up to 1 if the approximation is perfect.

Between them,  $b_{q1}, b_{q2}, b_{q3}$  summarize the whole array (with  $R_q$  indicating how much is thereby lost). Conveniently, they are also the components of a vector, i.e. the direction in 'vocation space' in which the  $v_{qi}$  increase. For instance, a high value of  $b_{q1}$  corresponds to a vector nearly parallel to the first dimension  $D1$ , and indicates a tendency to endorse or reject items according to their locations along  $D1$  (their  $x_{i1}$  values). The 99 values  $v_{qi}$  are thus reduced to global, low-resolution terms.

It is also useful to examine variations among subjects without the intermediary of  $\mathbf{X}$ . Comparing the  $p$ -th and  $q$ -th informants,  $r_{pq}$  is the correlation between  $v_{pi}$  and  $v_{qi}$ , with  $i$  ranging across items. Factor decomposition of the 137-by-137 correlation matrix would be 'inverse factor analysis' or Q-factoring. Here, for ease of comparison with the previous section, we analysed the matrix with MDS.

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## Results

First the question of dimensionality was considered. For the matrix  $\mathbf{D}^S$ , MDS solutions with two, three, four and five dimensions yielded  $\text{Stress}_1$  values (poorness-of-fit) of 0.309, 0.212, 0.160 and 0.135. The 2D solution is patently inadequate, while the 5D solution is not substantially better than 4D. We settled on three dimensions for convenience of display.

One 3D solution  $\mathbf{X}^S$  was derived from the matrices  $\mathbf{D}^S$  and  $\mathbf{D}^O$  together (using the repeated-measure feature of MDS). A second solution  $\mathbf{X}^M$  was derived from  $\mathbf{D}^M$ . Comparing  $\mathbf{X}^S$  and  $\mathbf{X}^M$  with CANCELL, the three canonical correlates were  $R_c = 0.87$ ,  $R_2 = 0.77$ ,  $R_3 = 0.66$ . All are significant at  $p < 0.0001$  (according to a  $\chi^2$  test of Wilk's  $\Lambda$  statistic). In other words, three pairs of mutually-recognizable linear combinations can be extracted from the coordinate sets, or to put it more loosely, the two solutions can be rotated so that each of the three dimensions from either solution has a recognizable counterpart in the other.

Two other indices of similarity between  $\mathbf{X}^S$  and  $\mathbf{X}^M$  are the Procrustes distance  $g_i$  between them; and the correlation  $r_{SM}$  between corresponding inter-item distances. According to these indices,  $\mathbf{X}^S$  and  $\mathbf{X}^M$  are acceptably similar, with  $g_i = 0.117$  and  $r_{SM} = 0.58$ . We concluded that the data from (2) and (3) are manifestations of the same underlying structure, and analyzed all three matrices together, producing a compromise between them that was reasonably compatible with each. This was the 3D solution  $\mathbf{X}$ . A 4D solution  $\mathbf{X}_4$  was also retained, for comparison with the triadic results, which again involved CANCELL.

Since the MoT data relate to two disjoint sets of items, two 4D solutions  $\mathbf{X}^{T1}$  and  $\mathbf{X}^{T2}$  were obtained, containing 21 and 57 items respectively. Due to subsequent removal of items, only 15 of the items in  $\mathbf{X}^{T1}$  found their way into  $\mathbf{X}_4$ , meaning that canonical correlates can be large without reaching the threshold of significance. Even so, the first two correlates were significant at  $p < 0.013$  ( $R_c = 0.99$ ,  $R_2 = 0.91$ ,  $R_3 = 0.72$ ,  $R_4 = 0.08$ ).

All 57 items in  $\mathbf{X}^{T2}$  also appear in  $\mathbf{X}_4$ . This time, all canonical correlates were significant at  $p < 0.002$  ( $R_c = 0.96$ ,  $R_2 = 0.94$ ,  $R_3 = 0.84$ ,  $R_4 = 0.41$ ). While this does not guarantee that the structure of  $\mathbf{X}$  is meaningful, it confirms that it is at least reproducible, and

not attributable to noise or an artefact confined to one specific procedure.

In fact there are four mutually-recognizable axes. The fourth dimension is interpretable but minor, and it is omitted in the following discussion, for ease when displaying the solution. It seems to draw a distinction between internally-focussed self-reliance at one extreme (with items such as 71, *Dealing with a variety of challenges*; 74, *Working by myself, alone*; and 97, *Doing it "my way"*), and external focus at the other extreme (with items such as 25, *Working in the food industry*; 43, *Working with people from other countries*; and 103, *Being a "team player"*). Fortunately, retention or omission of this fourth dimension has little impact on items' coordinates along the first three dimensions.

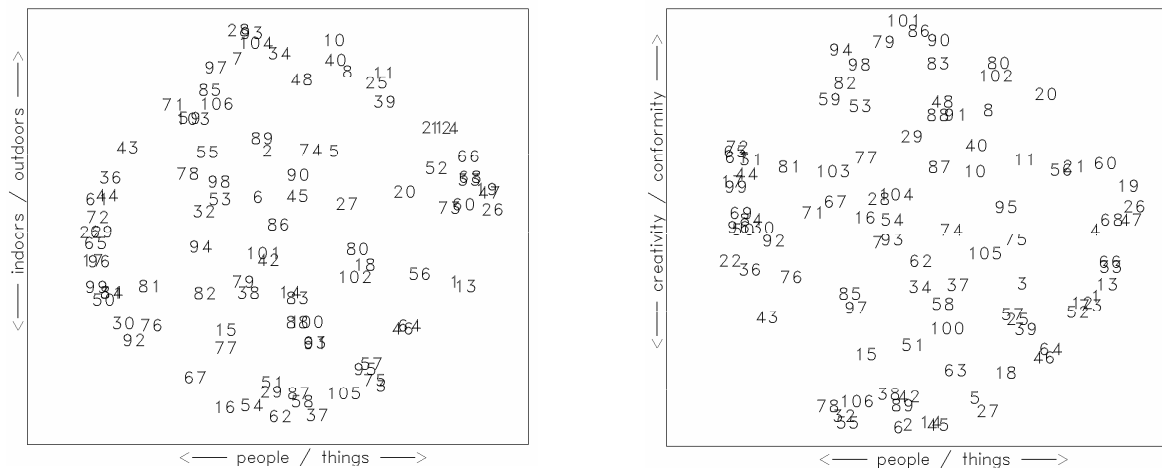
We interpret  $D1$ , the first dimension of  $\mathbf{X}$ , as a gradient from 'people' to 'things' (see Figure 1).  $D2$  can be glossed as 'indoors versus outdoors'; alternative labels for the distinction are 'cerebral versus physical', or simply 'heads versus hands'.  $D3$  is a gradient from 'creativity' to 'routine'.

On close inspection, the structure of Figure 1 turns out to be a hollow sphere, with the points located roughly equidistant from the origin.<sup>1</sup> This spherical quality provides an alternative way of displaying the MDS solution. By ignoring the minor variations in their radial distances from the center, they can be treated as points on the surface of a globe, and projected onto two dimensions. For this, the globe is divided into two hemispheres (positive- and negative- $D1$  halves) and flattened separately. This perspective shows how the points would look from the center of the sphere, i.e. the origin. Figure 2 is the outcome.

The two outer circles indicate the 'equator' where  $D1 = 0$ . The  $D1$  axis is at the center of each circle, with the inner circles corresponding to  $30^\circ$  and  $60^\circ$  angles away from that axis. These concentric circles represent the relative magnitude of the People/Things component, compared to others (i.e. the ratio between  $D1$  on one hand, and  $D2$  and  $D3$  on the other).

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<sup>1</sup> Radial distance from the center in MDS solutions is often interpretable as 'specificity'. The fringes of the solution contain very specific items, while vague, widely-applicable items are found near the origin. Specificity is more-or-less constant in a well-designed set of items, so the spherical property is frequently encountered.



**Figure 1.** Three-dimensional MDS solution for 99 Vocation items: (a) D1 / D2 plane; (b) D1 / D3 plane.

Examples of items at the two extremes of D1 ('People versus things') are

22 Working with people (rather than with "things"),  
65 Working with sick or injured people,  
69 Teaching others;

ranging through to

19 Operating big machinery,  
26 Working with machines,  
47 Servicing heavy equipment.

Examples of items at the two extremes of D2 ('Indoors versus outdoors' – alternatively, 'Cerebral vs. Physical') are

16 Providing others with legal advice,  
37 Working with documents,  
62 Working with private information;

to

28 Being a professional sports person,  
93 Looking for adventure,  
104 Pushing my body to the physical limits.

Examples of items at the two extremes of D3 ('Creativity versus Routine') are

6 Creating material which can be used for entertaining others,  
45 Working with video and film,  
55 Performing in the entertainment industry;

to

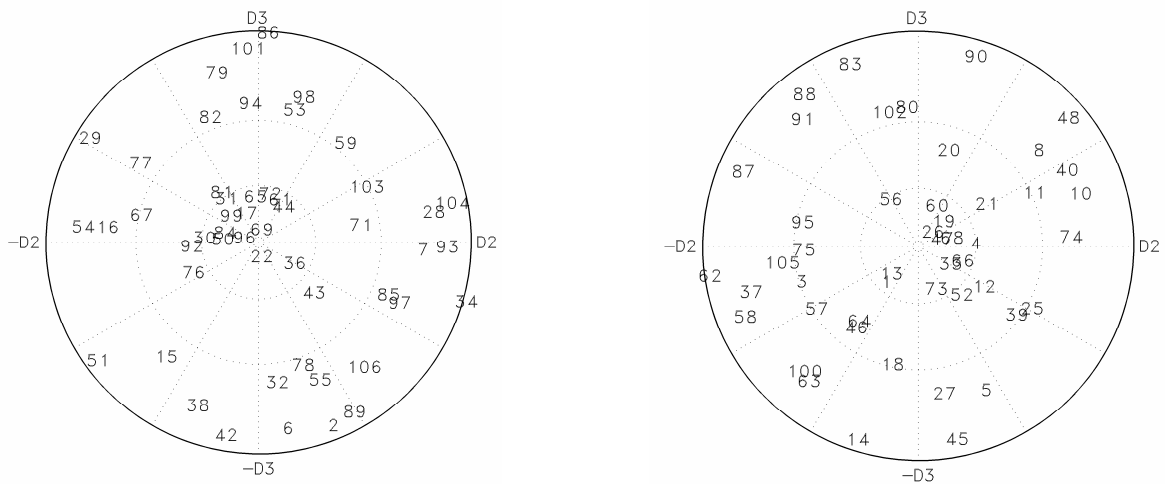
79 Following known pathways, walking in others' footsteps,  
86 Keeping to traditional ways,  
101 Doing as my elders/parents suggest.

Thus Figure 2 can be thought of as a pair of polar coordinate plots, with concentric circles as the radial coordinate. The angular coordinate represents the ratio between D2 (Indoors / Outdoors) and D3 (Creativity / Routine) components. In each hemisphere, the positive and negative extremes of D2 are at "3 o'clock" and "9 o'clock" respectively; while the positive and negative extremes of D3 are at "12 o'clock" and "6 o'clock".

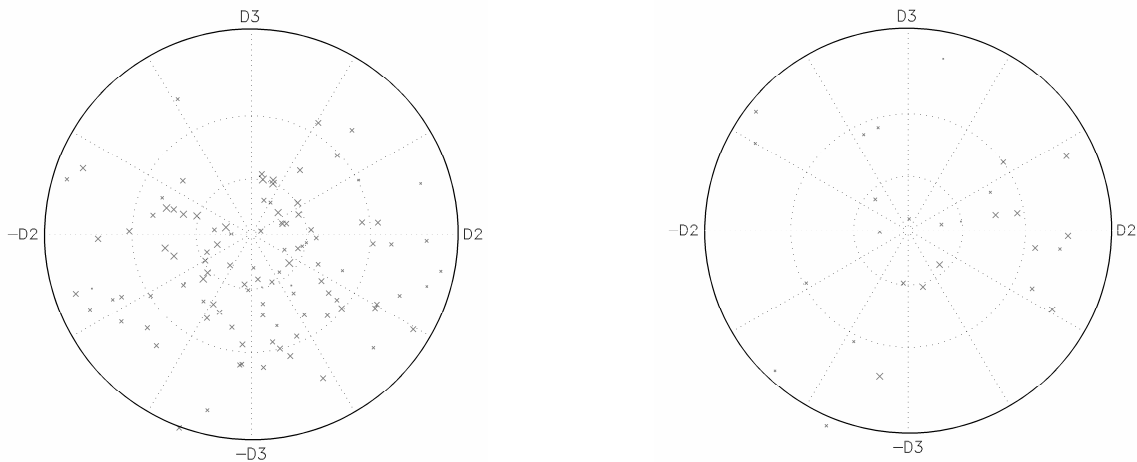
We turn now to the informants' personal rankings of the items. These are incorporated in **X** by fitting a vector (a direction) to each

informant, running from least-preferred items on one side of the solution, through to most-preferred items on the other side, tracing the gradient of preference. The average of the multiple correlations  $R_q$  was high.

The vector components  $b_{q1}$ ,  $b_{q2}$ ,  $b_{q3}$  show the relative importance of each dimension of 'vocation space'. For example,  $b_{q1}$  indicates the extent to which the  $q$ -th informant's preference for any item is determined by its location along the People / Things axis. Similarly, high values of  $b_{q2}$  or  $b_{q3}$  indicate a tendency to endorse or reject items



**Figure 2.** MDS solution for 99 Vocation items: their locations, as seen from the center. The two hemispheres of the solution are shown separately (stereographic projection).



**Figure 3.** Crosses represent vectors in the MDS solution, projected into the same split-hemisphere diagram of Figure 2. Each vector is one school pupil's MOSS data set.

according to their locations along  $D2$  or  $D3$ : their connotations of Indoors / Outdoors and Creativity / Routine. A vector can be included in a projection such as Figure 2, by noting the point where it intersects the notional sphere, and projecting that point (along with the items) into two dimensions. Figure 3 is the result.

One can assert that this structure is inherent in the preference rankings, rather than somehow imposed during their conversion into vectors, since it can also be found in the pattern of correlations  $r_{pq}$  amongst informants. MDS analysis of the correlation matrix yields a three-dimensional solution,  $\mathbf{Y}$ , in which the 137 informants are each represented by a point  $\mathbf{y}_q$ . These locations have much in common with

their vector components (this is little more than a re-statement of the overall compatibility between the preference rankings and the aptitude map  $\mathbf{X}$ ). Specifically: the correlations between  $y_{q1}$ ,  $y_{q2}$ ,  $y_{q3}$  (the coordinates representing the  $q$ -th informant in  $\mathbf{Y}$ ) and  $b_{q1}$ ,  $b_{q2}$ ,  $b_{q3}$  respectively are 0.91, 0.92 and 0.83.

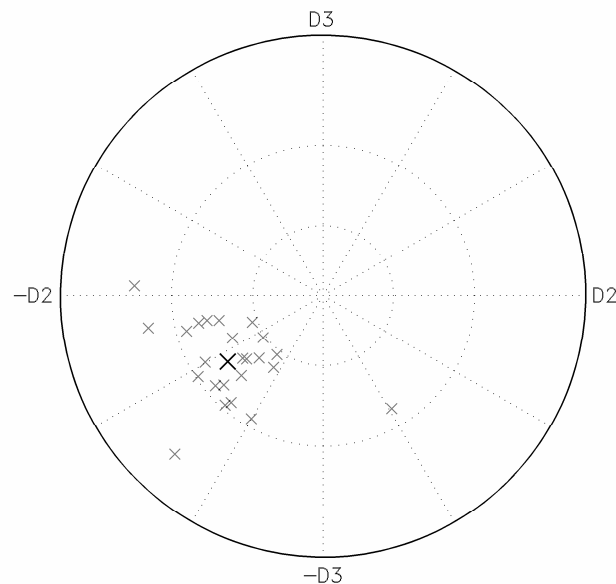
In that case, one may wonder why the creation of the 'subject space'  $\mathbf{Y}$  wasn't enough, and what more is learnt by creating  $\mathbf{X}$  and using it as an intermediary to convert the rankings into vectors. The answer is that vector components are interpretable (having identified the axes of aptitude space). Coordinates within  $\mathbf{Y}$  are not directly

interpretable, nor do they provide any key to newly-acquired data.

Figure 3 reveals a strong tendency for subjects to prefer 'people' over 'thing'-oriented items – that is, most vectors have negative  $b_{q1}$  components, and concentrate in the 'People' hemisphere to the left of the figure. Superimposed on this is a gender difference: the general preference for People-centered activities was stronger among girls. There are large within-group variations; even so, if  $b_{q1} > 0$ , one can say with some confidence that the informant was male. This difference is clear in other data sets, involving earlier versions of the item set, but regrettably gender was not recorded for all cases shown here.

In another application, 24 market researchers ranked the items with a target of

"Ideal Market Researcher" (at the 2004 Conference of the New Zealand Market Research Society). That is, each activity or aptitude was scored by the likelihood or desirability of finding it expressed in a actual researcher. Due to time constraints, they were only presented with 45 items (every second one). These individual descriptions fitted well as vectors into  $\mathbf{X}$ , with 0.57 as the mean value of  $R_q$ . As shown in Figure 4, the average description was summarized as  $b_{q1} = -0.69$ ,  $b_{q2} = -0.62$ ,  $b_{q3} = -0.37$  (the ideal Market Researcher favors working with people rather than things; indoor rather than outdoor forms of work; and creative rather than routine tasks). Individual deviations from this unsurprising consensus were small.



**Figure 4.** Crosses represent vectors in the MDS solution, as in Figure 3 ('People' hemisphere only). Vectors shown as small crosses are individual descriptions of 'ideal market researcher'; large cross is the average description.

## Discussion

By virtue of the way it was obtained, the three-dimensional geometrical model or 'aptitude space'  $\mathbf{X}$  reflects a widely-shared cultural consensus: a *Weltanschauung* (Day *et al.*, 1998), or "collective conscience" in Durkheim's term. In a pilot study we applied the same MDS methodology to a list of 70 'nouns' (items of the form "working with ----")

used by Career Services New Zealand, and a second list of 74 'verbs', with very similar outcomes. The same structure is likely to emerge from any sufficiently comprehensive and homogeneous inventory such as the Career Interest Test (Athanasou, 2002). The present scheme subsumes two of three axes extracted in a MDS study (Day & Rounds, 1998) of the 90 items comprising the unisex American College Test or UNIACT (Swaney,

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1995);<sup>2</sup> there the third axis was uninterpretable.

There is nothing innovative about our use of three dimensions to map a vocation space. Roe (1956) and Strong (1943) presented three-dimensional frameworks. Forty years of planar maps followed, before Tracey and Rounds (1996) returned to a spherical occupational map. However, the present D2 ('cerebral / physical', or 'indoor / outdoor') appears to be new.

Conversely, some of the axes found in studies of related but not identical item domains were not encountered here, such as 'Status' among occupational titles. Hence we reiterate that of the salient attributes of occupations, used to discriminate among them, not all can be reflected by or accommodated within 'aptitude space'. Nevertheless, occupations can be represented within our model, using item rankings by suitably-qualified informants. The multidimensional framework further provides a measure of an informant's suitability for a job: the similarity between two vectors, one representing the job, the other summarizing his or her activity preferences.

Of the dimensions reported here, 'People / Things' (D1) and 'Creativity / Routine' (D2) can be combined in various proportions to generate other axes and polarities encountered in the literature: Orientation, 'Data / Ideas', 'Conventional / Artistic', Sociability and Conformity (Hogan, 1983). In an objective sense, no set of axes is better than its alternatives: because rotation has no effect on inter-item distances, a spatial model can be rotated to new axes without affecting how well it accounts for the data. Rotational indeterminacy is an unavoidable feature of such models. Vocational models are a prime example of Guttman's observation (1966) that a ring or *circumplex*, a continuous circular configuration of points (as in the D1/D3 plane

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<sup>2</sup> This instrument is not completely homogeneous. Its constituent items purport to be interests or activities. But on inspection, many items designed to capture an individual's level on the Investigative scale – one sector of the RIASEC continuum – are not 'things one might do', but rather 'things one knows' (or would like to know). UNIACT Item 25, for instance, is "Understand biology". To an extent this scale is incommensurate with the other five scales, and set aside from them, whether or not the theoretical distinction between the Investigative and other categories is valid.

here), can subsume a proliferation of rival factors and polarities (see also Tracey & Rounds, 1995, 1996).<sup>3</sup>

*Regions of the model can be related back to the familiar RIASEC categories of Holland's 1973 scheme. The positive and negative extremes of D3, for example, contain items such as 79, Following known pathways and 2, Working with visual arts or crafts respectively, which would be categorized as 'Conservative' and 'Artistic'. But six categories delineating a hexagon are clearly too few to exhaust a three-dimensional manifold.*

One rationale for carving the circumplex into categories such as Holland's is that vector components are arguably too broad, and too abstract for clients to grasp when counselors present the outcome of analysis. Alternative ways of aggregating the item values  $v_{qi}$  are desirable, to provide a finer-grained battery of more intuitive summary scales. These also have the potential of capturing more information, lost in such a drastic, Procrustean reduction of the data as vector components. At any rate, generating finer-grained scales is a matter of pooling the values from a 'catchment area' of sufficiently-related items, to obtain a single score that is more robust than the values of single items. Selecting related items is straightforward with a MDS map, in which relatedness is shown as geometrical proximity.

## Conclusion

If young school-leavers entering the job market held clearly-formulated opinions about the world of work, vocational guidance would simply be a matter of eliciting their views about personal aptitudes and preferences, and matching these to available career paths. In practice, however, the teenage mind is notoriously inchoate, veiled in inarticulate obscurity – as much to self-report as to outside observers.

So far several hundred senior secondary school students have described their activity preferences by sorting the VOC-99 item inventory (or earlier recensions). Other subjects have used the inventory by following a 'trilemma' technique that we developed as an alternative to MOSS-sorting. Here the informant chooses the most- and least-preferred alternatives from a choice of three.

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<sup>3</sup> "One ring to rule them all, one ring to find them; one ring to bring them all, and in the darkness bind them."

Sixty-six of these three-way forced-ranking choices comprise the entire questionnaire (so each item is ranked twice, in two different contexts). Each choice has been optimized to make it as stark (and informative) as possible (Bimler & Kirkland, submitted).

Their responses were summarized within a three-dimensional framework. There has been general satisfaction among the informants with this feedback; the summaries made sense, and rang true, while telling the informants more than they previously knew (or were aware of). It has been used with adults as well as school-leavers.

Over the years, the broad topic of vocational cognition – divisible into sub-topics of job titles, reinforcers, etc. – has been one popular focus of MDS research. MDS studies of the vocational realm have burgeoned into a substantial literature (Davison *et al.*, 1986; Rounds & Zevon, 1983). The interest is practical as well as theoretical. From the outset, MDS explorations of an item set have been intimately involved with the design of instruments for practical assessment. That was certainly the case here.

Our model of aptitude space has multiple purposes. These include to facilitate communication between vocational counselors and clients, and to provide the latter with an explicit schema for integrating vocational information and clarifying options. Since its structure was obtained from a shared, widely-accessible consensus about item inter-relationships, it should serve these purposes better than models driven by theory.

### Rezumat

*Hărțile schematice ale mediului muncii sunt des utilizate în consilierea vocațională. O hartă este mai eficientă în condițiile în care coincide cu reprezentarea deja internalizată de candidații pentru un post. În acest studiu, scalarea multidimensională a fost utilizată pentru a realiza o reprezentare consensuală pentru judecățile referitoare la similaritățile din cadrul unui set de descriptori pentru aptitudinile vocaționale. Pentru a exclude artefactele limitate de o singură procedură de obținere a judecăților similare sau de o singură formă de analiză au fost utilizate trei proceduri diferite și grupuri multiple de participanți. Rezultatele converg spre un „spațiu vocațional” cu cel puțin trei dimensiuni. Axele sale au fost interpretate ca „oameni/ lucruri”, „interior/ exterior” și aspecte „creative/ rutiniere” ale muncii – deși harta nu este determinată rotativ, astfel încât și alte cadre de referință sunt valide. S-a arătat că această hartă*

*cuprinde clasificările descriptorilor realizate de participanți reprezentându-le ca vectori.*

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