DOCUMENT RESUME

ED 074 283 VT 019 725

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TITLE	A Markov Chain Analysis of the Movement of Young Men Using the Holland Occupational Classification.
INSTITUTION	Johns Hopkins Univ., Baltimore, Md. Center for the Study of Social Organization of Schools.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
REPORT NO	JHU-CSSOS-148
PUB DATE	Jan 73
GRANT	OEG-2-7-061610-0207
NOTE	102p.
EDRS PRICE	MF-$0.65 HC-$6.58
DESCRIPTORS	*Career Change; Career Education; Classification; Comparative Analysis; *Employment Patterns; Males; *Mathematical Models; Occupational Mobility; *Predictive Validity; Vocational Development; Work Experience; *Young Adults
IDENTIFIERS	*Holland Occupational Classification; Markov Chain Model

ABSTRACT

In order to describe and predict career patterns of young men, this report provides: (1) Markov chains of the career patterns for four groups of 5,225 young men divided according to race and age, (2) tests of the predictive validity of the chains, and (3) comparisons of the four race-groups using the Markov models. Using the Holland occupational classifications, initial interviews revealed statistically significant differences among the four groups. For instance, younger men generally showed a narrower range of occupational experience. For black men, the narrow range of experience persisted for the older group. Older white men held jobs in a broader range of occupational categories, and were more stable in their initial occupational categories. An attempt to establish the predictive validity of two of the four models was largely unsuccessful, indicating that the derived models could not be generalized. Since the Markov models did not improve the predictive efficiency of the Holland occupational classification, it is predicted that the subjects would maintain the Holland category of their initial occupation. (Author/AG)

Center for Social Organization of Schools

REPORT NO. 148

JANUARY, 1973

A MARKOV CHAIN ANALYSIS OF THE MOVEMENT OF YOUNG MEN USING THE HOLLAND OCCUPATIONAL CLASSIFICATION

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GRANT NO. OEG-2-7-061610-0207

PROGRAM NO. R16J5
PROJECT NO. R16J5A

DEAN H. NAFZIGER

REPORT NO. 148

JANUARY, 1973

Published by the Center for Social Organization of Schools, supported in part as a research and development center by funds from the National Institute of Education, Department of Health, Education, and Welfare. The opinions expressed in this publication do not necessarily reflect the position or policy of the National Institute of Education, and no official endorsement by the National Institute of Education should be inferred.

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INTRODUCTORY STATEMENT

The Center for Social Organization of Schools has two primary objectives: to develop a scientific knowledge of how schools affect their students, and to use this knowledge to develop better school practices and organization.

The Center works through five programs to achieve its objectives. The Academic Games program has developed simulation games for use in the classroom. It is evaluating the effects of games on student learning and studying how games can improve interpersonal relations in the schools. The Social Accounts program is examining how a student's education affects his actual occupational attainment, and how education results in different vocational outcomes for blacks and whites. The Schools and Maturity program is studying the effects of educational experience on a wide range of human talents, competencies, and personal dispositions in order to formulate -- and research -- important educational goals other than traditional academic achievement. The School Organization program is currently concerned with authority - control structures, task structures, reward systems, and peer group processes in schools. The Careers and Curricula program bases its work upon a theory of career development. It has developed a self-administered vocational guidance device to promote vocational development and to foster satisfying curricular decisions for high school, college, and adult populations.

This report, prepared by the Careers and Curricula program, is an attempt to improve the predictive efficiency of the Holland occupational classification by using Markov chain analysis to examine the career movement of four groups of young men within the classification.

ABSTRACT

The present study used the Holland occupational classification and Markov chain analysis for describing and predicting career patterns of young men. Models of movement among the six categories of the Holland classification were derived for four groups of young men (N=5,225) who were divided according to race and age. In short, this report provides (1) Markov chains of the career patterns for four groups of young men, (2) tests of the predictive validity of the chains, and (3) comparisons of the four race-age groups using the Markov models.

Some statistically significant and important differences occurred among the four groups both in the patterns of career transitions and in the distribution of individuals among the six Holland categories at the time of the initial interview. In general, younger men showed a narrow range of occupational experience. For black men, the narrow range of experience persisted for the older group. Older white men held jobs in a broader range of occupational categories. And, they were more stable in their initial occupational categories than the other groups.

An attempt to establish the predictive validity of two of the four models was performed. The Markov models for older white males and older black males were used to predict patterns of movement and occupational categories of the ten-year transitions for a second sample. These attempts were largely unsuccessful, indicating that the derived models could not be generalized to any real extent.

In general, the use of the Markov models did not improve the predictive efficiency of the Holland occupational classification. The most efficient and parsimonious strategy was to predict that the subjects would maintain the Holland category of their initial occupation.

ACKNOWLEDGMENT

The author is grateful to John L. Holland and Gerald D. Williams of The Johns Hopkins University, and Timothy J. Pettibone of New Mexico State University for their useful suggestions on earlier drafts of this report. He is also indebted to Alyce J. Nafziger and Margaret Lewis for their major contributions in editing and preparing the manuscript.

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INTRODUCTION

A major concern of vocational psychologists has been to discover regular patterns of occupational behavior. In the case of careers, one aim has been to determine whether decisions about occupational choices are random or predictable. Many studies have used psychometric techniques to predict occupational variables and have created a large and loosely organized body of knowledge about the relationship of sociological and psychological variables to vocational success, satisfaction, and occupational membership. Recently the movement of individuals from job to job has gained more recognition as a research topic, and the recent emphasis on career education has underscored the importance of studies of vocational history.

Research about occupational history can be divided into two categories. Studies of one type are concerned with the progression of prestige, income, or social positions for an individual or set of individuals over a lifetime. These studies of occupational mobility, performed largely by sociologists, have contributed a broad base of knowledge about how family background, educational level, and race affect occupational status (Osipow, 1968).

A second group of studies, more typical of vocational psychologists, consists of longitudinal studies of occupational preferences or positions. The purpose of these studies has been to assess the commonality that occurs within occupational histories. They assume that the relatedness of successive job choices and the patterns of career movement depend heavily upon a person's aptitudes, interests, values, and other characteristics.

Although earlier research on vocational preference was generally atheoretical in its approach, more recent studies analyze and interpret occupational histories with respect to some theoretical framework (Holland, in press, b). Typical of these recent studies are those using the occupational classification systems of Roe (Doyle, 1965; Roe, Hubbard, Hutchinson, and Bateman, 1966; Hutchinson and Roe, 1968) or Holland (Holland, Sørensen, Clark, Nafziger, and Blum, 1971; Lucy, 1971; Parsons, 1971).

The study reported here is based upon a theory of careers and an associated occupational classification proposed by Holland. The usefulness of Holland's classification scheme for organizing oocupations into homogeneous groups has been demonstrated for several college and employed populations (Holland and Whitney, 1968; Holland, Sørensen, Clark, Nafziger, Blum, 1971; Parsons, 1971). Studies using the classification scheme have demonstrated that large percentages of people remain in the same occupational category over long periods of time. Many of the studies about occupational histories have been restricted to small, unrepresentative samples. Larger research projects have studied some selected age groups. In general, most reports have ignored the total pattern of movement that exists among the six Holland categories.

The purpose of the present study was to develop and test predictive models of vocational movement by taking advantage of both Holland's classification scheme and Markov chain models. It differs from earlier research in the populations studied and in the analytical technique employed.

Theoretical Orientation

The most recent published statement of the theory of careers upon which Holland's classification is based is given in Holland (1966b). A revised, but closely related statement of the theory is in press (Holland, in press, a).

Holland's theory of careers describes personality types, occupational environments, and the interaction of individuals with their job environments. The theory assumes that an individual's personal characteristics are manifest in his vocational interests and occupational choices; that is, an individual's occupation is an extension of his personality. As a result of this assumed relationship, interest inventories and personality inventories are considered different methods for measuring similar attributes.

Further, it is assumed that there are valid stereotypes, with respect to psychological and sociological characteristics, of individuals in given occupations that can be hypothesized, measured, and tested. And, people with similar personal characteristics and developmental backgrounds choose similar jobs. In short, people in the same occupation are alike in many respects, and people in similar occupations also have much in common. Thus, knowledge of a man's occupation provides useful information about his personality.

Because people with simila[r] ...ies tend to enter the same or similar occupations, indivi... job can be expected to possess typical responses to ...ous situations and problems that characterize that occupation. When an individual's personal characteristics are unlike the environmental characteristics -- i.e., if a person does not "fit" in a particular occupational environment -- he is more likely to experience frustration and failure. Briefly, Holland's theory of vocational choice asserts that individuals find the greatest satisfaction in environments that are congruent with their personality types, and that they tend to seek out and move toward such environments.

Further, Holland proposes a classification system for people and occupations consisting of six main types or categories. The main categories are Realistic (R), Investigative (I)[1], Artistic (A), Social (S), Enterprising (E), and Conventional (C). Within these major categories are 72 subcategories or subtypes, such as Realistic-Investigative-Social (RIS) or Conventional-Enterprising-Realistic (CER).

Occupational environments can be classified using Holland's scheme by assigning to each occupation a three-letter Holland code of persons in that occupation. For example, such codes as Realistic-Conventional-Enterprising (RCE) for truck drivers and Investigative-Social-Artistic (ISA) for physicians have been obtained. Occupations have been classified by Holland, Whitney, Cole, and Richards (1969); and Holland, Viernstein, Kuo, Karweit, and Blum (1970).

[1] In early statements of the theory, the Investigative category was termed Intellectual.

Viernstein (1971) has developed a conversion system for classifying all occupations in the Dictionary of Occupational Titles according to Holland's scheme. Consequently, Holland's classification can be applied to the entire labor force.

The theoretical assumptions imply that an individual of a given type will seek out and enter occupations of the same type. For example, Conventional types usually enter Conventional occupations. In addition, secondary and tertiary personal characteristics are influential in occupational choices. That is, Conventional-Enterprising-Social individuals are expected to enter occupations that emphasize this permutation of those dimensions. Persons who are unable to enter occupations that agree exactly with their Holland code would be expected to enter related occupations that emphasize similar occupational and personal characteristics.

A hexagonal arrangement (Figure 1) summarizing the inter- and intra-class relationships of the Holland personality types was proposed by Holland, Whitney, Cole, and Richards (1969). The hexagonal configuration has been supported in several studies using Holland's VPI and other vocational assessment instruments. Most of the studies have obtained planar representations using configural analysis (Cole and Cole, 1970).

Insert Figure 1

Interrelationships of types from the hexagon should be interpreted as follows. Contiguous categories are the most related; for example, Conventional and Realistic or Conventional and Enterprising. Categories connected by the shorter diagonal are somewhat less related, such as Conventional and Investigative or Conventional and Social. The categories that are directly opposite each other on the hexagon are least related. Thus, Conventional and Artistic categories are among the least related pairs.

Cole and Hansen (1971) applied configural analysis to the scales of the Strong Vocational Interest Blank (SVIB), the Kuder Occupational Interest Survey (OIS), the Holland VPI, the American College Testing Program Vocational Interest Profile (VIP), and the Minnesota Vocational Interest Inventory (MVII). The planar representations were remarkably like the earlier hexagonal arrangement, (Holland et al., 1969). The points in the planar representation of the VPI formed an irregular hexagon, but were in the precise order as expected (RIASEC). Configurations of the SVIB, OIS, VIP, and MVII resulted in similar configurations and all conformed to the hexagonal model. Likewise, Roe's (1956) circular ordering of interest groups is similar to the ordering of the Holland model (Cole and Hansen, 1971).

Crabtree (1971) assessed samples of high school students (759 boys and 672 girls) with the VPI, applied Cole's configural analysis to the intercorrelation matrices, and obtained planar representations that approximated earlier results. More recently Edwards and Whitney (1972) have shown that the scales of Holland's Self-Directed Search (Holland, 1970), a more comprehensive vocational assessment than the VPI, also produce hexagonal configurations in the same order as suggested in previous studies. And, Cole (1972) has shown that the data for women have the same hexagonal ordering as the data for men.

This configuration of the Holland scales has similar properties to the general circumplex model described by Guttman (1954). According to Guttman, a set of responses forms a circumplex if the intercorrelation matr[illegible] ponses has a structure such that as one moves away from the main diagonal the correlations first decrease in magnitude and then increase again until the distance from the main diagonal is maximum.

Indirect evidence of the validity of the hexagonal arrangement was also provided in a cluster analysis study by Nafziger and Helms (1972). They applied McQuitty's Interative, Intercolumnar Correlational Analysis (McQuitty and Clark, 1968) separately to the seventy-two occupational scales of the Strong Vocational Interest Blank (SVIB), the twenty-one occupational scales of the Minnesota Vocational Interest Inventory (MVII), the twenty-three core scales of the Kuder occupational Interest Survey (OIS) for men, and the twenty-one core scales of the Kuder OIS for women. The results of the study provide evidence of the validity of Holland's occupational classification in three ways. First, the clusters suggest that a relatively few broad groups of occupations exist that are internally consistent and sensible. Second, the empirical clusters from each of the four vocational inventories generally consist of occupations with the same or similar Holland occupational codes. Finally, the hierarchical structure of the clusters follows the hexagonal ordering of the occupational categories; that is, at progressively higher levels in the cluster trees, occupations that were related (hexagonally contiguous) were grouped together. Further, Nafziger and Helms demonstrated that their clusters of occupations could be located in predictable areas of the occupational configurations presented by Cole and Hansen (1971).

Methodological Considerations

In the study reported here, Markov chain analysis was used to examine the history of career movement within the Holland occupational classification. The study of career behavior by social scientists using Markov models has been described in several places (Carlsson, 1958; Hodge, 1966) and has been specifically suggested for vocational psychology (Lohnes, 1965; Crites, 1969; Super, 1971). Gribbons and Lohnes (1966, 1969) have demonstrated the usefulness of Markov chains in characterizing the patterns of intragenerational career choices in longitudinal studies.

Variables used in Markov chain analysis are typically nominal or ordinal, and subjects are observed on these variables at successive times. A Markov chain is a probability model describing the ongoing process of movement within the Markov variable. Two testable assumptions are made about Markov chains. First, the probability matrix characterizing the process is assumed to be invariant over time, and any observed deviations from this theoretical probability matrix are assumed to be the result of random error. Second, Markov chains assume that the probability of the process being in a given category at time t depends only upon the category the process was in at time t-1, and is independent of the history of transitions that occurred before time t-1. This property is called the one step memory or Markovian property.

As Gribbons and Lohnes (1969) indicate, the Markov assumptions are stringent ones to be made about human behavior. However, statistical tests are available for both assumptions. When the Markov assumptions are tenable for a process, Markov chains are a useful method of characterization and prediction.

To summarize, Markov chains can be applied conveniently to the study of work histories of movement within a classification scheme because they are derived from observation of the movement process itself. They are useful because they provide a concise and easily interpreted characterization of the process.

An additional technique, categorical analysis of variance (CATANOVA), was used to determine the amount of association that exists between the classification of a given group of individuals within the Holland scheme at two points in time. CATANOVA is used in this study as an auxilliary technique to the Markov chain analysis; the Markov chains describe the patterns of movement that occur between two time points, say t-1 and t, while CATANOVA indicates how much the classification at time t depends upon the classification at time t-1.

It was expected that the subjects in each of the four groups would tend to maintain their initial occupational categories. And, when moves from category to category were made, they would be primarily among categories that were similar.

Further, it was anticipated that each of the four groups would exhibit a distinct pattern of vocational movement. The younger blacks and younger whites were expected to show movement patterns that were less well-defined than the older blacks and older whites. Large percentages of both groups of blacks were expected to be in the Realistic and Conventional categories. Although many whites were expected to appear in the Realistic category, larger percentages of Social, Artistic, and Enterprising types were expected to appear than for blacks.

Method

The study consists of two parts. First, longitudinal data for a representative, national sample of young men were used to develop Markov models for four race-age groups. Second, the validity and generality of the Markov models for two of these race-age groups were determined by comparing the theoretical patterns of movement with the actual work histories of another national, representative sample of men of comparable age.

This section describes the samples and data analysis. Data for the study were collected from two samples: a sample from which the career models were derived, termed the Model Development Sample; and a sample used to test the validity of the models, called the Validation Sample.

The Samples

The Model Development Sample represented the civilian, noninstitutional population of men in the United States who were between the ages of 14 and 24, inclusive, in April of 1966. Respondents were selected through multi-state probability sampling techniques by the Bureau of the Census. The sample was arrived at by grouping all the nation's counties and independent cities into approximately 1900 sampling units. Of these, 235 strata of relatively homogeneous socioeconomic characteristics were [illegible] one sampling unit from each stratum was used for the sample. A probability sample of households from each of the 235 selected sampling units was taken. Blacks were over-sampled by a three-to-one ratio to provide more reliable statistics for that group. A more detailed description of the sampling design may be found in Parnes, Miljus, and Spitz (1969); Zeller, Shea, Kohen, and Meyer (1970); and Kohen and Parnes (1971).

For the Model Development Sample, data were collected by the Bureau of the Census for The Center for Human Resource Research at the Ohio State University under the sponsorship of the Manpower Administration of the United States Department of Labor as a part of the National Longitudinal Survey. The interviews were conducted in three successive years; 1966, 1967, and 1968. Questionnaires from each of the years contain items unique to that year; i.e., all questionnaires are not identical. Items used from the interviews were the respondents' race, age, and occupations for 1966, 1967 and 1968. The three interview schedules are given in Kohen and Parnes (1971).

The total sample size in 1966 was 5,225, consisting of 3,734 whites, 1,435 blacks, and 56 persons of other racial and ethnic groups. Of these, 4,281 blacks and whites, or 82.8%, remained in 1968. The primary source of attrition was entrance into the military, which accounted for nearly 70 percent of the noninterviews. Attrition for blacks was slightly higher than for whites. The total number reporting occupations at all three interview times was 3,418, or 66.1% of the total number of blacks and whites. For the purposes of this study, the Model Development Sample was divided into four groups: whites, ages 14 through 17; whites, ages 18 through 24; blacks, ages 14 through 17; and blacks, ages 18 through 24. The number of respondents in each of the four groups for which complete data were available is given in Table 1.

TABLE 1

Distribution of Model Development Sample
Among Four Groups

Group	Number interviewed all three years	Number reporting occupations all three years
Whites, 14-17	1522	1073
Blacks, 14-17	691	470
Whites, 18-24	1595	1447
Blacks, 18-24	473	428
Total	4281	3418

Individuals in the category of other races were excluded from the analyses because of the small sample size and because of the heterogeneity within the group. The category included Mexican-Americans, American-Indians, Chinese-Americans, and Japanese-Americans.

The Validation Sample consisted of retrospective work histories of the first ten years of employment beginning with the first full-time job for 851 whites and 738 blacks. A standard multi-stage probability sample was selected by the National Opinion Research Center (NORC) at the University of Chicago. The sample represented civilian males in households in the United States who were between the ages of 30 and 39, inclusive, in 1968. As in the Model Development Sample, blacks were over-sampled to obtain more reliable estimates. For this sample, an over-representation of blacks was achieved by supplementing a national representative sample with a sample consisting of all blacks. Data for the Validation Sample were collected by the National Opinion Research Center(NORC) for the Social Accounts Program of the Center for the Social Organization of Schools at The Johns Hopkins University. Respondents were interviewed one time; that interview occurring in 1968. For this study, the data used were the respondents' race and the respondents' 10-year retrospective work history beginning with the first full-time job. A more detailed description of the Validation Sample, the data collection process, and the tape storage techniques is given in Blum, Karweit, and Sørensen (1969).

Occupational histories for both samples were coded and stored using the census coding system. The occupational classification in Holland et al (1970) was used to assign Holland codes (three-letter codes) to the census codes (three-digit codes) for each of the occupations in the work histories. A few revisions and exceptions were made: (a) military service was excluded from consideration, and (b) truck drivers were classified as RCE rather than CRE.

A limitation of the study is that the samples were not matched exactly. The data for the Model Development Sample were all full-time and part-time jobs held by respondents of a fixed age group (14 through 24) during the interviews. These data were obtained through longitudinal surveys. The data for the Validation Sample consisted of only full-time jobs that were held after respondents had left school, and were obtained retrospectively. Thus, respondents in the Validation Sample may have been more advanced in their occupational development.

Analysis

Two analytical techniques were used in this study; analysis of variance for categorical data and Markov chain analysis. The purpose of this section is to outline the two techniques.

Analysis of variance for categorical data

Light and Margolin (1971) developed a one-way analysis of variance for categorical data (CATANOVA) which is applicable to two dimensional contingency tables with one margin fixed. An advantage of their approach is that it provides a measure of variation in the response variable accounted for by the predictor variable. Light and Margolin also offer a test statistic for an independence hypothesis.

The computational formulae developed by Light and Margolin are as follows. Consider a set of n responses such that each response is classified into one and only one of I possible categories. Let n_i be the number of responses in the i^{th} category, i = 1, . . ., I so that $\sum_{i=1}^{I} n_i = n$. Then the variation of these responses is defined to be

$$\frac{1}{2n}\left[\sum_{i \neq j} n_i\, n_j\right] = \frac{1}{2n}\left[n^2 - \sum_{i=1}^{I} n_i^2\right] = \frac{n}{2} - \frac{1}{2n}\sum_{i=1}^{I} n_i^2 .$$

This measure of variation has the properties that variation is minimized if all responses occur in only one category, and it is maximized if the responses are spread as evenly as possible among the I categories.

Consider an analysis of variance table with G nominal experimental groups and I nominal response categories. For the present study, it is useful to think of the data as forming a two-dimensional (I x G) contingency table with I = G = 6. The number in the (i,j) cell is n_{ij}. The six Holland types observed at time 1 constitute the G experimental groups, and the six Holland types at a following time 2 constitute the I response categories. Now, the total sum of squares, or variation, in the response variable is

$$TSS = \frac{n}{2} - \frac{1}{2n}\sum_{i=1}^{I} n_{i.}^2$$

where $n_{i.} = \sum_{j=1}^{G} n_{ij}$. The within group variation is given by

$$WSS = \sum_{j=1}^{G} \left[\frac{n_{.j}}{2} - \frac{1}{2n_{.j}} \sum_{i=1}^{I} n_{ij}^2 \right] = \frac{n}{2} - \frac{1}{2} \sum_{j=1}^{G} \frac{1}{n_{.j}} \sum_{i=1}^{I} n_{ij}^2 .$$

The between group variation, BSS, is the difference of the total sum of squares and within group sum of squares, i.e., BSS = TSS - WSS. The proportion of variance explained by the predictor variable is $R^2 = \frac{BSS}{TSS}$. If there is perfect predictability in the contingency table, then $R^2 = 1$. For an even distribution over the table, $R^2 = 0$. Otherwise, $0 < R^2 < 1$.

Light and Margolin also developed a statistic to test the null hypothesis $p_{ij} = p_{i.}$. The statistic is

$$C = \frac{(n-1)(I-1)\ BSS}{TSS}$$

Under the null hypothesis the statistic is asymptotically approximated by X^2 (I-1)(G-1). In the present study, CATANOVA technique was applied to the two 6 x 6 one-year observed transition matrices for each of the four groups to determine the relationship of Holland occupational categories at successive points of time.

<u>Markov chain analysis</u>

A number of sources on Markov chains are available. The discussion that follows relies on the definitions and order of presentation by Hillier and Lieberman (1969) and Kemeny and Snell (1960).

A Markov process is a particular type of stochastic process. A stochastic process is a set of indexed random variables $X_1, X_2, X_3 \ldots,$ observed over time, where the subscript usually represents the time at which the random variable was observed. For this study, it was required that the random varia*les be discrete and have a finite number of states. Of general int... the study of stochastic processes is the probability of movi.. ..ong given states over time -- usually in a single time period. Specifically, the basic probabilities of interest are $P\{X_{t+1} = j \mid X_t = i\}$ for given i, j, and t. This conditional probability statement is the probability of the process being in state j at time t+1 given that it was in state i at time t. The set of all conditional probabilities $P\{X_{t+1} = j \mid X_t = i\}$ for a given t is called the set of transition probabilities for time t.

A stochastic process and the related transition probabilities must have two properties in order to fulfill the conditions of a Markov chain. First, for a stochastic process $\{ X_t \}$ to be a Markov process it must have the property that

$$P\left\{X_{t+1} = j \mid X_o = k_o, X_1 = k_1, \ldots, X_{t-1} = k_{t-1}, X_t = i\right\} =$$
$$P\left\{X_{t+1} = j \mid X_t = i\right\} \text{ for all sequences } i, j, k_o, k_1, \ldots, k_{t-1}.$$

This is called the Markovian property, or more graphically the one-step memory, and states that the process is first-order. Second, the transition probabilities must be independent of time. That is, they must have the property that

$$P\{X_{t+1} = j \mid X_t = i\} = P\{X_1 = j \mid X_o = i\} \text{ for all } t = 0, 1, \ldots .$$

This means that the probability of moving from one state to another is the same for all transition periods. Under this condition, the transition probabilities are called stationary probabilities, and they are denoted by p_{ij}.

It is now possible to define Markov chains of the sort to be used in this study.

> A stochastic process $\{ X_t \}$, $(t = 0, 1, \ldots)$ is said to be a finite-state Markov chain if it has the following:
>
> (1) a finite number of states,
> (2) the Markovian property,
> (3) stationary transition probabilities,
> (4) a set of initial probabilities, $P\{X_0 = i\}$ for all i (Hillier and Leiberman, 1969, p. 404).

It is convenient to represent Markov models as probability matrices in which the rows constitute leaving states and the columns constitute arriving states. Thus, the stationary transition matrix for a system of m states may be written as

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1m} \\ p_{21} & & & p_{2m} \\ \vdots & & & \vdots \\ p_{m1} & & \cdots & p_{mm} \end{bmatrix}$$

The ij^{th} element of a Markov process matrix is the probability of going from the i^{th} category to the j^{th} category in a single step or time interval.

Kemeny and Snell (1960) demonstrate from the Markov assumptions the powerful result that the n^{th} step probability matrix is merely the n^{th} power of P, the stationary transition matrix. Thus, the probability of an individual being in state l after the n^{th} transition given that he started in state k is the kl^{th} element of $P^{(n)}$, the n^{th} power of the stationary probability matrix. (Note that this is not the same as the n^{th} power of the kl^{th} element of P.) The successive powers of P provide theoretical transition matrices which describe the movement patterns of individuals among the categories over time. In addition, Kemeny and Snell show that under certain regularity conditions the powers of the stationary probability matrix approach a limiting probability matrix, say A. A has the property that its rows are identical and its components are all positive. The final states of a Markov process, therefore, may be thought as independent of the initial states.

Tests of assumptions, parameter estimation, and comparison of Markov processes

The following section discusses the tests of assumptions and methods of parameter estimation. The two assumptions for which tests are necessary are the stationary probability property and the Markovian property. In addition, a test for comparing Markov processes is given.

Stationarity hypothesis. As noted, Markov chain analysis assumes that the probabilities of transitions among states are independent of time, so that the probability of moving between any two states is the same for all time periods. The matrix of transition probabilities is called the matrix of stationary probabilities, stationary matrix, or theory matrix and is estimated from the observed transition matrices. The following notation is used to describe the observed transitions. Let there be $i = 1, \ldots, m$ states, or categories, which are observed at times $t = 1, \ldots, T$. Further, let $n_{ij}(t)$

denote the number of units observed to be in state i at time t - 1 and state j at time t for i, j = 1, . . . m, and t = 1, . . ., T. Then $p_{ij}(t)$ is the observed transition probability corresponding with the frequency $n_{ij}(t)$. Anderson and Goodman (1957) show that the maximum likelihood estimates for the stationary probabilities, p_{ij}, are

$$\hat{p}_{ij} = \sum_{t=1}^{T} n_{ij}(t) \Big/ \sum_{k=1}^{m} \sum_{t=1}^{T} n_{jk}(t) = \sum_{t=1}^{T} n_{ij}(t) \Big/ \sum_{t=0}^{T-1} n_{j}(t).$$

The initial probabilities are estimated by the proportions of individuals in each state when the process is first observed. The hypothesis of stationarity, i.e., that $p_{ij}(t) = p_{ij}$, may be tested using the statistic

$$X^2 = \sum_{i=1}^{m} X_i^2 = \sum_{i} \sum_{t,j} \left\{ n_i(t-1) \left[p_{ij}(t) - \hat{p}_{ij} \right]^2 \Big/ \hat{p}_{ij} \right\}.$$

where $n_i(t-1) = \sum_j n_{ij}(t)$. The statistic has a chi-square limiting distribution with m(m-1) (T-1) degrees of freedom under the null hypothesis. It is necessary to accept the stationarity hypothesis to support the notion that the process is a Markov chain.

Markovian property test. Suppes and Atkinson (1960) give two tests that may be used to establish the order of a Markov variable. A process of first-order has the Markovian property.

The first statistic is used to test the hypothesis that the Markov variable is zero-order against the alternative that it is greater than zero-order. The null hypothesis is that the process is zero-order, i.e., that it is a random process. Assuming a variable with m states, observed at T times, the test statistic is

$$X^2 = \sum_{i=1}^{m} \sum_{j=1}^{m} n_i \frac{\left(\frac{n_{ij}}{n_i} - \frac{n_j}{N}\right)^2}{n_{j/N}}$$

where $n_{ij}(t)$ is the number in state i at time t-1 and in state j at time t, $n_{ij} = \sum_{t=1}^{T} n_{ij}(t)$, $n_i = \sum_{j=1}^{m} n_{ij}$, $n_j = \sum_{i=1}^{m} n_{ij}$ and $N = \sum_{i=1}^{m} \sum_{j=1}^{m} n_{ij}$.

X^2 has a chi-square limiting distribution with $(m-1)^2$ degrees of freedom. It is easily recognized that this statistic is simply a chi-square test for independence generalized to include all T observations. It is desirable to reject the zero-order hypothesis to support the non-randomness of the process.

A second statistic given by Suppes and Atkinson can be used to test the hypothesis that a Markov variable is first-order against the alternative that it is greater than first order. The test statistic is

$$X^2 = \sum_{i=1}^{m} \sum_{j=1}^{m} \sum_{k=1}^{m} n_{ij} \frac{\left(\frac{n_{ijk}}{n_{ij}} - \frac{n_{jk}}{n_j}\right)^2}{n_{jk/n_j}}$$

where n_{ijk} is the number of individuals making the transition from state i to state j and then to state k in two transition periods. Under the null hypothesis of a first-order process, the test statistic is asymptotically chi-square with $m(m-1)^2$ degrees of freedom. The more general test that a process is of order r against the alternate that it is of order s $(r < s)$ can be achieved using the statistics presented by Anderson and Goodman (1957).

Comparison of Markov processes. The Markov models for the four groups were compared pairwise using a statistic reported by Anderson (1954). The statistic is

$$\chi^2 = \sum_{i=1}^{m} C_i \sum_{j=1}^{m} \frac{\left(p_{ij}^{(1)} - p_{ij}^{(2)}\right)^2}{p_{ij}^{*}}$$

where $\frac{1}{C_i} = \frac{1}{\sum_{t=1}^{T} n_i^{(1)}(t-1)} + \frac{1}{\sum_{t=1}^{T} n_i^{(2)}(t-1)}$.

The quantity $p_{ij}^{(k)}$ is the probability of an ij^{th} transition for the k^{th} group, and p^{*}_{ij} is the probability of an ij^{th} transition for the two groups combined. This statistic has a chi-square limiting distribution with m(m-1) degrees of freedom under the null hypothesis of no cross group differences. The comparison statistic is developed for first-order Markov chains. Where this requirement is violated, the results must be considered only approximations. In addition to the comparison of career patterns, the initial distributions of the four groups were compared pairwise using standard chi-square tests of independence.

Validation

To test the validity of the derived Markov models, two techniques were used; prediction of career patterns and prediction of Holland occupational category. The first involved comparing actual transitions of the Validation Sample to the theoretical transitions predicted from the successive powers of the stationary transition matrix P for each of the four groups. Statistically, this comparison was achieved by using a goodness of fit test.

Goodness of fit was tested using the following method. Let p_{ij} be the observed transition probability for leaving state i and entering state j. Let $\hat{p}_{ij}$ be the corresponding theoretical probability. Then the test statistic for goodness of fit is

$$X^2 = \sum_{i=1}^{m} \sum_{j=1}^{m} n_i \frac{[p_{ij} - \hat{p}_{ij}]^2}{\hat{p}_{ij}}$$

which is asymptotically chi-square with m(m-1)-1 degrees of freedom under the null hypothesis (Suppes and Atkinson, 1960).

The second technique for determining the validity of the models was to test the efficiency of the prediction of occupational categories from the theoretical transitions. In effect, predictive efficiency is a measure of the usefulness of the models as well as their validity.

Predictions of categories using Markov chains have been demonstrated by Gribbons and Lohnes (1966 and 1969). The predictions of subjects among states at transition r can be arrived at by assigning each individual to that state for which the entry is the largest in the row of the r^{th} power of the theory matrix corresponding to his entry group. This method is recognizable as a maximum likelihood decision principle (Lindgren, 1968). A given row of the theory defines the maximum likelihood decision function, conditioned upon a given entry point, and the state for which the decision function takes its maximum value is considered to be the best explanation of the data. The validity of extrapolating the model to long term transitions can be evaluated by the accuracy of the predictions.

These predictions were compared with predictions from the Holland classification alone.

Example

The following example using artificial data illustrates predictions of movement patterns and of categories. Consider a stochastic process in which the random variables $\{X_t\}$ take on the unordered values I, II and III, i.e., the process moves among three categories. Assume that the stochastic process meets the assumptions of a Markov chain, and has the stationary matrix P shown below

$$P = \begin{bmatrix} .63 & .13 & .25 \\ .17 & .67 & .17 \\ .60 & .40 & .00 \end{bmatrix}$$

Note that the rows of P sum to unity (errors are due to round off). The stationary matrix predicts the pattern of mobility over single transition periods. Successive powers of P predict longer step transitions.

Assume that it is of interest to predict the fourth step transition of a sample of 200, of which 100 were initially in category I, 50 in category II, and 50 in category III. Assume further that the actual fourth step transition is as shown in Table 2.

TABLE 2

Actual Fourth-Step Transitions
for Example Problem

Initial Category	Category after fourth transition			Total
	I	II	III	
I	53	25	22	100
II	23	21	6	50
III	20	20	10	50

The expected pattern after the fourth transition is based upon $P^{(4)}$, the fourth transition of the stationary matrix where

$$P^{(4)} = \begin{bmatrix} .48 & .35 & .18 \\ .41 & .42 & .17 \\ .45 & .37 & .18 \end{bmatrix}$$

The matrix of predicted frequencies is calculated as follows. Let F be a diagonal matrix of initial frequencies where f_{ii} is the number in the i^{th} category at initial point. For the present example,

$$F = \begin{bmatrix} 100 & 0 & 0 \\ 0 & 50 & 0 \\ 0 & 0 & 50 \end{bmatrix}$$

Then the matrix of predicted frequencies, say $T^{(4)}$, is $T^{(4)} = FP^{(4)}$. These theoretical frequencies are compared with the observed frequencies in Table 3.

TABLE 3

Comparison of Predicted Transitions with Actual Transitions for Example Problem

Initial Category	Category after Fourth Transition			Total
	I	II	III	
I	53 (48.0)	25 (35.0)	22 (18.0)	100
II	23 (20.5)	21 (21.0)	6 (8.5)	50
III	20 (22.5)	20 (18.5)	10 (9.0)	50

Note. - Theoretical frequencies are in parentheses.

The goodness of fit test indicates that the theoretical predictions give a reasonably accurate representation of the actual fourth step transition ($X^2 = 5.82$, d.f. = 5, $.25 < p < .50$). Thus, the pattern prediction of the model (for at least one transition period) appears relatively good.

The maximum likelihood principle prediction of categories is easily obtained. All individuals initially in a given category are assigned to the category for which the corresponding row of the fourth power of the transition, $P^{(4)}$, has the highest probability. Thus, the 100 individuals beginning in state I are predicted to remain in that state, the 50 in state II are expected to remain in state II, and the 50 in state III are expected to move to state I. This prediction strategy results in 53 + 21 +20 = 94 hits out of 200, or 47%.

Application of the model

For this study, there were six states corresponding to the six personality types in Holland's classification, R I A S E C. The stationary matrix for each group was based upon two observed transitions. These observed transitions were from the 1966 to 1967 and the 1967 to 1968 transition periods of the Model Development Sample. The stationary matrices are of the form shown in Table 4.

TABLE 4

General Form of Markov Model for the Holland Occupational Classification

Leaving States	Entering States					
	R	I	A	S	E	C
R	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}	p_{16}
I	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}	p_{26}
A	p_{31}	p_{32}	p_{33}	p_{34}	p_{35}	p_{36}
S	p_{41}	p_{42}	p_{43}	p_{44}	p_{45}	p_{46}
E	p_{51}	p_{52}	p_{53}	p_{54}	p_{55}	p_{56}
C	p_{61}	p_{62}	p_{63}	p_{64}	p_{65}	p_{66}

Stationary matrices and the resulting hypothesis tests were computed using four groups of the first sample: whites, ages 14 through 17; whites, ages 18 through 24; blacks, ages 14 through 17; blacks, ages 18 through 24.

Using the stationary matrices for older whites and older blacks, transitions within Holland's classification were predicted on white and black men in the Validation Sample. Predictions were made for the first, second, third, fourth, fifth, and tenth years after entering the labor market. The accuracy of the theoretical models in describing actual transitions in the second sample were tested using a goodness of fit test.

RESULTS

This section presents the results of the analysis in two parts. The first part presents the observed transitions of each of the four groups in the Model Development Sample along with the associated CATANOVA statistics and the resulting Markov models. The results for the younger white males, age 14 through 17, are discussed first; younger black males second; older white males, age 18 through 24, third; and older black males fourth.

The second part of the results section discusses the attempts to predict future career patterns and occupational categories for the Validation Sample. Here, the theoretical career patterns from the Markov chains are compared with the actual patterns of the Validation Sample. And, the predictive efficiency of the maximum likelihood decision rules from the Markov chains are compared with the predictive efficiency of the Holland occupational classification alone.

Model Development

Several race and age differences are apparent among the four groups in the Model Development Sample. These occur both in the career patterns and in the initial distribution among the six categories.

White Males, age 14 through 17

Observed transitions within Holland's classification for the younger whites are shown in Tables 5 and 6. The CATANOVA for these contingency tables appear in Tables 7 and 8. For both transition periods the CATANOVA C statistic was significant: for 1966 to 1967, C = 887.47, d.f. = 25, and $p < .001$; for the second transition, the 1967 to 1968 period, C = 681.87, d.f. = 25, and $p < .001$. The significance of C for both transitions implies that the Holland category of an individual's occupation was dependent upon the Holland classification of his job the previous year. The large magnitude of the C statistic reflects the power of the test resulting from the large sample size. However, in both transition tables the amount of variance in the categorization of individuals at the second time period accountable to the first time period, R^2, is small, 16.6% and 12.7% respectively.

Insert
Tables 5, 6, 7, 8, 9

The Markov model for these transitions is given in Table 9. Statistical tests indicate that the assumptions necessary for a Markov chain are reasonable. That the two observed transition matrices can be described by a stationary probability matrix is accepted ($X^2 = 19.71$, d.f. = 30, $.90 < p < .95$). The zero-order hypothesis is rejected, implying that the process is at least first-order ($X^2 = 1454.42$, d.f. = 25, $p < .001$). Rejection of the zero-order hypothesis was consistent with the significant C statistics reported above for the observed transition matrices individually. To a large extent the tests of independence conducted on the transition matrices singly are redundant with the test of the zero-order hypothesis. The hypothesis that the process was second-order rather than first-order was not supported (X^2 = 137.16, d.f. = 150, $.75 < p < .90$).

A notable feature of the Markov model is the large percentage of younger whites who were in jobs in the Realistic category. According to the vector of initial probabilities, 79.5% of the group were in Realistic occupations in 1966. The category next highest in frequency was the Enterprising class, with 11.7%. Fewer than one percent were in Investigative occupations. In addition, the stationary matrix indicates a high rate of movement into Realistic occupations. For individuals in all categories but Artistic, the category into which a move was most likely was Realistic. Those in the Artistic category tended to remain there. The movement into hexagonally continguous classes that was expected did not occur.

These career patterns seem to indicate limited opportunities in the labor market for the group. Men of this age are frequently legally excluded from many occupations or fail to meet training and educational requirements. During this age period most young whites fail to receive occupational experiences in a diverse set of jobs.

Black males, age 14 through 17

The results found for younger black males are similar results to those found for younger whites. The observed transitions for this group are given in Tables 10 and 11. As seen in the CATANOVA tables (Tables 12 and 13), the C statistic was significant for both transitions. For the 1966 to 1967 period, no members of this group began occupations in the Investigative category. Thus, the Investigative classification was eliminated from the experimental groups for the CATANOVA for that transition period. The resulting statistics were C = 417.41, d.f. = 20, and $p < .001$, and for the 1967 to 1968 period, C = 234.01, d.f. = 25, and $p < .001$. The percentage of common variance between the distributions at the first and second time points was 17.8% for 1966 to 1967, and 10.0% for 1967 to 1968. Again, the significant C statistics indicate that the occupational classification of an individual in this group was dependent upon his occupational classification for the preceding year. Judging from the R^2, however, the dependence was only moderate.

Insert
Tables 10, 11, 12, 13, 14

Table 14 shows the stationary probability matrix of the Markov chain for the younger black males. The assumptions for a Markov chain are tenable for this group. The stationarity hypothesis was not rejected ($X^2 = 18.96$, d.f. = 30, $.95 < p < .975$). And, the assumption of a zero-order process (independence) was rejected, as was expected from the significant C statistics for the individual transition matrices. For the test of the zero-order hypothesis, $X^2 = 1081.53$, d.f. = 25, $p < .001$. That the process was not greater than first-order was an acceptable hypothesis ($X^2 = 78.47$, d.f. = 150, $.99 < p < 1.0$).

To an even greater extent than was the case for the younger white males, the occupational structure for young blacks was dominated by Realistic jobs. The vector of initial probabilities shows that 87.2% of the younger black males were in Realistic jobs in 1966. The category with the next highest percentage was Enterprising, with less than 5% of this group. No younger black males were in Investigative occupations.

The stationary matrix shows that once in a Realistic occupation, there was less than a 10% chance of being in another type of job the following year. Those in the Artistic classification also tended to remain in their initial category. The probability of remaining in an Artistic occupation from one year to the next was .83 for the small number in that group. The group that was least probable to remain in its initial category was the Social group. Only 23% of those who were in Social occupations were in them the following year. Comparison of younger blacks and younger whites showed that the distribution among the Holland categories at the initial time period, 1966, was dependent upon race ($X^2 = 24.39$, d.f. = 5, $p < .01$). Comparison of the stationary matrices, however, indicated that no significant difference existed in the patterns of career movement for the two groups ($X^2 = 43.18$, d.f. = 30, $.05 < p < .10$).

White Males, age 18 through 24

For older white males, the two observed transition matrices are given in Tables 15 and 16. As was the case for younger whites and younger blacks, the CATANOVA for both transition periods indicated that the Holland category of a man's occupation was dependent upon the Holland type of the job for the previous year (Tables 17 and 18): for the 1966 to 1967 period, C = 2375.60, d.f. = 25, $p < .001$; and for the 1967 to 1968 interval C = 2604.51, d.f. = 25, $p < .001$. The R^2 values for the two transition periods are 32.9% and 36.0%, respectively. These values are substantially higher than those for either of the younger groups, and indicate that there was a greater relationship between the Holland categories of successive jobs for the older whites than for the younger groups.

Insert
Tables 15, 16, 17, 18, 19

The Markov model for the older white males appears in Table 19. The hypothesis of stationarity was acceptable ($X^2 = 24.17$, d.f. = 30, $.75 < p < .90$), and the hypothesis of a zero-order process was rejected ($X^2 = 4398.10$, d.f. = 25, $p < .001$). However, the test statistic of the first-order process hypothesis test was also rejected ($X^2 = 307.15$, d.f. = 150, $p < .01$). Thus, the Markovian assumption was not acceptable for older white males. Rather, an individual's occupational category was dependent upon his job classification in the preceding two years for this group. Therefore, statistical tests using the Markov model are only approximate.

The stochastic model for older whites differed from that of the younger whites in several ways. First, the initial distributions of the men among the Holland categories differed for the two age groups ($X^2 = 113.63$, d.f. = 5, $p < .01$). The probability of being in a Realistic occupation at the initial point was considerably lower for older whites. According to the initial probabilities, 67.7% of the group were in the Realistic jobs in 1966. The next largest category of jobs was Enterprising, with 10.2%, followed by Investigative and Conventional occupations, each with 7.3%. Least popular in terms of the number of men in them were the Social and Artistic categories.

Second, the stationary probability matrices differed significantly for the two groups ($X^2 = 226.61$, d.f. = 30, $p < .001$). The older white men were more likely to remain in a single occupational category than the younger whites. For a single transition period, the probability was highest that individuals in the older group would remain in the category in which they began. Most stable were men in Realistic jobs, with a probability of .84 of remaining in that category over a single period. All moves from Realistic occupations into other categories had small probabilities. The next most stable classification was Social, with a probability of .69 of remaining in that category. Somewhat surprisingly, the most frequent move out of the Social category was into the Realistic category, with a probability of .13. Since the personal characteristics of individuals in Realistic and Social categories differ greatly, a much smaller percentage was expected. The remaining groups in order of stability were Enterprising (.67), Investigative (.60), Conventional (.54), and Artistic (.49). In none of the categories was the expected pattern of moving into hexagonally contiguous categories observed.

Black Males, age 18 through 24

Transition tables for older black males, 18 through 24, are shown in Tables 20 and 21, with the associated CATANOVA results in Tables 22 and 23. Again the C statistic for both transition periods was highly significant; for the 1966 to 1967 period C = 515.07, d.f. = 25, $p < .001$, and for the 1967 to 1968 period C = 656.87, d.f. = 25, and $p < .001$. The R^2 values for the older blacks were somewhat lower than those for whites of the same age group, but higher than the R^2 values for both younger groups. The R^2 for the older black males was 24.1% for 1966 to 1967 and 30.8% for 1967 to 1968.

Insert
Tables 20, 21, 22, 23, 24

The Markov model for the older black males is shown in Table 24. All assumptions for a Markov chain appeared reasonable. The stationarity hypothesis for the model was not rejected (X^2 = 24.61, d.f. = 30, $.50 < p < .75$). The test of the zero-order process hypothesis was rejected (X^2 = 907.02, d.f. = 25, $p < .001$). And, the process did not appear to be second order or greater (X^2 = 55.85, d.f. = 150, and $.99 < p < 1.0$).

Statistically significant differences were obtained when the initial 1966 distribution of older blacks within the Holland categories was compared with the initial distribution of younger blacks (X^2 = 11.57, d.f. = 5, $p < .05$) and with the initial distribution of older whites (X^2 = 76.97, d.f. = 5, $p < .01$). Of these, the differences with the older whites seemed to be the more important.

From the vector of initial probabilities it is seen that 87.1% of the older black males were in Realistic occupations in 1966. This was nearly 20% higher than the number of white males of the same age group who initially were in the Realistic category. The next most frequent occupational category for older black males was Conventional (5.6%). Neither the Investigative nor the Artistic category held more than one percent of the group.

One of the most notable differences between older blacks and older whites occurred in the Enterprising category. Because occupations in the Enterprising category are those that involve business, management, and selling activities, those in that category are generally associated with leadership and authority positions. These Enterprising occupations were held by 1.6% of the older blacks but by 10.2% of the older whites. This result was interpreted to mean that at an early stage of career development, black men are usually in subordinate roles rather than policy-making positions.

The difference between the two age groups of blacks was not large. The source of the difference appeared to be in the Enterprising and Conventional categories; more of the younger group were in the former and more of the older group were in the latter.

Race differences also occurred for the two older groups between the stationary matrices of the Markov chains ($X^2 = 132.01$, d.f. = 30, $p < .001$). However, age differences between the stationary matrices for the two groups of black men were not found ($X^2 = 37.95$, d.f. = 30, $.10 < p < .25$). Category by category, members of the older black male group appeared less likely to remain in their initial category over one transition period than older whites. For older blacks in the Realistic, Investigative, Artistic, Social and Conventional categories of the group, the highest probability was for remaining in their job category. The probability was particularly high for the Realistic group (.95) and then decreased for Investigative (.63), Social (.53), Conventional (.47) and Artistic (.29). In the Enterprising category, there was a higher probability of moving into Realistic occupations than of remaining in

Enterprising jobs. As occurred for the three other groups of men, the expected pattern of career movement into hexagonally contiguous categories was not found.

Prediction and Validation

This section gives the results of the predictions of career patterns and occupational categories for the Validation Sample using the Markov chains. As noted previously, no validation sample was available for the two younger age groups, so the predictive strategies that were obtained for the two groups are reported without any associated validity tests. These results are followed by the validation tests for the two older groups of men.

White Males, age 14 through 17

Because the stationary matrices of the Markov models do not differ significantly across race for the two younger groups, the maximum likelihood prediction principle results in very similar predictive strategies. The successive powers of the stationary matrix for younger whites from which the predictions are determined are shown in Table 9.

For the first transition period of the younger white males, the maximum likelihood principle predicts that those who were initially in the Realistic and Artistic groups would remain in occupations in the same category. Those in Investigative, Social, Enterprising and Conventional categories would be predicted to have shifted into Realistic occupations. At the second transition and all transitions thereafter, the maximum likelihood principle predicts that everyone would be in Realistic occupations, regardless of the Holland classification of the initial job. The efficiency of this prediction, as judged by the hit rate, would equal the percentage of individuals in the Realistic category at each interval. Because that percentage is high for this group, the prediction would be relatively efficient.

The stationary matrix converges after the seventh power. The limiting probability vector indicates that, no matter what the initial category, the probability was .81 of being in a Realistic occupation after seven transitions; .01 of being in an Investigative occupation; .02 for Artistic, .02 for Social, .07 for Enterprising, and .06 for Conventional. However, the model for the younger men applies only to a narrow age range and the Markov model for older males would apply to the group before the limiting probability vector.

Black Males, age 14 through 17

The powers of the stationary matrix from which predictions were made for the younger black men appear in Table 14. After the first transition period the maximum likelihood principle predicts that individuals in the Realistic, Investigative, and Artistic categories would remain in their initial categories and those in the Social, Enterprising, and Conventional categories would move into Realistic occupations. The predictions following the second, third, and fourth transitions are that individuals in the Realistic and Artistic categories would remain in them, and those in the other categories would move into Realistic jobs. Following the fifth transition, the maximum likelihood category was Realistic regardless of the initial state.

The process for the younger black males converged at the twenty-seventh power of the stationary matrix. According to the limiting vector, the probability of being in the Realistic category was .86, in Investigative .01, in

Artistic .01, in Social .02, in Enterprising .02, and in Conventional .07. Again the number of transitions to convergence is well beyond the number of years for which this model is applicable.

White Males, age 18 through 24

Predictions of career patterns in the Validation Sample using the Markov models were not particularly successful for either group of older men. The successive powers of the stationary matrix for older whites is shown in Table 19. It should be recalled that the transition process for older white males did not meet all the assumptions of a Markov chain, and that this chain is an approximation of a first-order process.

The theoretical patterns that the Validation Sample was expected to follow are compared with the actual transitions for six different points in time in Table 25. All chi-square goodness of fit tests for these

Insert
Table 25

comparisons yield significant test statistics, indicating that they cannot be assumed to be patterns from the same population. For the first transition for the white males $X^2 = 114.21$, d.f. = 29, and $p < .001$. The magnitude of the chi-square test statistics increased for each year's comparison through the fifth year, but not for the tenth year. A reasonable conjecture about the poor fit of the prediction is that the model does not allow for the continued dominant diagonal pattern that occurs in the Validation Sample's actual mobility pattern. This difficulty is more apparent when predictions of occupational categories are attempted.

Hit rates for predictions for the six time points resulting from the maximum likelihood principle are shown in Table 26. These are compared

Insert Table 26

with the hits resulting from the prediction that men would remain in their initial Holland category. For the first transition period, the strategy predicts that everyone would remain in his initial category. This gives 90.8% who were correctly classified. After the second year the same strategy holds except that those initially in the Artistic group were predicted to fall into the Realistic classification. For this prediction, 85.0% hits were obtained. At the prediction for the third year transition, the Markov strategy begins to become less efficient. Based upon the third power of the theory matrix, those who began in the Social group were predicted to remain in that group while all others were predicted to b in the Realistic category. This strategy yields 66.6% hits. A much higher percentage of hits, 80.5%, results from predicting that everyone would have remained in his initial group. Predictions for the fourth, fifth, and tenth years are that everyone would be in a Realistic occupation regardless of his first occupational category. From these predictions, the resulting hits are 61.5%, 59.9%, and 62.5%, respectively. Again these percentages are lower than ignoring the Markov model and predicting that individuals would remain in their initial occupational classification. This latter strategy results in 74.4%, 74.7%, and 71.7% hits, respectively.

Black Males, age 18 through 24

Unlike the situation for older whites, the assumptions for a Markov chain were tenable for the career pattern of older blacks. However, the theoretical patterns of movement were still not good predictors of the actual transitions that were observed in the Validation Sample. The successive powers of the stationary matrix from which the theoretical transitions were derived are shown in Table 24. Convergence is attained after the eleventh power of the matrix.

Actual transitions are compared with theoretical transitions in Table 27. For the comparison of actual and theoretical transitions after the

Insert
Table 27

first year a X^2 of 72.20 ($p < .001$, d.f. = 29) was obtained. The magnitude of the X^2 values increased through the fourth year ($X^2 = 416.89$, d.f. = 29, $p < .001$), but then decreased for the fifth and tenth years. These values were $X^2 = 295.67$ (d.f. = 29, $p < .001$), and $X^2 = 206.89$ (d.f. = 29, $p < .001$), respectively.

These results imply that the theoretical transition patterns for older black males derived from the Model Development Sample cannot be generalized as expected. One important difference between the theoretical transitions and the actual transitions is that the latter maintain diagonal dominance over the observation period while the former, by their mathematical nature, cannot.

The results of the maximum likelihood prediction strategy on the Validation Sample are summarized in Table 26. For the one-year transition, the strategy is to predict that everyone will remain in his initial category. This results in 93.9% hits. After the two year period, those initially in Realistic and Investigative occupations are predicted to remain in those categories while those in Artistic, Social, Enterprising, and Conventional occupations are expected to move into Realistic occupations. The hit rate for this prediction is 87.4%. A higher hit rate, 91.4%, is obtained by predicting that everyone would maintain his initial occupational category. For the three year period and beyond, the maximum likelihood strategy is to predict that everyone will move into the Realistic category. In most cases this strategy is slightly less efficient than predicting that everyone would maintain his initial classification. After three years the maximum likelihood prediction gives 85.3% hits compared with 89.2% who remain in their first category; 85.4% compared with 88.2% after four years; and 84.3% compared with 86.1% after five years. Following the tenth year, the two strategies give nearly the same number of hits, 84.8% compared with 84.3%.

SUMMARY, DISCUSSION, AND LIMITATIONS

The present study used the Holland occupational classification and Markov chain analysis for describing and predicting career patterns of young men. Models of movement among the six categories of the Holland classification were derived for four groups of young men who were divided according to race and age. In short, this report provides (1) Markov chains of the career patterns for four groups of young men, (2) tests of the predictive validity of the chains, and (3) comparisons of the four race-age groups using the Markov models.

Four groups were obtained by stratifying a sample of 5,225 young men, age 14 through 24, according to race and age: white males, 14 through 17; black males, 14 through 17; white males, 18 through 24; and black males, 18 through 24. Men were interviewed in each of three years (1966, 1967, and 1968) as part of the National Longitudinal Survey sponsored by the Bureau of the Census. Occupational histories were recoded according to the Holland occupational classification and analyzed in two ways. First, the pattern of movement among the categories was summarized by deriving Markov models for each of the four age-race categories. Second, the amount of association within the cross categories of individuals according to the Holland classification over the one year transition periods was determined using analysis of variance for categorical data (CATANOVA) for each of the four groups. The technique provides a test for independence and a measure of common variance, R^2, in a classification at two successive points in time.

An attempt to establish the predictive validity of two of the four models was performed. The Markov models for older white males and older black males were used to predict patterns of movement and occupational categories of the ten-year transitions for a second sample. These attempts were largely unsuccessful. The sample upon which predictions were attempted consisted of ten-year retrospective work histories, coded according to the Holland occupational classification, for 851 white males and 738 black males, beginning with their first full-time job after leaving school.

Discussion

Some statistically significant and important differences occurred among the four groups -- i.e., with respect to race and age -- both in the patterns of career transitions and in the distribution of individuals among the six Holland categories at the time of the initial interview. In general, younger men showed a narrow range of occupational experience. About eight of every ten young males, age 14 through 17, were in the Realistic occupational category at the time of the first interview in 1966; and this number was higher for blacks than for whites. Occupations in the Investigative class were all but unknown for this age group. It is likely that this distribution among the occupational groups reflects both legal and educational requirements that make Realistic occupations the most accessible for high school youth.

Once in Realistic occupations, younger males of both races remained in them at a high rate. In addition, men in other categories tended to gravitate toward Realistic occupations at a higher rate than they maintained their original categories. This pattern was not dependent upon race.

For black men, age had little apparent effect on occupational movement. Although the older group appeared to be more stable than the younger group in their occupational categories, the stationary matrices of the Markov models for the two groups were not statistically different. In addition, the initial distribution among the Holland categories differed only slightly for the two age groups of blacks. Therefore, the narrow range of occupational opportunity experienced by younger men continues to occur for older blacks. For blacks, racial barriers seem as important as age barriers in precluding occupational opportunity.

In contrast to other groups, older whites held jobs in a broader range of occupational categories. In addition, the Markov chain indicates that older whites would be expected to maintain their beginning occupational classifications over single transition periods. Unlike the other three groups, the first order Markov chain for the older whites did not yield a statistically reasonable fit. Specifically, the Markovian property was untenable for the data, and a process of at least second order was indicated. This result implies that occupational movement is a process that is dependent on a greater portion of the job history for older whites than for the other groups.

None of the Markov models for these groups revealed the predicted pattern of the movement among categories. It was expected that for each of the four race-age groups, movement within the classification would reflect the relatedness of the categories; that is, most of the men would maintain their occupational category, the next highest proportion would move into related categories, etc. The failure to obtain such models may have been an artifact of the distribution of available jobs among the Holland categories. Since most occupations in the world of work are classified as Realistic, it would be expected that many men would move into Realistic jobs regardless of personality type. Similarly, there are very few Artistic jobs for men to enter. Thus, it is probably unlikely that these predicted patterns would be apparent unless labor market demand was controlled. One possible method of controlling for the proportion of jobs in each category would be through the index of perfect mobility (Rogoff, 1953; Carlsson, 1958).

Important differences in the stability of occupational choices for the four groups were also found. As measured by the amount of common variance (R^2) in the Holland classification of the groups at two successive points in time, there was a greater amount of association in successive Holland categories for whites than for blacks, and for older men than for younger men. It should be recalled that since the R^2 values are ratios of variation components, they in effect are controlled for a high or low general job rate in one or more categories (such as the high Realistic rate that is generally manifest for black men and younger men). In general, the results imply that older white males are the most consistent and predictable in their successive occupational choices, rating slightly above older black men. Younger men demonstrate much less consistency in their successive occupational choices.

The evidence also implies that the older men become increasingly stable in their Holland categories over time. For older men of both races, the R^2 values for the second transition, 1967 to 1968, were larger than for the first period, 1966 to 1967. Such a result suggests that as men of this age group progress in their careers they find occupations with which they are compatible and, therefore, become more consistent in their successive choices. Opposite results occurred for younger men of both races, as their R^2 values decreased for the second transition period. This may have resulted because many younger men were leaving high school and previously unavailable job opportunities became available to them. Further, with age, younger men were no longer subject to child labor law restraints.

Although the Markov chains derived from the Model Development Sample provide useful information about race and age differences in career patterns, the models fail to have any predictive validity. Two problems with using the first order Markov models for predictive purposes on the Validation Sample seemed to occur. First, the stationary probability matrices did not fit the short term transitions of the Validation Sample. This problem was most apparent in the comparisons of the predicted and actual transitions for the first year. To a large degree, the differences here may simply have been the result of attempting to match two samples, the Model Development

Sample and the Validation Sample, that deviated from each other in too many ways. Secondly, the actual occupational transitions did not converge in the manner of the successive powers of the stationary probability matrix. Instead, men in the Validation Sample became more persistent in maintaining their Holland categories over the ten-year interval. Markov chains, of course, are unable to account for such behavior.

The inadequacy of the Markov chains in providing reasonable long range predictions indicates that these models cannot be extrapolated or generalized to any real extent. Rather, if Markov models are to be used they must be derived for small segments of time. Even then, as occurred for the older white group, a first-order Markov chain may not be adequate to describe the process. However, Markov chains of an order greater than one require the estimation of a large number of parameters and can be difficult to derive and interpret.

In short, the results of this study indicate that first order Markov chains have limited usefulness in providing prospective information of movement among jobs although they may adequately characterize short term career processes. A more efficient and parsimonious strategy for predicting categories of the older men is to predict that they will maintain their initial Holland category. For younger men, it is generally efficient to predict that they would be in Realistic categories at any point in time.

This study suggests the usefulness of the Holland occupational classification for analyzing and interpreting work histories. The results indicate that the predictive efficiency of the classification, when applied to employed adults, is maximized when it is predicted that individuals will maintain their initial Holland category. And, predictive efficiency is not necessarily improved by using stochastic process models.

Limitations

Generalizations of the results of this study are subject to the limitations discussed in this section. It should be noted that this study attempted to avoid two common difficulties -- small sample size and lack of representativeness. Both samples used in this study were nationally representative, and both were very large. Only males were sampled and no attempt should be made to generalize these results to females.

Despite the large sample size, however, some problems with small cell sizes did arise. Because of the high proportion of men who were in the Realistic category, the transition probabilities of the stationary matrix for other categories were sometimes estimated using a very small number of men. This reduces the reliability of some of the parameter estimates in the Markov models and of some of the chi-square based tests. Although the number of small cell sizes could have been reduced by combining categories, that alternative was deemed unacceptable because it would have limited the usefulness of the results even more.

Another limitation is that the Model Development Sample and Validation Sample were probably not closely matched. The plan was to predict transitions of a group of men in full-time jobs (the Validation Sample) from the models derived from the part-time and full-time occupations of another group of comparable age (the Model Development Sample). In retrospect, it appears that some of the predictive errors may have been due to differences in the stage of occupational development and in the method of measurement for these samples.

An additional limitation is that the assumptions necessary for Markov chain analysis were not met for all groups. Specifically, the process for the older white male group failed to meet the Markovian assumption. Failure to meet this assumption left two alternatives. First, it would have been possible to have constructed a second-order chain for that group. However, such a chain would have required a reduction to the first-order case which would demand an enormous transition matrix (36 x 36 with half of the entries zero). This alternative was rejected because of the impracticality of interpreting such a large matrix and because of the relatively few observed transitions available for estimation of the stationary probabilities. The second alternative was to ignore the Markovian assumption and use an approximate first-order model. This alternative was adopted, largely because of the problems with fitting a second order chain. In addition, there is some precedence for using the approximate first order chain (Gribbons and Lohnes, 1969).

Finally, the present study does not directly consider the question of why men move from job to job, or why they remain in a given occupation. Rather it studies where men tend to move given an initial occupational category. It assumes that if men remain in a given occupational category for a long period, they have obtained a relatively good match between their personal characteristics and occupational skills and the job demands of the occupations in that category.

BIBLIOGRAPHY

Abe, C., & Holland, J. L. A description of college freshmen: I. Students with different vocational choices. ACT Research Report No. 3. The American College Testing Program, Iowa City, Iowa, 1965.

American Education. Marland on career education. DHEW Publication No. (OE) 72-52, November, 1971.

Anderson, T. W. Probability models for analyzing time changes in attitudes. In P. F. Lazarsfield (Ed.), Mathematical thinking in social sciences. Glencoe, Ill.: The Free Press, 1954.

Anderson, T. W., & Goodman, L. A. Statistical inference about Markov chains. Annals of Mathematical Statistics, 1957, 28, 89-110.

Blum, Z. D., Karweit, N. L., & Sørensen, A. B. A method for the collection and analysis of retrospective life histories. Report No. 48, Center for Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland, 1969.

Campbell, D. P. Handbook for the Strong vocational interest blank. Stanford: Stanford University Press, 1971.

Campbell, D. P., & Holland, J. L. Applying Holland's theory to Strong's data. Journal of Vocational Behavior, 1972, in press.

Carlsson, G. Social mobility and class structure. Lund: C. W. K. Gleerup, 1958.

Cole, N. S. On measuring the vocational interests of women, ACT Research Report No. 49. The American College Testing Program, Iowa City, Iowa, 1972.

Cole, N. S., & Cole, J. W. L. An analysis of spatial configuration and its application to research in higher education. ACT Research Report No. 35. The American College Testing Program, Iowa City, Iowa, 1970.

Cole, N. S., & Hanson, G. R. An analysis of the structure of vocational interests. ACT Research Report No. 40, The American College Testing Program, Iowa City, Iowa, 1971.

Crabtree, P. D. A test of Holland's hexagonal model of occupational classification using a rural high school population. Unpublished doctoral dissertation, Ohio University, 1971.

Crites, J. O. Vocational psychology. New York: McGraw-Hill, 1969.

Cunningham, J. W., & McCormick, E. J. Factor analyses of "worker-oriented" job variables. Occupational Research Center, Purdue University, Lafayette, Indiana, June 1964. (Prepared for Office of Naval Research under contract Nonr-1100 (19), Report No. 4.)

Doyle, R. E. Career patterns of male college graduates. Personnel and Guidance Journal, 1965, December, 410-414.

Edwards, K. J., Nafziger, D. H., & Holland, J. L. Do occupational perceptions become more differentiated with age? Report No. 141, Center for Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland, 1972.

Edwards, K. J., & Whitney, D. R. A structural analysis of Holland's personality types using factor and configural analysis. Journal of Counseling Psychology, 1972, 19, 136-145.

Gordon, G. G., & McCormick, E. J. The identification, measurement and factor analyses of "worker-oriented" job variables. Occupational Research Center, Purdue University, Lafayette, Indiana, July 1963. (Prepared for Office of Naval Research under contract Nonr-1100 (19), Report No. 3.)

Gribbons, W. D., & Lohnes, P. R. Career development. Cooperative Research Project No. 5-0088, Regis College, Weston, Massachusetts, 1966.

Gribbons, W. D., & Lohnes, P. R. Career development from age 13 to age 25. Final Report, Project No. 6-2151, U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C., 1969.

Guttman, L. A new approach to factor analysis: The radex. In P. F. Lazarsfield (Ed.), Mathematical thinking in social sciences. Glencoe, Ill: The Free Press, 1954.

Herr, E. L. Review and synthesis of foundations for career education. The Center for Vocational and Technical Education, The Ohio State University, Columbus, Ohio, 1972.

Hillier, F. S., & Lieberman, G. J. Introduction to operations Research. San Francisco, Calif.: Holden-Day, 1969.

Hodge, R. W. Occupational mobility as a probability process. Demography, 1966, 3, 19-34.

Holland, J. L. A theory of vocational choice. Journal of Counseling Psychology, 1959, 6, 35-44.

Holland, J. L. Manual for the vocational preference inventory. Palo Alto, Calif.: Consulting Psychologists Press, 1965.

Holland, J. L. A psychological classification scheme for vocations and major fields. Journal of Counseling Psychology, 1966, 13, 278-288. (a)

Holland, J. L. The psychology of vocational choice. Waltham, Mass.: Blaisdell, 1966. (b)

Holland, J. L. Explorations of a theory of vocational choice: VI. A longitudinal study using a sample of typical college students. Journal of Applied Psychology, 1968, 52, 1-37.

Holland, J. L. The self-directed search for educational and vocational planning. Palo Alto, Calif.: Consulting Psychologists Press, 1970.

Holland, J. L. Making vocational choices. Englewood Cliffs, New Jersey: Prentice Hall, 1973, in press (a).

Holland, J. L. Vocational preferences. In M. D. Dunnette (Ed.), Handbook of Industrial and Organizational Psychology. Chicago: Rand-McNally, 1973, in press (b).

Holland, J. L., Sørensen, A. B., Clark, J. P., Nafziger, D. H., & Blum, Z. D. Applying an occupational classification to a representative sample of work histories. Report No. 119, Center for Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland, 1971.

Holland, J. L., Viernstein, M. C., Kuo, H., Karweit, N. L., & Blum, Z. D. A psychological classification of occupations. Report No. 90, Center for Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland, 1970.

Holland, J. L., & Whitney, D. R. Changes in the vocational plans of college students: Orderly or random? ACT Research Report No. 25, American College Testing Program, Research and Development, Iowa City, Iowa, April, 1968.

Holland, J. L., Whitney, D. R., Cole, N. S., & Richards, J. M., Jr. An empirical occupational classification derived from a theory of personality and intended for practice and research. ACT Research Report No. 29, The American College Testing Program, Iowa City, Iowa. 1969.

Hutchinson, T., & Roe, A. Studies of occupational history: Part II. Attractiveness of occupational groups of the Roe system. Journal of Counseling Psychology, 1968, 15, 107-110.

Jeanneret, P. R., & McCormick, E. J. The job dimensions of "worker-oriented" job variables and their attribute profiles as based on data from the position analysis questionnaire. Report No. 2, 1969. Occupational Research Center, Purdue University, Lafayette, Indiana, Contract Nonr-1100 (28), Office of Naval Research.

Jeanneret, P. R., & McCormick, E. J. The dimensions of human work. Personnel Psychology, in press.

Kemeny, J. G., & Snell, J. L. Finite Markov chains. New York: Van Nostrand, 1960.

Kohen, A., & Parnes, H. S. Career thresholds: A longitudinal study of the educational and labor market experience of male youth. Vol. 3., Center for Human Resource Research, Ohio State University, Columbus, Ohio, 1971.

Light, R. J., & Margolin, B. H. An analysis of variance for categorical data. Journal of the American Statistical Association, 1971, 66, 534-544.

Lindgren, B.W. Statistical theory. London: The Macmillan Company, 1968.

Lohnes, P. R. Markov models for human development research. Journal of Counseling Psychology, 1965, 12, 322 - 327.

Lucy, W. T. A study designed to test the validity of selected formulations from John Holland's theory of vocational choice. Unpublished doctoral dissertation, University of Maine, 1971.

McCormick, E. J., Cunningham, J. W., & Gordon, G. G. Job dimensions based on factorial analysis of worker-oriented job variables. Personnel Psychology, 1967, 20, 417-430.

McCormick, E. J., Cunningham, J. W., & Thornton, G. C. The prediction of job requirements by a structured job analysis procedure. Personnel Psychology, 1967, 20, 431-440.

McCormick, E. J., Finn, R. H., & Sheips, C. D. Patterns of job requirements. Journal of Applied Psychology, 1957, 41, 358-364.

McCormick, E. J., Jeanneret, P. R., & Mecham, R. C. The development and background of the position analysis questionnaire. Office of Naval Research Contract Nonr-1100 (28), Report No. 5. Occupational Research Center, Purdue University, Lafayette, Indiana, 1969.

McQuitty, L. L., & Clark, J. A. Clusters from iterative, intercolumnar correlational analysis. Educational and Psychological Measurement, 1968, 28, 211-238.

Mecham, R. C., & McCormick, E. J. The use of data based on the position analysis questionnaire in developing synthetically-derived attribute requirements of jobs. Office of Naval Research Contract Nonr-1100 (28), Report No. 4. Occupational Research Center, Purdue University, Lafayette, Indiana, 1969.

Nafziger, D. H., & Helms, S. T. Cluster analyses of the SVIB, MVII, and Kuder OIS as tests of an occupational classification. Report No. 138, Center for Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland, 1972.

Osipow, S. H. Theories of career development. New York: Appleton-Century-Crofts, 1968.

Parnes, H. S., Miljus, R. C., & Spitz, R. S. Career thresholds: A longitudinal study of the educational and labor market experience of male youth 14-24 years of age. Vol. 1, Center for Human Resource Research, Ohio State University, Columbus, Ohio, 1969.

Parsons, E. An application of Holland's vocational theory to an empirical study of occupational mobility of men age 45-59. Ph. D. dissertation, Ohio State University, 1971.

Roe, A. The psychology of occupations. New York: Wiley, 1956.

Roe, A., Hubbard, W. D., Hutchison, T., & Bateman, T. Studies of occupational histories: Part I. Job changes and the classification of occupations. Journal of Counseling Psychology, 1966, 13, 387-393.

Rogoff, N. Recent trends in occupational mobility. New York: The Free Press, 1953.

Sørensen, A. B. Models of social mobility. Report No. 98, Center fcr Social Organization of Schools. The Johns Hopkins University, Baltimore, Maryland, 1971.

Super, D. E. Vocational development theory in 20 years: How will it come about? In J. M. Whiteley (Ed.), Perspectives in vocational development. Columbus, Ohio: Charles Merrill, 1971.

Suppes, P., & Atkinson, R. C. Markov learning models for multiperson interactions. Stanford, Calif.: Stanford University, 1960.

Viernstein, M. C. The extension of Holland's occupational classification to all occupations in the Dictionary of Occupational Titles. Report No. 100, Center for the Social Organization of Schools, The Johns Hopkins University, Baltimore, Maryland, April, 1971.

Zeller, F. A., Shea, J. R., Kohen, A. I., & Meyer, J. A. Career thresholds: A longitudinal study of the educational and labor market experience of male youth. Volume 2, Center for Human Resource Research, Ohio State University, Columbus, Ohio, 1970.

FIGURE 1

A Hexagonal Model for Interpretating Inter- and Intra-Class Relationships

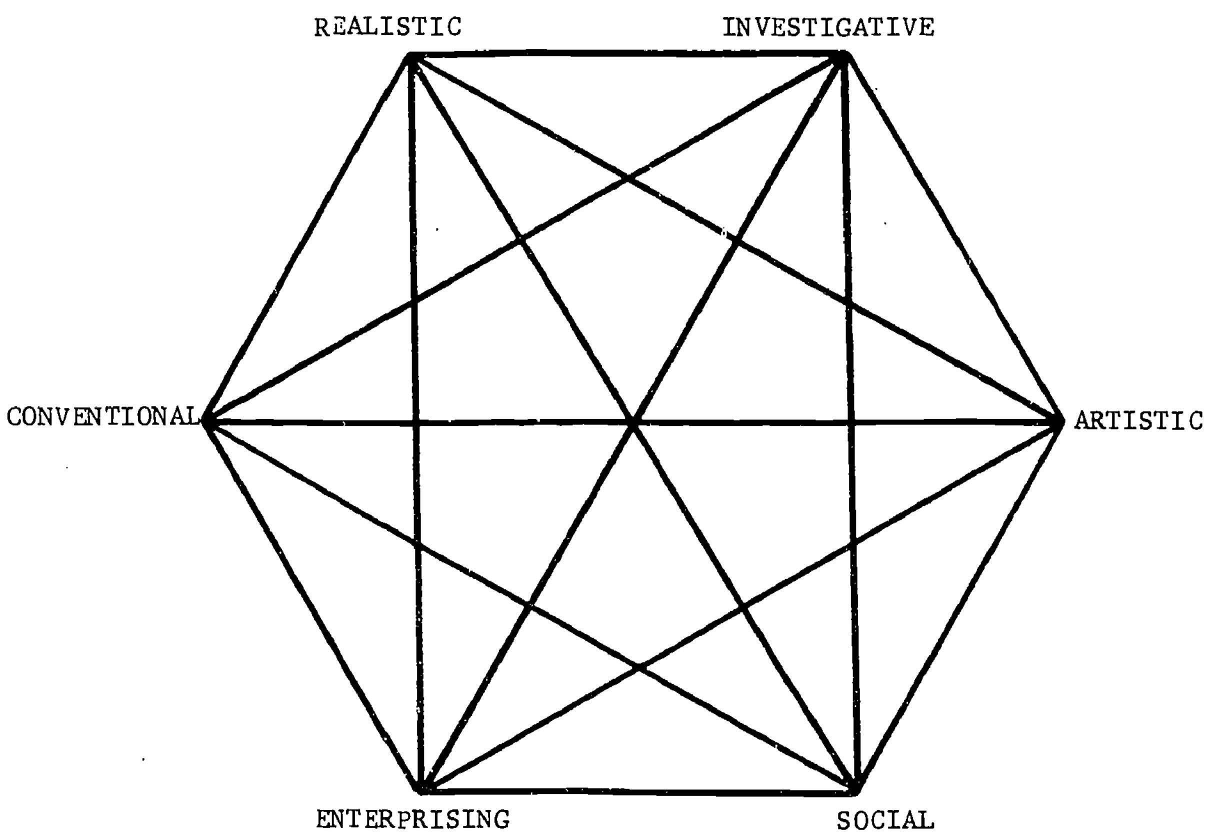

TABLE 5

Relation of Holland Category of 1966 Job to
Holland Category of 1967 Job for White Males, Age 14 through 17

Holland Category for 1966 Occupation	Holland Category for 1967 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	749	6	6	14	40	38	28	853
Investigative	2	0	0	0	0	0	1	2
Artistic	5	0	9	0	1	1	0	16
Social	28	0	1	16	0	3	2	48
Enterprising	57	1	1	0	60	7	3	126
Conventional	15	0	0	1	1	11	1	28
Other[a]	165	1	2	10	11	11	214	
Total	856	7	17	31	102	60		1073

[a]occupation not reported or unemployed.

TABLE 6

Relation of Holland Category of 1967 Job to

Holland Category of 1968 Job for White Males, Age 14 through 17

Holland Category for 1967 Occupation	Holland Category for 1968 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	757	15	8	14	32	30	56	856
Investigative	5	2	0	0	0	0	2	7
Artistic	6	0	9	1	1	0	1	17
Social	16	0	0	11	1	3	7	31
Enterprising	55	0	2	2	36	7	8	102
Conventional	34	1	0	1	4	20	2	60
Other[a]	108	0	4	7	8	5	241	
Total	873	18	19	29	74	60		1073

[a]occupation not reported or unemployed.

TABLE 7

CATANOVA of Transitions for Younger Whites, 1966-1967

Source	SS	R^2	C
Between Categories	31.12	.166	887.47*
Within Categories	156.81		
Total	187.93		

*p < .001; d.f. = 25

TABLE 8

CATANOVA of Transitions for Younger Whites, 1967-1968

Source	SS	R^2	C
Between Categories	22.44	.127	681.87*
Within Categories	153.98		
Total	176.42		

*p < .001; d.f. = 25

TABLE 9

Markov Chain of Holland Occupational Classification

for White Males, Age 14 through 17

Initial Probability Vector	
Realistic (R)	.795
Investigative (I)	.002
Artistic (A)	.015
Social (S)	.045
Enterprising (E)	.117
Conventional (C)	.026

Stationary Transition Matrix

	R	I	A	S	E	C
R	.88	.01	.01	.02	.04	.04
I	.78	.22	.00	.00	.00	.00
A	.33	.00	.55	.03	.06	.03
S	.56	.00	.01	.34	.01	.08
E	.49	.00	.01	.01	.42	.06
C	.56	.01	.00	.02	.06	.35

Stationarity Hypothesis $X^2 = 19.71$, d.f. = 30, $.90 < p < .95$

Order Zero Versus Order One $X^2 = 1454.42$, d.f. = 25, $p < .001$

Order One Versus Order Two $X^2 = 137.16$, d.f. = 150, $.75 < p < .90$

Second Power of Transition Matrix

	R	I	A	S	E	C
R	.84	.01	.01	.02	.06	.05
I	.86	.06	.01	.01	.03	.03
A	.54	.00	.30	.03	.08	.05
S	.73	.01	.02	.13	.04	.08
E	.69	.01	.02	.02	.20	.07
C	.74	.01	.01	.03	.07	.15

TABLE 9 (Continued)

Third Power of Transition Matrix

	R	I	A	S	E	C
R	.82	.01	.01	.02	.06	.06
I	.84	.02	.01	.02	.05	.05
A	.66	.01	.17	.03	.08	.05
S	.79	.01	.02	.06	.05	.07
E	.76	.01	.02	.02	.12	.07
C	.79	.01	.01	.02	.07	.09

Fourth Power of Transition Matrix

	R	I	A	S	E	C
R	.82	.01	.02	.02	.07	.06
I	.83	.02	.01	.02	.06	.06
A	.73	.01	.10	.03	.07	.06
S	.81	.01	.02	.04	.06	.06
E	.79	.01	.02	.02	.09	.06
C	.81	.01	.01	.02	.07	.07

Fifth Power of Transition Matrix

	R	I	A	S	E	C
R	.82	.01	.02	.02	.07	.06
I	.82	.01	.02	.02	.06	.06
A	.77	.01	.06	.03	.07	.06
S	.81	.01	.02	.03	.07	.06
E	.81	.01	.02	.02	.07	.06
C	.81	.01	.01	.02	.07	.06

Limiting Probability Vector
(Equilibrium at Seventh Power)

R	I	A	S	E	C
.81	.01	.02	.02	.07	.06

Note. - Maximum likelihood categories are denoted by underscoring.

TABLE 10

Relation of Holland Category of 1966 Job to
Holland Category of 1967 Job for Black Males, Age 14 through 17

Holland Category for 1966 Occupation	Holland Category For 1967 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	385	1	1	7	5	11	14	410
Investigative	0	0	0	0	0	0	0	0
Artistic	1	0	2	0	0	0	0	3
Social	12	1	0	4	0	0	0	17
Enterprising	10	0	0	0	11	1	0	22
Conventional	11	0	0	1	0	6	0	18
Other[a]	101	0	0	3	2	4	97	
Total	419	2	3	12	16	18		470

[a]occupation not reported or unemployed.

TABLE 11

Relation of Holland Category of 1967 Job to
Holland Category of 1968 Job for Black Males, Age 14 through 17

Holland Category For 1967 Occupation	Holland Category for 1968 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	368	2	0	16	5	28	37	419
Investigative	1	1	0	0	0	0	0	2
Artistic	0	0	3	0	0	0	0	3
Social	8	0	0	2	0	2	0	12
Enterprising	9	0	0	0	6	1	2	16
Conventional	10	0	0	2	0	6	1	18
Other[a]	45	0	1	2	1	4	128	
Total	396	3	3	20	11	37		470

[a]occupation not reported or unemployed.

TABLE 12

CATANOVA of Transitions for Younger Blacks, 1966-1967

Source	SS	R^2	C
Between Categories	8.46	.178	417.41*
Within Categories	38.99		
Total	47.45		

*$p < .001$; d.f. = 20

TABLE 13

CATANOVA of Transitions for Younger Blacks, 1967-1968

Source	SS	R^2	C
Between Categories	6.61	.100	234.01*
Within Categories	59.54		
Total	66.14		

*$p < .001$; d.f. = 25

TABLE 14

Markov Chain of Holland Occupational Classification

for Black Males, Age 14 through 17

Initial Probability Vector	
Realistic (R)	.872
Investigative (I)	.000
Artistic (A)	.006
Social (S)	.036
Enterprising (E)	.047
Conventional (C)	.038

Stationary Transition Matrix

	R	I	A	S	E	C
R	.91	.00	.00	.03	.01	.05
I	.50	.50	.00	.00	.00	.00
A	.17	.00	.83	.00	.00	.00
S	.69	.03	.00	.21	.00	.07
E	.50	.00	.00	.00	.45	.05
C	.58	.00	.00	.08	.00	.33

Stationarity Hypothesis $X^2 = 18.96$, d.f. = 30, $.95 < p < .975$

Order Zero Versus Order One $X^2 = 1081.53$, d.f. = 25, $p < .001$

Order One Versus Order Two $X^2 = 78.47$, d.f. = 150, $.99 < p < 1.0$

Second Power of Transition Matrix

	R	I	A	S	E	C
R	.88	.01	.00	.04	.02	.06
I	.70	.25	.00	.01	.01	.02
A	.29	.00	.69	.00	.00	.01
S	.83	.03	.00	.07	.01	.07
E	.71	.00	.00	.02	.21	.06
C	.78	.01	.00	.06	.01	.14

TABLE 14 (Continued)

Third Power of Transition Matrix

	R	I	A	S	E	C
R	.87	.01	.00	.04	.02	.06
I	.79	.13	.00	.02	.01	.04
A	.39	.00	.58	.01	.00	.02
S	.86	.02	.00	.04	.01	.07
E	.80	.00	.00	.03	.10	.07
C	.84	.01	.00	.05	.01	.09

Fourth Power of Transition Matrix

	R	I	A	S	E	C
R	.87	.01	.00	.04	.02	.07
I	.83	.07	.00	.03	.01	.05
A	.47	.00	.48	.01	.01	.02
S	.86	.01	.00	.04	.02	.07
E	.84	.01	.00	.03	.05	.07
C	.86	.01	.00	.04	.02	.07

Fifth Power of Transition Matrix

	R	I	A	S	E	C
R	.87	.01	.00	.04	.02	.07
I	.85	.04	.00	.03	.02	.06
A	.54	.00	.40	.02	.01	.03
S	.86	.01	.00	.04	.02	.07
E	.85	.01	.00	.04	.03	.07
C	.86	.01	.00	.04	.02	.07

TABLE 14 (Continued)

Tenth Power of Transition Matrix

	R	I	A	S	E	C
R	.86	.01	.00	.04	.02	.07
I	.86	.01	.00	.04	.02	.07
A	.73	.01	.16	.03	.01	.05
S	.86	.01	.00	.04	.02	.07
E	.86	.01	.00	.04	.02	.07
C	.86	.01	.00	.04	.02	.07

Limiting Probability Vector
(Equilibrium at Twenty Seventh Power)

R	I	A	S	E	C
.86	.01	.01	.04	.02	.07

Note. - Maximum likelihood categories are denoted by underscoring.

TABLE 15

Relation of Holland Category of 1966 Job to
Holland Category of 1967 Job for White Males, Age 18 through 24

Holland Category For 1966 Occupation	Holland Category For 1967 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	822	32	8	27	60	30	51	979
Investigative	27	62	1	6	4	5	7	105
Artistic	4	4	15	1	3	5	1	32
Social	13	6	0	53	6	0	3	78
Enterprising	30	4	1	5	96	12	6	148
Conventional	21	4	2	6	14	58	5	105
Other[a]	8	0	0	0	2	12	53	
Total	917	112	27	98	183	110		1447

[a]occupation not reported or unemployed.

TABLE 16

Relation of Holland Category of 1967 Job to
Holland Category of 1968 Job for White Males, Age 18 through 24

Holland Category For 1967 Occupation	Holland Category For 1968 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	765	35	8	14	65	30	32	917
Investigative	23	69	1	6	9	4	6	112
Artistic	6	3	14	2	2	0	0	27
Social	9	6	3	69	7	4	1	98
Enterprising	31	2	2	6	124	18	1	183
Conventional	19	6	2	5	20	58	4	110
Other[a]	40	9	0	6	7	6	36	
Total	853	121	30	102	227	114		1447

[a]occupation not reported or unemployed.

TABLE 17

CATANOVA of Transitions for Older Whites, 1966-1967

Source	SS	R^2	C
Between Categories	134.48	.329	2375.60*
Within Categories	274.80		
Total	409.28		

*$p < .001$; d.f. = 25

TABLE 18

CATANOVA of Transitions for Older Whites, 1967-1968

Source	SS	R^2	C
Between Categories	158.80	.360	2604.51*
Within Categories	282.02		
Total	440.82		

*$p < .001$; d.f. = 25

TABLE 19

Markov Chain of Holland Occupational Classification

for White Males, Age 18 through 24

Initial Probability Vector

Realistic (R)	.677
Investigative (I)	.073
Artistic (A)	.022
Social (S)	.054
Enterprising (E)	.102
Conventional (C)	.073

Stationary Transition Matrix

	R	I	A	S	E	C
R	.84	.04	.01	.02	.07	.03
I	.23	.60	.01	.06	.06	.04
A	.17	.12	.49	.05	.08	.08
S	.13	.07	.02	.69	.07	.02
E	.18	.02	.01	.03	.66	.09
C	.19	.05	.02	.05	.16	.54

Stationarity Hypothesis $X^2 = 24.17$, d.f. = 30, $.75 < p < .90$

Order Zero Versus Order One $X^2 = 4398.10$, d.f. = 25, $p < .001$

Order One Versus Order Two $X^2 = 307.15$, d.f. = 150, $p < .01$

Second Power of Transition Matrix

	R	I	A	S	E	C
R	.73	.06	.01	.04	.11	.05
I	.36	.38	.01	.08	.10	.06
A	.29	.15	.25	.08	.13	.11
S	.23	.10	.02	.49	.12	.04
E	.30	.04	.01	.05	.47	.12
C	.31	.07	.02	.08	.21	.32

TABLE 19 (Continued)

Third Power of Transition Matrix

	R	I	A	S	E	C
R	.66	.07	.02	.05	.14	.07
I	.43	.25	.02	.09	.13	.07
A	.37	.14	.13	.09	.16	.11
S	.31	.11	.02	.36	.14	.06
E	.38	.05	.02	.07	.36	.12
C	.38	.08	.02	.09	.22	.21

Fourth Power of Transition Matrix

	R	I	A	S	E	C
R	.62	.08	.02	.06	.15	.07
I	.47	.18	.02	.10	.15	.08
A	.43	.13	.07	.10	.17	.10
S	.37	.11	.02	.27	.16	.07
E	.43	.06	.02	.08	.29	.12
C	.43	.08	.02	.09	.22	.15

Fifth Power of Transition Matrix

	R	I	A	S	E	C
R	.59	.08	.02	.07	.17	.08
I	.49	.14	.02	.10	.16	.08
A	.46	.12	.05	.10	.18	.10
S	.41	.11	.02	.21	.17	.08
E	.46	.07	.02	.08	.25	.11
C	.47	.09	.02	.09	.21	.12

TABLE 19 (Continued)

Tenth Power of Transition Matrix

	R	I	A	S	E	C
R	.53	.09	.02	.09	.18	.09
I	.52	.09	.02	.09	.18	.09
A	.52	.09	.02	.09	.19	.09
S	.51	.09	.02	.11	.19	.09
E	.52	.09	.02	.09	.19	.09
C	.52	.09	.02	.09	.19	.09

Limiting Probability Vector
(Equilibrium at Thirteenth Power)

R	I	A	S	E	C
.53	.09	.02	.09	.19	.09

Note. - Maximum likelihood categories are denoted by underscoring.

TABLE 20

Relation of Holland Category of 1966 Job to
Holland Category of 1967 Job for Black Males, Age 18 through 24

Holland Category For 1966 Occupation	Holland Category For 1967 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	345	1	0	12	6	9	20	373
Investigative	1	2	0	0	0	0	0	3
Artistic	2	0	2	0	0	0	0	4
Social	6	0	0	9	0	2	1	17
Enterprising	2	0	1	2	2	0	0	7
Conventional	10	2	0	0	0	12	0	24
Other[a]	10	0	0	2	1	0	11	
Total	366	5	3	23	8	23		428

[a]occupation not reported or unemployed.

TABLE 21

Relation of Holland Category of 1967 Job to

Holland Category of 1968 Job for Black Males, Age 18 through 24

Holland Category For 1967 Occupation	Holland Category For 1968 Occupation						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	345	0	0	6	6	9	7	366
Investigative	0	3	0	0	0	2	0	5
Artistic	0	2	0	1	0	0	0	3
Social	8	0	2	12	0	1	0	23
Enterprising	5	0	0	0	3	0	0	8
Conventional	10	0	0	3	0	10	2	23
Other[a]	18	2	0	0	0	0	16	
Total	368	5	2	22	9	22		428

[a]occupation not reported or unemployed.

TABLE 22

CATANOVA of Transition. . Older Blacks, 1966-1967

Source	SS	R^2	C
Between Categories	13.55	.241	515.07*
Within Categories	42.61		
Total	56.16		

*p< .001; d.f. = 25

TABLE 23

CATANOVA of Transitions for Older Blacks, 1967-1968

Source	SS	R^2	C
Between Categories	16.78	.308	656.87*
Within Categories	37.76		
Total	54.54		

*p< .001; d.f. = 25

TABLE 24

Markov Chain of Holland Occupational Classification

for Black Males, Age 18 through 24

Initial Probability Vector

Realistic (R)	.871
Investigative (I)	.007
Artistic (A)	.009
Social (S)	.040
Enterprising (E)	.016
Conventional (C)	.056

Stationary Transition Matrix

	R	I	A	S	E	C
R	.93	.00	.00	.02	.02	.02
I	.13	.63	.00	.00	.00	.25
A	.29	.29	.29	.14	.00	.00
S	.35	.00	.05	.52	.00	.08
E	.47	.00	.07	.13	.33	.00
C	.43	.04	.00	.06	.00	.47

Stationarity Hypothesis $X^2 = 24.61$, d.f. = 30, $.50 < p < .75$

Order Zero Versus Order One $X^2 = 907.02$, d.f. = 25, $p < .001$

Order One Versus Order Two $X^2 = 55.84$, d.f. = 150, $.99 < p < 1.0$

Second Power of Transition Matrix

	R	I	A	S	E	C
R	.90	.00	.00	.04	.02	.04
I	.30	.40	.00	.02	.00	.28
A	.43	.26	.09	.12	.00	.09
S	.56	.02	.04	.30	.01	.08
E	.66	.02	.05	.13	.12	.02
C	.63	.05	.00	.07	.01	.24

TABLE 24 (Continued)

Third Power of Transition Matrix

	R	I	A	S	E	C
R	.88	.00	.00	.05	.02	.04
I	.46	.26	.00	.04	.01	.24
A	.55	.19	.03	.09	.01	.13
S	.68	.03	.03	.18	.01	.08
E	.74	.03	.03	.11	.05	.04
C	.72	.04	.01	.07	.01	.15

Fourth Power of Transition Matrix

	R		A	S	E	C
R	.87	.01	.00	.05	.02	.04
I	.58	.18	.00	.05	.01	.19
A	.64	.14	.01	.08	.01	.13
S	.74	.03	.02	.12	.01	.07
E	.78	.03	.02	.09	.03	.05
C	.78	.03	.01	.07	.02	.10

Fifth Power of Transition Matrix

	R	I	A	S	E	C
R	.86	.01	.01	.05	.02	.05
I	.66	.12	.00	.05	.01	.15
A	.70	.09	.01	.07	.01	.11
S	.78	.03	.01	.09	.02	.07
E	.81	.03	.01	.08	.02	.06
C	.80	.03	.01	.06	.02	.08

TABLE 24 (Continued)

Tenth Power of Transition Matrix

	R	I	A	S	E	C
R	<u>.84</u>	.01	.01	.06	.02	.05
I	<u>.82</u>	.03	.01	.06	.02	.07
A	<u>.83</u>	.02	.01	.06	.02	.06
S	<u>.84</u>	.02	.01	.06	.02	.06
E	<u>.84</u>	.02	.01	.06	.02	.05
C	<u>.84</u>	.02	.01	.06	.02	.05

Limiting Probability Vector
(Equilibrium at Eleventh Power)

R	I	A	S	E	C
<u>.84</u>	.01	.01	.06	.02	.05

Note. - Maximum likelihood categories are denoted by underscoring.

TABLE 25

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After One Year for White Males

Category of First Full Time Job	Category of Job After One Year						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	447 (409.08)	7 (19.48)	1 (4.87)	6 (9.74)	9 (34.09)	17 (14.61)	84	487
Investigative	2 (11.27)	46 (29.40)	0 (0.49)	0 (2.94)	1 (2.94)	0 (1.96)	4	49
Artistic	0 (0.68)	0 (0.48)	2 (1.96)	0 (0.20)	2 (0.32)	0 (0.32)	2	4
Social	1 (5.33)	0 (2.87)	0 (0.82)	38 (28.29)	1 (2.87)	1 (0.82)	2	41
Enterprising	3 (11.34)	2 (1.26)	0 (0.63)	1 (1.89)	55 (41.58)	2 (5.67)	9	63
Conventional	4 (9.50)	0 (2.50)	0 (1.00)	1 (2.50)	3 (8.00)	42 (27.00)	5	50
Other[a]	2	0	0	0	0	0	20	
Total	45[illegible]	55	3	46	71	62		694

Note. - For goodness of fit test, $X^2 = 114.21$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 25 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Two Years for White Males

Category of First Full Time Job	Category of Job After Two Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	400 (329.96)	7 (27.12)	1 (4.52)	6 (18.08)	18 (49.72)	20 (22.60)	119	452
Investigative	4 (17.28)	39 (18.24)	1 (0.48)	2 (3.84)	1 (4.80)	1 (2.88)	5	48
Artistic	1 (1.16)	0 (0.60)	2 (1.00)	0 (0.32)	1 (0.52)	0 (0.44)	2	4
Social	1 (8.51)	1 (3.70)	0 (0.74)	33 (18.13)	1 (4.44)	1 (1.48)	6	37
Enterprising	5 (17.10)	2 (2.28)	1 (0.57)	1 (2.85)	44 (26.79)	4 (6.84)	15	57
Conventional	8 (14.88)	0 (3.36)	1 (0.96)	4 (3.84)	4 (10.08)	31 (15.36)	7	48
Other[a]	2	0	0	0	0	0	20	
Total	419	49	6	46	69	57		646

Note. - For goodness of fit test, $X^2 = 176.34$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 25 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Three Years for White Males

Category of First Full Time Job	Category of Job After Three Years							
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional	Other[a]	Total
Realistic	361 (282.48)	7 (29.96)	4 (8.56)	7 (21.40)	28 (59.92)	21 (29.96)	143	428
Investigative	4 (19.78)	36 (11.50)	1 (0.92)	1 (4.14)	3 (5.98)	1 (3.22)	7	46
Artistic	1 (1.11)	0 (0.42)	2 (0.39)	0 ([illegible].27)	0 (0.48)	0 (0.33)	3	3
Social	0 (12.09)	2 (4.29)	0 (0.78)	33 (14.04)	[illegible] (5.46)	2 (2.34)	4	39
Enterprising	7 (22.04)	3 (2.90)	1 (1.16)	1 (4.06)	41 (20.88)	5 (6.96)	14	58
Conventional	8 (18.24)	1 (3.84)	1 (0.96)	4 (4.32)	[illegible] (10.56)	28 (10.08)	7	48
Other[a]	2	0	0	0	0	0	20	
Total	381	49	9	46	80	57		622

Note. - For goodness of fit test, $X^2 = 265.14$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 25 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Four Years for White Males

Category of First Full Time Job	Category of Job After Four Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	344 (259.16)	12 (33.44)	3 (8.36)	9 (25.08)	34 (62.70)	16 (29.26)	153	418
Investigative	7 (21.15)	32 (8.10)	1 (0.90)	2 (4.50)	2 (6.75)	1 (3.60)	8	45
Artistic	1 (1.29)	0 (0.39)	2 (0.21)	0 (0.30)	0 (0.51)	0 (0.30)	3	3
Social	1 (12.95)	1 (3.85)	0 (0.70)	29 (9.45)	2 (5.60)	2 (2.45)	8	35
Enterprising	7 (23.22)	3 (3.24)	1 (1.08)	1 (4.32)	39 (15.66)	3 (6.48)	18	54
Conventional	10 (20.21)	1 (3.76)	2 (0.94)	4 (4.23)	4 (10.34)	26 (7.05	8	47
Other[a]	3	0	0	0	0	0	19	
Total	370	49	9	45	81	48		602

Note. - For goodness of fit test, $\chi^2 = 348.30$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 25 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Five Years for White Males

Category of First Full Time Job	Category of Job After Five Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	352 (267.27)	17 (36.24)	5 (9.[illegible])	12 (31.71)	47 (77.01)	20 (36.24)	118	453
Investigative	9 (22.05)	31 (6.30)	1 (0.90)	1 (4.50)	2 (7.20)	1 (3.60)	8	45
Artistic	1 (1.38)	0 (0.36)	2 (0.15)	0 (0.30)	0 (0.54)	0 (0.30)	3	3
Social	2 (14.76)	2 (3.96)	0 (0.72)	27 (7.56)	2 (6.12)	3 (2.88)	7	36
Enterprising	11 (27.14)	3 (4.13)	0 (1.18)	0 (4.72)	43 (14.75)	2 (6.49)	13	59
Conventional	11 (22.56)	0 (4.32)	1 (0.96)	3 (4.32)	7 (10.08)	26 (5.76)	7	48
Other[a]	2	0	0	0	0	0	20	
Total	386	53	9	43	101	52		644

Note. - For goodness of fit test, $X^2 = 428.69$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a] occupation not reported or unemployed.

TABLE 25 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Ten Years for White Males

Category of First Full Time Job	Category of Job After Ten Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	375 (259.70)	20 (44.10)	8 (9.80)	11 (44.10)	59 (88.20)	17 (44.10)	81	490
Investigative	6 (15.08)	15 (2.61)	2 (0.58)	1 (2.61)	5 (5.22)	0 (2.61)	24	29
Artistic	0 (1.04)	0 (0.18)	0 (0.04)	0 (0.18)	2 (0.38)	0 (0.18)	4	2
Social	2 (7.65)	0 (1.35)	0 (0.30)	11 (1.65)	1 (2.85)	1 (1.35)	28	15
Enterprising	7 (30.16)	3 (5.22)	0 (1.16)	2 (5.22)	41 (11.02)	5 (5.22)	14	58
Conventional	8 (22.36)	2 (3.87)	0 (0.86)	6 (3.87)	12 (8.17)	15 (3.87)	12	43
Other[a]	5	1	0	0	0	0	16	
Total	398	40	10	31	120	38		637

Note. - For goodness of fit test, $\chi^2 = 405.26$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 26

Comparison of Efficiency for Two Predictive Strategies

Time Interval	Percent maintaining initial occupational code	Percent correctly classified from maximum likelihood principle	N
	White Men		
One Year	90.8	90.8	694
Two Years	85.0	84.8	646
Three Years	80.5	66.6	622
Four Years	78.4	61.5	602
Five Years	74.7	59.9	644
Ten Years	71.7	62.5	637
	Black Men		
One Year	95.8	93.9	624
Two Years	91.4	87.4	580
Three Years	89.2	85.3	563
Four Years	88.2	85.4	575
Five Years	86.1	84.3	581
Ten Years	84.3	84.8	585

TABLE 27

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After One Year for Black Males

Category of First Full Time Job	Category of Job After One Year						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	533 (504.99)	1 (0.0)	0 (0.0)	2 (10.86)	3 (10.86)	4 (10.86)	76	543
Investigative	0 (0.91)	7 (4.41)	0 (0.0)	0 (0.0)	0 (0.0)	0 (1.75)	0	7
Artistic	1 (0.58)	0 (0.58)	1 (0.58)	0 (0.28)	0 (0.0)	0 (0.0)	0	2
Social	4 (10.50)	0 (0.0)	0 (1.50)	25 (15.60)	1 (0.0)	0 (2.4)	4	30
Enterprising	2 (7.52)	0 (0.0)	0 (1.12)	0 (2.08)	14 (5.28)	0 (0.0)	2	16
Conventional	4 (11.18)	0 (1.04)	0 (0.0)	2 (1.56)	2 (0.0)	18 (12.22)	1	26
Other[a]	1	0	0	0	0	0	30	
Total	544	8	1	29	20	22		624

Note. - For goodness of fit test, $X^2 = 72.20$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a] occupation not reported or unemployed.

TABLE 27 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Two Years for Black Males

Category of First Full Time Job	Category of Job After Two Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	484 (456.30)	1 (0.0)	0 (0.[illegible]	5 (20.28)	8 (10.14)	9 (20.28)	112	507
Investigative	0 (1.80)	6 (2.40)	0 (0.0)	0 (1.20)	0 (0.0)	0 (1.68)	1	6
Artistic	2 (0.86)	0 (0.52)	0 (0.18)	0 (0.24)	0 (0.0)	0 (0.18)	0	2
Social	6 (15.12)	0 (0.54)	0 (1.08)	18 (8.10)	1 (0.27)	2 (2.16)	7	27
Enterprising	2 (3.58)	0 (0.26)	0 (0.65)	1 (1.69)	10 (1.56)	0 (0.26)	5	13
Conventional	7 (15.75)	0 (1.25)	0 (0.0)	[illegible] (1.75)	3 (0.25)	12 (6.00)	2	25
Other[a]	1	0	0	0	0	0	30	
Total	501	7	0	27	22	23		580

Note. - For goodness of fit test, $X^2 = 149.17$, d.f. 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 27 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Three Years for Black Males

Category of First Full Time Job	Category of Job After Three Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	464 (434.72)	1 (0.0)	2 (0.0)	6 (24.70)	10 (9.88)	11 (19.76)	125	494
Investigative	0 (2.76)	6 (1.56)	0 (0.0)	0 (0.24)	0 (0.06)	0 (1.44)	1	6
Artistic	1 (1.10)	0 (0.38)	1 (0.06)	0 (0.18)	0 (0.02)	0 (0.26)	0	2
Social	8 (18.36)	0 (0.81)	1 (0.81)	15 (4.86)	1 (0.27)	2 (2.16)	7	27
Enterprising	2 (8.14)	0 (0.33)	0 (0.33)	2 (1.21)	6 (0.55)	1 (0.44)	7	11
Conventional	5 (16.56)	2 (0.92)	0 (0.23)	2 (1.61)	4 (0.23)	10 (3.45)	4	23
Other[a]	2	0	0	0	0	0	29	
Total	480	9	4	25	21	24		563

Note. - For goodness of fit test, $X^2 = 229.99$, d.f. = 29, $p < .01$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 27 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Four Years for Black Males

Category of First Full Time Job	Category of Job After Four Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	471 (438.48)	1 (5.04)	1 (0.0)	7 (25.20)	12 (10.08)	12 (25.20)	115	504
Investigative	0 (4.06)	7 (1.26)	0 (0.0)	0 (0.35)	0 (0.07)	0 (1.33)	0	7
Artistic	0 (1.28)	0 (0.28)	2 (0.02)	0 (0.16)	0 (0.02)	0 (0.26)	0	2
Social	10 (19.98)	0 (0.81)	1 (0.54)	12 (3.24)	2 (0.27)	2 (1.89)	7	27
Enterprising	3 (8.58)	0 (0.33)	0 (0.22)	2 (0.99)	5 (0.33)	1 (0.55)	7	11
Conventional	7 (18.72)	2 (0.72)	0 (0.24)	2 (1.68)	3 (0.48)	10 (2.40)	3	24
Other[a]	2	0	0	0	1	0	28	
Total	491	10	4	23	22	25		575

Note. - For goodness of fit test, $X^2 = 416.89$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a] Occupation not reported or unemployed.

TABLE 27 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Five Years for Black Males

Category of First Full Time Job	Category of Job After Five Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	468 (438.60)	1 (5.10)	1 (5.10)	8 (25.50)	13 (10.20)	19 (25.50)	109	510
Investigative	0 (2.64)	4 (0.48)	0 (0.0)	0 (0.20)	0 (0.04)	0 (0.60)	3	4
Artistic	1 (1.40)	0 (0.18)	1 (0.02)	0 (0.14)	0 (0.02)	0 (0.22)	0	2
Social	9 (22.62)	2 (0.87)	0 (0.29)	13 (2.61)	1 (0.58)	4 (2.03)	5	29
Enterprising	4 (9.72)	0 (0.36)	0 (0.12)	2 (0.96)	5 (0.24)	1 (0.72)	6	12
Conventional	8 (19.20)	2 (0.72)	0 (0.24)	3 (1.44)	2 (0.48)	9 (1.92)	3	24
Other[a]	2	0	0	0	0	0	29	
Total	490	9	2	26	21	33		581

Note. - For goodness of fit test, $X^2 = 295.67$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.

TABLE 27 (Continued)

Comparison of Predicted Transitions with Actual Transitions of the Validation Sample After Ten Years for Black Males

Category of First Full Time Job	Category of Job After Ten Years						Other[a]	Total
	Realistic	Investigative	Artistic	Social	Enterprising	Conventional		
Realistic	476 (445.20)	1 (5.30)	4 (5.30)	9 (31.80)	21 (10.[illegible])	19 (26.50)	89	530
Investigative	1 (2.46)	1 (0.09)	0 (0.03)	0 (0.18)	0 (0.06)	1 (0.[illegible]1)	4	3
Artistic	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.[illegible])	0 (0.0)	2	0
Social	7 (16.80)	2 (0.40)	0 (0.20)	5 (1.20)	3 (0.40)	3 (1.20)	14	20
Enterprising	7 (10.08)	0 (0.24)	0 (0.12)	0 (0.72)	3 (0.24)	2 (0.60)	6	12
Conventional	5 (16.80)	1 (0.40)	0 (0.20)	3 (1.20)	3 (0.40)	8 (1.00)	7	20
Other[a]	5	0	0	1	1	0	24	
Total	496	5	4	17	30	33		585

Note. - For goodness of fit test, $X^2 = 206.89$, d.f. = 29, $p < .001$. Predicted frequencies are given in parentheses.

[a]occupation not reported or unemployed.