MEASURING THE PERCEIVED RELATION BETWEEN JOBS AND SALARIES USING RELATIVE JUDGMENT THEORY

by

© JOHN CHRISTOPHER SNOW, B.A.

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfillment of the Requirements

for the Degree

Master of Arts

McMaster University

June 1981

MEASURING THE PERCEIVED RELATION BETWEEN JOBS AND SALARIES

MASTER OF ARTS (1981) MCMASTER UNIVERSITY

(Psychology) Hamilton, Ontario

TITLE: Measuring the Perceived Relation Between Jobs and Salaries Using Relative Judgment Theory

AUTHOR: John Christopher Snow, B.A. (Waterloo)

SUPERVISOR: Dr. S.W. Link

NUMBER OF PAGES:

Abstract

Thurstone's law of comparative judgment and a recent extension of his model, relative judgment theory were employed separately in two experiments to obtain scale values for a number of occupations. While Thurstone's theory uses only the probability of the subjects' judgments, relative judgment theory, which is based on a sequential random walk process provides further predictions concerning the latency probability function. In making judgments, a subject tends to take more time to respond when the value of the stimulus is close to a mental referent which the subject has adopted. The random walk model gives scale values in good agreement with the previous Thurstonian techniques. In addition, the fit of the data to the model for the predicted linear relationship between a function of response probability and response time was very close.

Acknowledgements

I would like to thank Steve Link for his advice and interest in the development of this thesis and for his invitation to work on this problem in the first place. I would also like to thank the members of my committee, Ian Begg and Richard Bourhis, for their comments and suggestions.

Finally, I would like to thank Jan Nicholson for her help in editing the original drafts, and my father for his encouragment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

This study is designed to investigate the use of relative judgment theory (Link, 1975) in determining scale values for subjective variables, such as occupations and income, which, prior to scaling, can be characterized at best by an ordinal metric. According to Torgerson (1958), measurement "concerns the process and rationale involved in the construction of a scale or measuring device and the properties that can be ascribed to it". He states further that it is not objects that we measure, but rather the properties of objects. On the other hand, "scaling is the actual process of assigning numbers to these properties" (Coombs, Dawes, & Tversky, 1970).

The main objective of the study is to apply relative judgment theory and Thurstone's (1927a) law of comparative judgment to the problem of measurement of social values. Relative judgment theory is an extension of Thurstone's theory and should provide a similar set of numerical scale values. The newer theory assumes that information about stimuli in a discrimination task is sequentially accumulated. This time-based process allows the theory to make predictions about the relations between response probability and response time. Consequently, relative judgment theory is a more complete theoretical model in that it can account for more performance measures available from discrimination studies than its Thurstonian predecessor.

While the problem of linking mental sensations with the physical world has long been of interest to behavioral scientists, the history of psychophysical measurement began with the work of Fechner and Weber in the mid 1800's. The problem as they saw it was to discover the relationship between subjective experience and the magnitude of the physical events that corresponded to this mental experience.

An earlier influence was Herbart's work in 1816 (Miller, 1964) which outlined a mathematical treatment of the concept of a "threshold of consciousness." A few years later, Weber's studies led to a mathematical relation that was based on the smallest noticeable change in stimulation (the just noticeable difference, or jnd). Weber's Law stated that "the just noticeable increase of a stimulus is a constant fraction from the stimulus." (Thurstone, 1959). Fechner later used this relation as the basis for his work in the budding science of psychophysics. In his 1860 monograph, Elemente der Psychophysik, (Miller, 1964) he outlined what we know as Fechner's Law, namely that sensation was a logarithmic function of the stimulus intensity.

Fechner's formulation was based on very extensive empirical investigations. In part of his experimental work Fechner used the method of comparing a stimulus weight in one hand to a standard weight in the other hand for a wide range of stimuli and standards. In a study reported in 1894, Cohn (Enger, 1971) used a modification of Fechner's method of comparing pairs of stimuli to measure preference for colours. It was this method of paired comparisons that was later used by Thurstone in his studies.

Thorndike (1910) used the principle of "equally often noticed differences" on the psychological continuum rather than the Fechnerian "just noticeable difference" notion of equality in scaling the excellence of handwriting specimens. In this case, as in Fechner's proposed measurement in aesthetics, there is no obvious physical correlate. Thorndike assumed that the difference in distances (between the scale values of the handwriting samples) was proportional to the difference in the normal deviates corresponding to the two proportions. The idea of "equally often noticed differences" was transformed into the notion that the psychological difference between two stimuli is proportional to the normal deviate transform of the proportion of times the difference is noticed.

Following Thorndike, L.L. Thurstone developed a theoretical framework for the application of traditional psychophysical methods to the problems of psychological scaling. There were a number of psychophysical techniques available at that time, such as the method of constant stimuli and the method of limits, that could be used to measure the subjective response to a physical variable, however, there was no known relevant physical correlate for many psychological variables, such as attitudes, interests and values. Thurstone extended Fechner's method of comparing a stimulus to a standard to find psychological scale values for complex stimuli which had no known physical measure. Using the method of paired-comparisons, he showed that it was possible to obtain internally consistent measurements for various psychological attributes such as "nationalities," relative merits of compositions and preferences for various foods.

The Law of Comparative Judgment

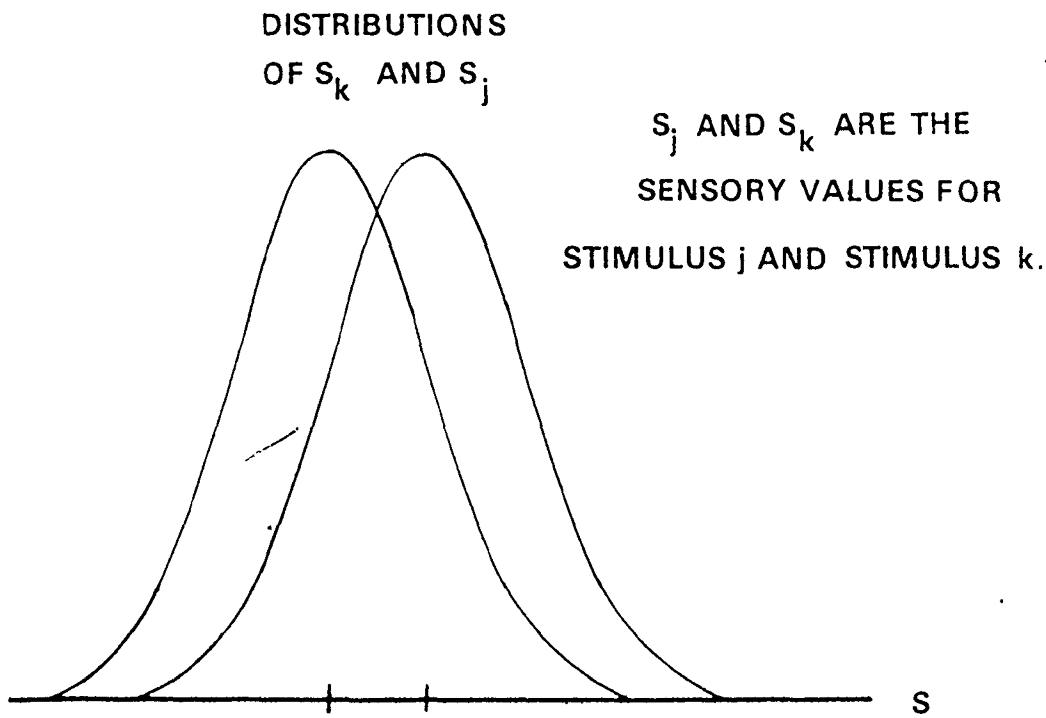
Thurstone formulated the law of comparative judgment (1927a) which was based on the common observation that the greater the difference between two stimuli in some physical magnitude, the more likely one will be judged greater than the other. Hypothetically, each stimulus gives rise to a momentary subjective value which can be described by a random variable normally distributed on the sensory continuum. When two stimuli are compared by a subject, the stimulus whose momentary value is greater is the one which seems larger to the subject. The more the two distributions are separated on the continuum (i.e. the less they overlap), the more frequently will the subject correctly identify the larger stimulus (Bock and Jones, 1968).

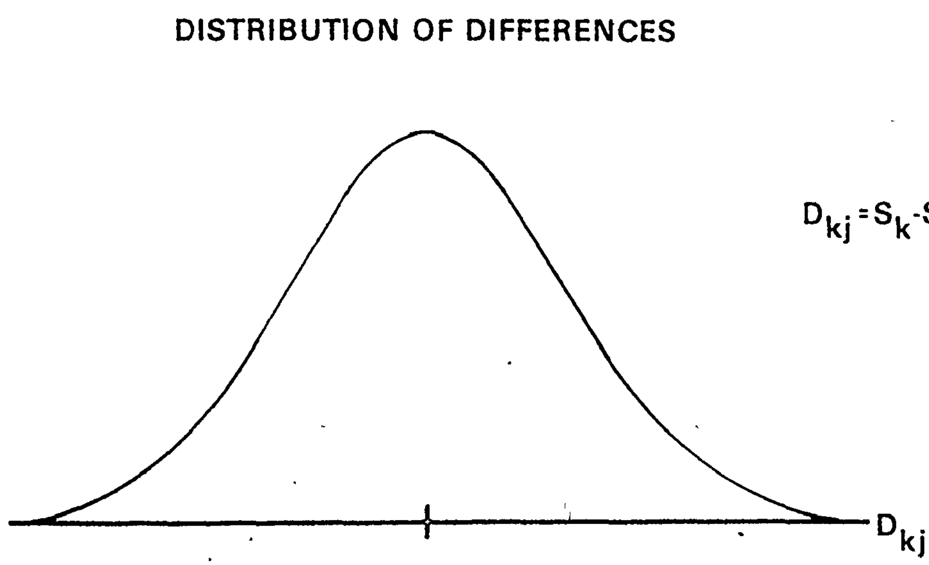
In Thurstone's formulation, each stimulus projects a distribution of stimulus magnitudes called discriminal dispersions onto the sensory scale. Each time a stimulus is presented, it is represented on an internal scale by a point determined by an unknown discriminal dispersion. On repeated trials, this same stimulus S will not always produce the same excitation so that a distribution of values s on the psychological scale is produced. The distribution of s values is assumed to be normal with a scale value (mean) μ and a discriminal dispersion (standard deviation) σ. In modern terms, s is considered a random variable.

If two stimuli S_k and S_j are presented for discrimination, the psychophysical difference between the two is called the discriminal difference. Over repeated trials, the discriminal differences form a normal distribution with mean $\mu_k-\mu_j$ and variance $\sigma_{kj}^2 = \sigma_k^2 + \sigma_j^2-2r_{kj}\sigma_k\sigma_j$ where r_{kj} is the correlation between the discriminal processes associated with j and k (Figure 1).

On each presentation of a pair of stimuli, S_j and S_k, the

Figure 1. A representation of the distributions of sampled values of stimuli S_1 and S_2 and the distribution of the difference S_1-S_2.


DISTRIBUTIONS
OF S_k AND S_j
S_j AND S_k ARE THE
SENSORY VALUES FOR
STIMULUS j AND STIMULUS k.
S


DISTRIBUTION OF DIFFERENCES
$D_{kj} = S_k - S_j$
D_{kj}

subject is asked to judge which of the stimuli is higher on the psychological continuum or which item dominates the other (Coombs, 1964). When the difference ($s_k - s_j$) is positive, the response that S_k is larger than S_j occurs; if the difference is negative, the response S_j is larger than S_k occurs.

From a large number of judgments, either by the same subject or by different subjects, the proportion of times (or probability) that S_k is judged larger than S_j $p(s_k > s_j)$ can be determined.

From the theoretical proportion of times that stimulus S_k is judged greater than stimulus S_j, the difference ($s_k - s_j$) can be determined from the area under the normal curve. This Z-score multiplied by the standard deviation of the difference distribution is a measure of the psychophysical difference between S_k and S_j:

$$Z_{kj} = \frac{s_k - s_j}{\sigma_{kj}}$$

This can be re-written as

$$s_k - s_j = Z_{kj} \; (\sigma_j^2 + \sigma_k^2 - 2r_{kj}\sigma_j\sigma_k)^{1/2}$$

which is Thurstone's complete form for the law of comparative judgment. A modification of this expression called Case V involves the assumptions that the correlation between the discriminal processes is zero (r_{kj} = 0), and the standard deviation of all the distributions is constant $\sigma = \sigma_k = \sigma_j$).

Case V: $$s_k - s_j = Z_{kj}\sqrt{2}\sigma.$$

This reduces further to $s_k - s_j = Z_{kj}$ if $\sqrt{2}\sigma$ is used as the unit of measurement. Z_{kj} in this case is a measure of difference between the scale values for stimuli S_k and S_j.

The Method of Paired-Comparisons

The method for obtaining empirical estimates of the proportion, $p(s_k > s_j)$, is known as the method of paired-comparisons. From a set of n stimuli ($S_1, S_2, \ldots S_n$) the experimenter forms the pair (S_k, S_j). The subject in this experiment must indicate which one of a pair of stimuli is greater; no judgments of equality are allowed. A large number of judgments for each of the possible pairs of the stimuli are collected, either by having one subject make several judgments of each pair (as in psychophysical studies) or by having several subjects make a single judgment of each pair. By this method a matrix is constructed which contains the observed proportion of times stimulus S_k was judged greater than stimulus S_j. These proportions are used to calculate the normal deviate (Z) scores for a second matrix..

An estimate of the scale values is the average of the columns of the Z-score matrix. The average of the rows could also be used since $Z_{kj} = -Z_{jk}$. The equation for this least squares solution (Torgerson, 1958) is

$$\mu_k = \frac{1}{n} \sum_{j=1}^{n} Z_{kj} \qquad (k = 1, 2, \ldots, n)$$

where n is the number of rows.

As an application of the law of comparative judgment to the measurement of social values, Thurstone (1927b) conducted a study to determine the perceived seriousness of 19 different crimes. He argued that because punishment for a crime was determined by the seriousness of the crime that there was a quantitative basis to the notion of seriousness. He used 266 university students to make paired comparison judgments between all possible pairs of 19 crimes. If n is the number of crimes, then the total number of pairs is $n(n-1)/2 = 171$.

The instructions were as follows:

The purpose of this study is to ascertain the opinions of several groups of people about crimes. The following list of crimes has been arranged in pairs. You will please decide which of each pair you think more serious and underline it.

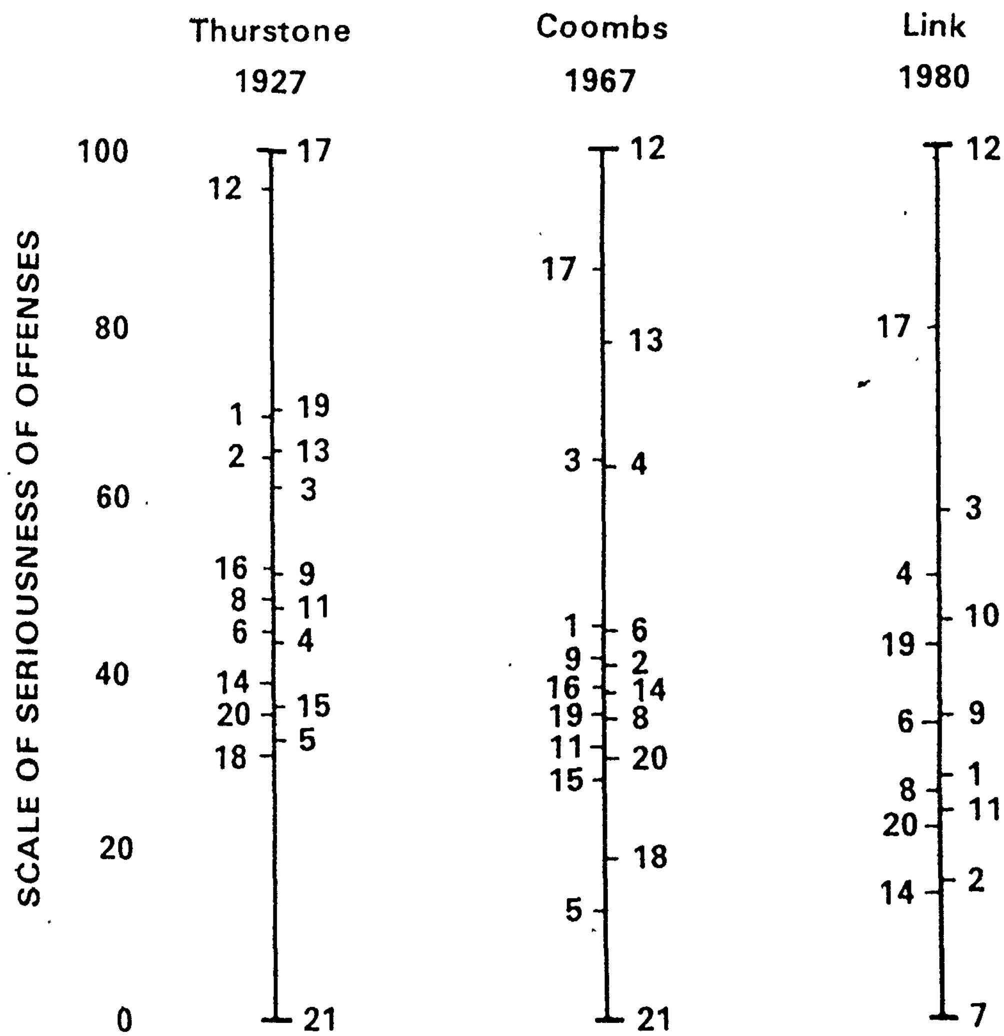
An example: Cheating - Murder

You would probably decide that murder is a more serious offense than cheating; therefore you would underline murder.

If you find a pair of crimes that seem equally serious, or equally inoffensive, be sure to underline one of them anyway, even if you have to make a sort of guess. Be sure to underline one in each pair.

Using the analysis methods described above, a probability matrix containing the proportion of times crime C_k was judged more serious than crime C_j, $P(C_k > C_j)$ and a corresponding Z score matrix were produced. From the Z matrix the scale value estimates were obtained by calculating the average of the columns. Since the zero point on this scale is arbitrary, it may be reset by adding a constant to each scale value, resulting in the least serious crime having an adjusted scale value of zero. As seen in the table below, the crime which was judged by the students to be the least serious was vagrancy and was assigned this zero scale value. The crime judged to be most serious was rape with an adjusted scale value of 3.275 followed closely by homicide at 3.156. Figure 2 graphically illustrates the positions of the 19 crimes on the scale, compared with two more recent investigations to be discussed below.

Figure 2. Scale values for the seriousness of crimes.



1. Abortion
2. Adultery
3. Arson
4. Assault
5. Bootlegging
6. Burglary
7. Cause of Disturbance
8. Counterfeiting
9. Embezzlement
10. Extortion
11. Forgery
12. Homicide
13. Kidnapping
14. Larceny
15. Libel
16. Perjury
17. Rape
18. Receiving Stolen Goods
19. Seduction
20. Smuggling
21. Vagrancy

Adjusted scale values for 19 crimes

Crime	Scale Value	Crime	Scale Value
Abortion	2.271	Kidnapping	2.198
Adultery	2.103	Larceny	1.326
Arson	2.021	Libel	1.124
Assault	1.474	Perjury	1.676
Bootlegging	1.032	Rape	3.275
Burglary	1.510	Receiving stolen goods	0.999
Counterfeiting	1.634	Seduction	2.273
Embezzelment	1.658	Smuggling	1.102
Forgery	1.562	Vagrancy	0.000
Homicide	3.156		

If the relative positions of some of these crimes appear to be strange, it is likely because this study was conducted over fifty years ago. Forty years later a replication by Coombs (1967) showed that, in fact, the relative positions of several crimes had changed, at least according to the new group of university student subjects. Notably, some of the sex crimes, seduction, abortion, and adultery were judged less serious at the later replication, but rape remained close to the serious end of the scale. Homicide was judged as the most serious crime.

Link (1980) also conducted a paired-comparison study using a set of 15 crimes, all but two of which had also been used by Thurstone and Coombs. Again, homicide was judged as the most serious by his university student subjects and rape was the second most serious. Two of the sex related crimes, abortion and adultery, were rated less serious than in Coomb's study.

While the scaling results are interesting, Thurstone's purpose was not to find any startling facts about crime; rather, he showed that "qualitative judgments of a rather intangible sort... (are) amenable to the type of quantitative analysis which is historically associated with psychophysics" (Thurstone, 1959, p. 81).

Following this study, Thurstone went on to apply these techniques to the measurement of attitudes, opinions, preference for food, and nationality preferences (Thurstone, 1959). Many researchers adopted Thurstone's methods in other areas such as educational and mental testing (Bock & Jones, 1978), while others sought to extend the model through new assumptions or techniques. For instance, Horst (1932) developed a method to determine a rational zero point for Thurstone's "affective scale." Another modification was the Case VI assumption reported by Stevens (1966) which suggests that the units on the scale should be equal ratios rather than equal distances.

The next section of this paper examines the use of the method of paired-comparisons in determining scale values for occupations similar to the way Thurstone found scale values for crimes. Following the first experiment, an extension of Thurstone's law of comparative judgment called relative judgment theory will be discussed. This description is followed by a second experiment, which empirically tests the predictions made by relative judgment theory.

The first experiment, which is outlined below, was to measure the differences between occupations using Thurstone's methodology. Two additional scaling techniques, a rank-order task and a magnitude estimation task, were included in this experiment.

EXPERIMENT 1

The Scaling of Occupation Using the Methods of Paired-Comparison, Rank-order, and Magnitude Estimation.

Method

Subjects: Sixty first year psychology students, 24 males and 36 females, received partial course credit for participating in this three part experiment. Subjects were run in three groups of about 20 each during a single session lasting between 30 and 45 minutes.

Stimuli and Procedures: All three parts of the first experiment were paper and pencil format. The experimental material was mimeographed and sorted into two booklets for each subject.

The occupations used in the experiment were chosen from the Careers Ontario Bulletins published by the Department of Manpower and Immigration. These bulletins included a 100-200 word description of each occupation as well as information on educational requirements, demands of the job, future outlook and other data. A preliminary list of about 35 job titles was selected. The main criteria in forming this list were that the jobs must be commonly found in southern Ontario, the range of jobs must represent a wide range of incomes, and the list must include jobs from different sub-groups of occupations, such as professional, skilled-labour, clerical, and service industry groups.

This initial list was reduced to the eighteen occupations used in Experiment 1 largely on the basis of the clarity of a shortened version of the job description. Some of the original choices were rejected because, while they were well-known occupations (i.e. professional athletes, artists) the amount of monetary compensation could vary greatly. Others were removed because there were too many in one of the sub-categories. For instance, in the clerical group, teller and bookeeper were removed while secretary was retained.

The first booklet began with general instructions (see Appendix A), followed by a list of definitions of the occupations. First, the subject was asked to read the list of definitions of the eighteen occupations (found in Appendix A) used in this experiment. Next was a list of job descriptions presented in a different order and without the job title attached. The subject was asked to fill in the blank beside each description with the correct job name and then to check back with the labelled definitions to verify the answers. This initial section was designed to familiarize the subjects with the occupations and to ensure that all of the subjects had the same basic concept of each of the occupations.

The next section, part (a) of the experiment, was the paired-comparison study. All eighteen jobs were paired with every other job resulting in $\frac{(18-1)18}{2} = 153$ pairs. The pairs were presented on seventeen pages of nine pairs each such that all eighteen jobs appeared on each page. The pairs were ordered randomly on each page. A list of these seventeen random orders appears in Appendix A. An example of a page is shown below:

DENTIST ---- CHEMIST
PSYCHOLOGIST ---- SECRETARY
WELDER ---- TEACHER
NURSE ---- PHYSICIAN
FLIGHT ATTENDANT ---- LAWYER
ACCOUNTANT ---- AIRPLANE PILOT
BUS DRIVER ---- BARTENDER
FARMER ---- ENGINEER
POLICEMAN ---- PROGRAMMER

The subject's task was to underline the occupation in each pair which was judged to have the higher annual salary. A given job appeared only once on each page and the subject was instructed not to turn back to any of the previous pages but to continue on to the next page until all seventeen pages were done. The seventeen pages were ordered differently for each subject.

The final section of the first booklet was part (b), the ranking task. On a single page, the subject was given a list of the occupations and asked to arrange them in the order of their annual salary. They were asked to place the the occupation which they judged was the highest paid occupation in the top of the eighteen spaces provided, the next highest directly under it and so on until the lowest paid job was placed in the bottom space. Again, the subject was asked not to refer to any other part of the booklet.

The second booklet was used in part (c) of the experiment. In this section, the subject was asked to estimate the annual salary (to the nearest thousand dollars) of each of the occupations. Each job was presented singly on a separate page. The pages were arranged in random order which was different for every subject.

Results:

The Method of Paired-Comparisons:

The responses from the paired-comparison task were averaged across all 60 subjects. The response probability matrix is shown in Table 1. In addition, the standardized (Z) scale values for the probability in each cell of Table 1 are given in Table 2. To calculate the scale values for each occupation, the sum of the standardized scores for each row was divided by the number of scores in that row. These calculated scale values are shown in Table 3 and are illustrated in Figure 3. The adjusted scores (the original scale value plus 1.558) are also reported. The occupation judged by the subjects to be the highest paid was the Lawyer with an adjusted scale value of 3.229, followed very closely by the Physician with a value of 3.224. The occupation which was judged as paid the least salary was Bartender at the zero point on the adjusted scale.

To test for the goodness of fit between observed and computed probability values, a chi-squared statistic was developed. The marginal probabilities represent the proportion of all the subjects who judge occupation O_j to be greater than O_i (the row occupation has a greater scale value than the column occupation). Therefore, each of the marginal probabilities measure the probability that the scale value for occupation O_i is greater than that of an unknown comparison occupation. If the value of this unknown comparison occupation is stable across

TABLE 1. Probability matrix for Experiment 1 paired comparison data containing the proportion of the subjects who judged that the row occupation was paid more than the column occupation.

	LAWYER	PHYSICIAN	DENTIST	ENGINEER	AIRPLANE PILOT	ACCOUNTANT	PSYCHOLOGIST	CHEMIST	PROGRAMMER	POLICEMAN	TEACHER	WELDER	NURSE	FARMER	FLIGHT ATTENDANT	SECRETARY	BUS DRIVER	BARTENDER
LAWYER	-	.583	.733	.833	.867	.933	.933	.950	.967	.967	1.000	.983	1.000	1.000	1.000	1.000	1.000	1.000
PHYSICIAN	.417	-	.683	.817	.867	.883	.917	.933	.983	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DENTIST	.267	.317	-	.733	.767	.883	.850	.850	.983	.967	1.000	.983	1.000	.983	1.000	1.000	1.000	1.000
ENGINEER	.167	.183	.267	-	.550	.750	.750	.900	.983	.950	1.000	.967	.983	1.000	1.000	1.000	.983	1.000
PILOT	.133	.133	.233	.450	-	.583	.633	.733	.767	.867	.900	.950	.900	.967	1.000	.967	.983	1.000
ACCOUNTANT	.067	.117	.117	.250	.417	-	.567	.667	.900	.767	.917	.917	.883	.933	.933	1.000	.983	1.000
PSYCHOLOGIST	.067	.083	.150	.250	.367	.433	-	.450	.700	.783	.800	.783	.867	.900	.950	.983	.967	.983
CHEMIST	.050	.067	.150	.100	.267	.333	.550	-	.667	.717	.850	.850	.900	.883	.950	.917	.983	1.000
PROGRAMMER	.033	.017	.017	.017	.233	.100	.300	.333	-	.567	.567	.700	.717	.933	.900	.967	.933	.933
POLICEMAN	.033	0	.033	.050	.133	.233	.217	.283	.433	-	.550	.717	.783	.883	.917	.917	1.000	.950
TEACHER	0	0	0	0	.100	.083	.200	.150	.433	.450	-	.567	.600	.800	.833	.967	.967	.967
WELDER	.017	0	.017	.033	.050	.083	.217	.150	.300	.283	.433	-	.533	.733	.750	.850	.867	.933
NURSE	0	0	0	.017	.100	.117	.133	.100	.283	.217	.400	.467	-	.650	.700	.883	.867	.867
FARMER	0	0	.017	0	.033	.067	.100	.117	.067	.117	.200	.267	.350	-	.517	.567	.550	.583
FLT. ATTEND.	0	0	0	0	0	.067	.050	.050	.100	.083	.167	.250	.300	.483	-	.600	.600	.850
SECRETARY	0	0	0	0	.033	0	.017	.083	.033	.083	.033	.150	.117	.433	.400	-	.483	.567
BUS DRIVER	0	0	0	.017	.017	.017	.033	.017	.067	0	.033	.133	.133	.450	.400	.517	-	.567
BARTENDER	0	0	0	0	0	0	.017	0	.067	.050	.033	.067	.133	.417	.150	.433	.433	-

TABLE 2. Normal deviate (z) scores corresponding to the proportions contained in Table 1.

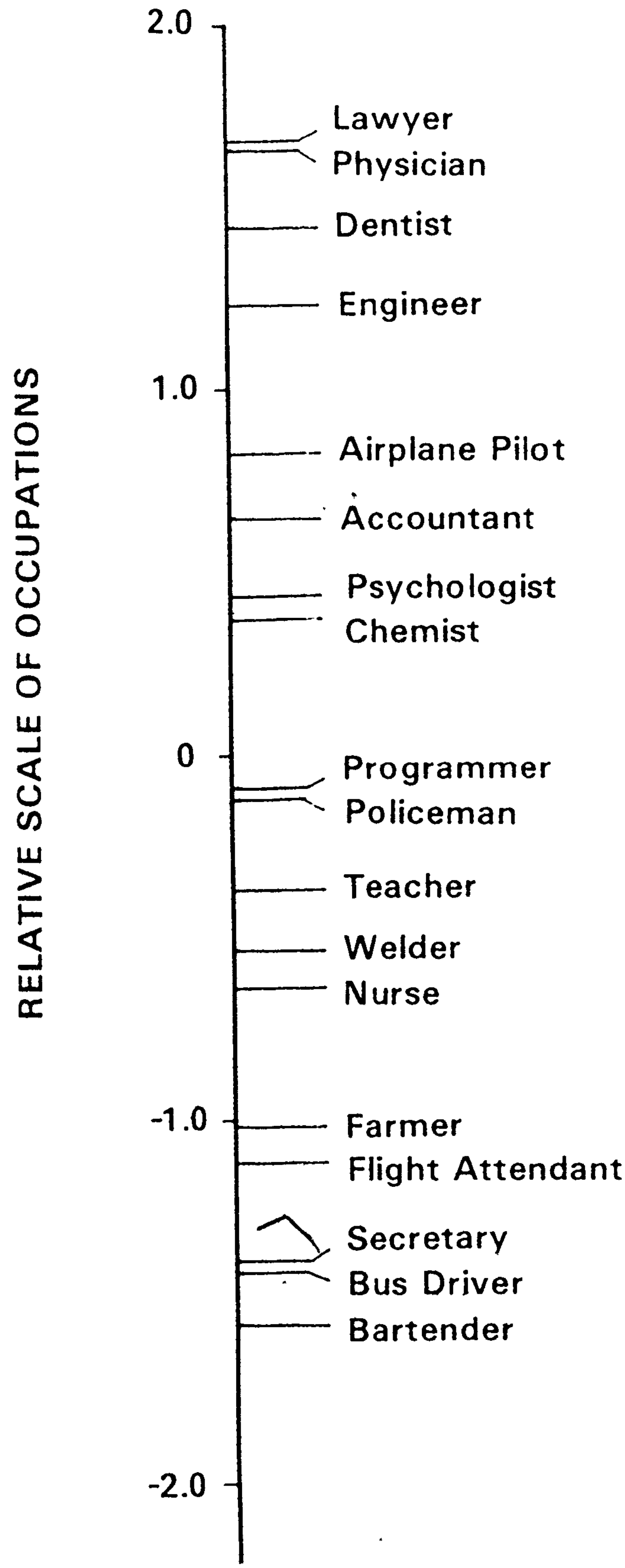
	LAWYER	PHYSICIAN	DENTIST	ENGINEER	AIRPLANE PILOT	ACCOUNTANT	PSYCHOLOGIST	CHEMIST	PROGRAMMER	POLICEMAN	TEACHER	WELDER	NURSE	FARMER	FLIGHT ATTENDANT	SECRETARY	BUS DRIVER	BARTENDER
LAWYER	0	.21	.62	.97	1.11	1.50	1.50	1.65	1.83	1.33	2.39	2.13	2.39	2.39	2.39	2.39	2.39	2.39
PHYSICIAN	-.21	0	.48	.90	1.11	1.19	1.38	1.50	2.13	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39
DENTIST	-.62	-.48	0	.62	.73	1.19	1.04	1.04	2.13	1.83	2.39	2.13	2.39	2.13	2.39	2.39	2.39	2.39
ENGINEER	-.97	-.90	-.62	0	.13	.67	.67	1.28	2.13	1.65	2.39	1.83	2.13	2.39	2.39	2.39	2.13	2.39
PILOT	-1.11	-1.11	-.73	-.13	0	.21	.34	.62	.73	1.11	1.28	1.65	1.28	1.83	2.39	1.83	2.13	2.39
ACCOUNTANT	-1.50	-1.19	-1.19	-.67	-.21	0	.17	.43	1.28	.73	1.38	1.38	1.19	1.50	1.50	2.39	2.13	2.39
PSYCHOLOGIST	-1.50	-1.38	-1.04	-.67	-.34	-.17	0	-.13	.52	.78	.84	.78	1.11	1.28	1.65	2.13	1.83	2.13
CHEMIST	-1.65	-1.50	-1.04	-1.28	-.62	.43	.13	0	.43	.57	1.04	1.04	1.28	1.19	1.65	1.38	2.13	2.39
PROGRAMMER	-1.83	-2.13	-2.13	-2.13	-.73	-1.28	-.52	-.43	0	.17	.17	.52	.57	1.50	1.28	1.83	1.50	1.50
POLICEMAN	-1.83	-2.39	-1.83	-1.64	-1.11	-.73	-.78	-.57	-.17	0	.13	.57	.78	1.19	1.38	1.38	2.39	1.65
TEACHER	-2.39	-2.39	-2.39	-2.39	-1.28	-1.38	-.84	-1.04	-.17	-.13	0	.17	.25	.84	.97	1.83	1.83	1.83
WELDER	-2.13	-2.39	-2.13	-1.83	-1.65	-1.38	-.78	-1.04	-.52	-.57	-.17	0	.08	.62	.67	1.04	1.11	1.50
NURSE	-2.39	-2.39	-2.39	-2.13	-1.28	-1.19	-1.11	-1.28	-.57	-.78	-.25	-.08	0	.38	.52	1.19	1.11	1.11
FARMER	-2.39	-2.39	-2.13	-2.39	-1.83	-1.50	-1.28	-1.19	-1.50	-1.19	-.84	-.62	-.38	0	.04	.17	.13	.21
FLT. ATTEND.	-2.39	-2.39	-2.39	-2.39	-2.39	-1.50	-1.65	-1.65	-1.28	-1.38	-.97	-.67	-.52	-.04	0	.25	.25	1.04
SECRETARY	-2.39	-2.39	-2.39	-2.39	-1.83	-2.39	-2.13	-1.38	-1.83	-1.38	-1.83	-1.04	-1.19	-.17	-.25	0	-.04	.17
BUS DRIVER	-2.39	-2.39	-2.39	-2.13	-2.13	-2.13	-1.83	-2.13	-1.50	-2.39	-1.83	-1.11	-1.11	-.13	-.25	.04	0	.17
BARTENDER	-2.39	-2.39	-2.39	-2.39	-2.39	-2.39	-2.13	-2.39	-1.50	-1.65	-1.83	-1.50	-1.11	-.21	-1.04	-.17	-.17	0

Table 3

Scale values for eighteen occupations estimated by the three Experiment 1 methods: a) Paired comparisons, b) rank order, and c) magnitude estimation.

Occupation	(a) Scale Value	(a) Adjusted Scale Value	(b) Mean Rank	(c) Mean Estimated Salary
Lawyer	1.671	3.229	2.65	$46,980
Physician	1.666	3.224	2.18	$50,910
Dentist	1.449	3.007	3.10	$44,930
Engineer	1.227	2.784	4.63	$33,020
Airplane Pilot	.817	2.375	6.42	$34,270
Accountant	.651	2.208	6.65	$29,820
Psychologist	.434	1.992	7.30	$29,750
Chemist	.373	1.931	7.65	$25,670
Programmer	-.119	1.439	9.49	$21,160
Policeman	-.088	1.469	10.38	$22,550
Teacher	-3.71	1.187	11.27	$20,070
Welder	-.532	1.026	12.24	$19,470
Nurse	-.641	.917	11.91	$18,270
Farmer	-1.060	.498	14.93	$16,750
Flight Attendant	-1.115	.443	14.38	$16,440
Secretary	-1.381	.177	15.60	$14,840
Bus Driver	-1.424	.134	16.12	$14,800
Bartender	-1.558	.000	16.50	$13,350

Figure 3. Scale values for 18 occupations estimated from Experiment 1 data.


RELATIVE SCALE OF OCCUPATIONS
2.0
1.0
0
-1.0
-2.0
Lawyer
Physician
Dentist
Engineer
Airplane Pilot
Accountant
Psychologist
Chemist
Programmer
Policeman
Teacher
Welder
Nurse
Farmer
Flight Attendant
Secretary
Bus Driver
Bartender

occupations, then each occupation is compared to the same value. An estimate of each cell's normalized score can be calculated using the following procedure.

Let P_{iR} be the marginal probability for row i (the R represents the assumed comparison value). Then an asymptotically normalized score is derived for each P_{iR} giving Z_{iR} for i=1,2. ..., n where n is the number of occupations. For example, the estimated (marginal) probability that a Lawyer is judged to be the higher paid of the two occupations in a pair is .903. This is calculated by adding up the number of times that a Lawyer was judged to be paid more when compared against another occupation, giving seventeen (pairings per subject) times sixty subjects. A Z-score is calculated for each of the eighteen marginal probabilities, giving Z_{LR} in the case of a Lawyer. If Z_{ER} (Engineer) is subtracted from Z_{LR} (Lawyer) $(Z_{LR}-Z_{ER})$, the R component is removed, leaving an estimate Z^*_{LE}, the distance between Lawyer and Engineer. The previous estimator of Z_{LE} shown in Table 2 is the Z-score calculated from the cell in Table 1 where Lawyer is judged greater than Engineer (P_{LE}=.833, Z_{LE}=.97). Since Z_{LR}=1.30 and Z_{ER}=0.75 (Z-values calculated from P_{LR}=.903 and P_{ER}=.774), then Z^*_{LE}=1.30-0.75=.55. The general case $Z_{ij}-Z_{ij}^*$ is normally distributed with mean zero and variance 2. Furthermore, $\frac{(Z_{ij} - Z_{ij}^*)^2}{2} = \chi_i^2$. To continue the example, $\frac{(Z_{LE} - Z_{LE}^*)^2}{2} = \frac{(.97 - .55)^2}{2} = .0882$. A total χ^2 value is obtained by computing these squared differences for all pairs and adding together the results. The total χ^2 value calculated in this way was 25.65.

The number of degrees of freedom was calculated by taking the total number of pairs, which equals $n(n-1)/2$, and subtracting n (due to estimating the Z_{iR} values from the marginal probabilities). This left $n(n-3)/2$, which for n = 18, is equal to $18(18-3)/2 = 135$. If the number of observations per cell is small, then the number of degrees of freedom will be reduced due to the discrepancy between these asymptotic results and the exact small sample size results.

The Method of Rank Order:

The data from part (b), the rank-order task, were summarized by calculating the mean rank for each of the occupations for all 60 subjects. This ordering of the occupations is very similar to the order of the paired-comparison scale values in part (a). Here, the Physician has been ranked on average as the highest paid occupation, followed by the Lawyer. Two other pairs also changed in relative position compared to the scale value order: Nurse is ranked higher than Welder and Flight Attendant is ranked higher than Farmer. These data appear in Table 3.

The Method of Magnitude Estimation:

In a similar fashion, the mean estimated salary was calculated for 58 subjects. The data for two subjects who gave numerical estimates which were clearly inconsistent with the majority were excluded. The mean salary estimates are shown in Table 3. The order of the mean estimated salaries is again, quite close to that of the other two measures. On the average, the Physician was attributed the highest salary of about $51,000, and the Lawyer was second at about $47,000.

The lowest rated occupation on all three scales is the Bartender, in this case with a salary of $13,350.

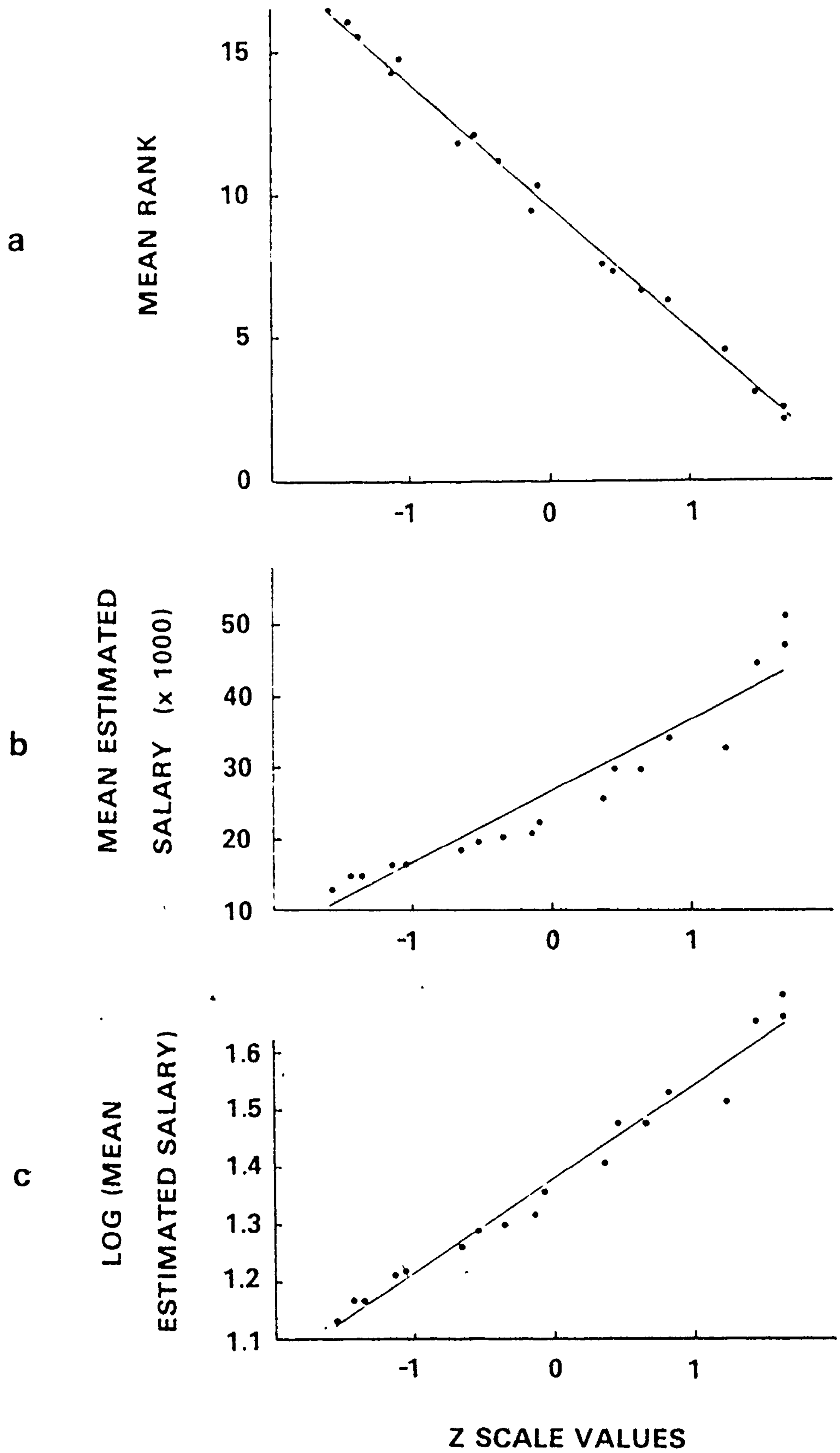
A multiple regression analysis of the three measures of occupations from the three parts of Experiment 1 revealed the correlation between the paired-comparison scale values and the mean rank was -.997; the correlation between the scale values and the mean estimated salary was .953 and the correlation between the mean rank and the mean estimated salary was -.948.

	Z-SCALE	RANK	SALARY
Z-SCALE	1.000	-.997	.953
RANK	-	1.000	-.948
SALARY	-	-	1.000

TABLE 4. Multiple correlation matrix.

In Figure 4, mean rank and mean estimated salary are plotted against the paired-comparison values. As would be expected from the very high correlation coefficient, the relation between the scale values and the mean rank scores is quite linear with very little deviation from the best fit line. The function relating the scale values and the estimated salary values, however, does not appear to be linear. To test the hypothesis that this function was logarithmic as suggested by Ekman's Law (Stevens, 1966), the correlation between the scale values and the log (salary) was computed and the relationship plotted (Figure

Figure 4. Results from Experiment 1: a) scale values versus mean rank; b) scale values versus estimated salary; c) scale values versus log (estimated salary).



a
MEAN RANK
15
10
5
0
-1
0
1
b
MEAN ESTIMATED SALARY (x 1000)
50
40
30
20
10
-1
0
1
c
LOG (MEAN ESTIMATED SALARY)
1.6
1.5
1.4
1.3
1.2
1.1
-1
0
1
Z SCALE VALUES

4c). The correlation was .987 and the function appears to be linear for the transformed data, but then, nearly any monotonic function becomes more linear when a log transformation is made.

The results of the first experiment show that the methodology used by Thurstone gives scale values for occupations which are comparable to values produced by other scaling techniques. The next section of the paper describes a more recent theory which is an extension of the Thurstonian model.

Relative Judgment Theory

Thurstone's law of comparative judgment has been used to determine scale values for crimes, occupations and many other psychological and psychophysical variables. The method of paired-comparisons has been applied in many areas to measure preference or choice or the degree to which one item is favoured over another (David, 1969). Other methods for analysing paired-comparison data have also been proposed. For instance, the Bradley-Terry-Luce (B-T-L) model (cf. Baird & Noma, 1978) which assumes a logistic rather than normal distribution as its basis, provides scale values from comparative judgment data.

These models deal with only one aspect of a subject's response behavior, namely the frequency of making a certain response. Ideally, a deeper, more comprehensive model should also incorporate other measures of the subject's performance such as response time and response confidence.

That a relationship exists between response time and the discrimination or detection of a stimulus is well known. Several psychophysical experimenters found that as the difference between a variable stimulus and a standard stimulus increased, the response time decreased. The maximum latencies tended to be elicited by stimuli near the point of subjective equality (Henmon, 1911; Kellogg, 1931; Johnson, 1944). Other researchers found relations between confidence and response probability and latency (Festinger, 1943); however there were very few models which could account for all of them.

One such model, Relative Judgment Theory, is a direct extension of Thurstone's concepts. It is a relatively simple theoretical model which maintains the framework of existing, established decision theory and data, and also can account for many of the behavioral measures that are usually associated with psychophysical experiments, including response probability, latency, confidence and bias.

Relative Judgment Theory uses the concept of a mental referent as suggested by Coombs (1960) and Helson (1959) which differs from the experimenter-provided standard of Thurstonian theory. It also postulates that the subject has control over the amount of information, A, that is required to make a judgment. This feature relates to the well known speed-accuracy trade-off, so that under accuracy conditions, more information can be processed to give better performance. Under speeded conditions less information is input so that an imposed deadline can be met, but with decreased accuracy in performance. Relative judgment theory incorporates a subject controlled mechanism for bias by the positioning of a variable starting point, C, closer to one or the other of the response thresholds. Finally, similar to many other theories of choice, it provides a single variable which measures sensitivity or discriminability (υ).

Returning to the concept of a mental referent, the subject is assumed to construct an internal, psychological standard which is based on his or her prior experience with the stimuli. This internal referent may be established through the subject's familiarity with commonly occurring stimuli (such as the names of crimes) or through training or practice (such as line length in a psychophysical experiment). With the latter type of psychophysical stimuli, many practice trials may be required to produce a sufficiently well defined referent. With the former type of familiar objects, a well established referent may exist prior to an experimental task. The mental standard may be modified through repeated exposures to the stimuli. (Link & Heath, 1975).

The relative nature of the judgments refers to the mental comparison between this subjective referent and a psychological (or psychophysical) value caused by the presentation of a stimulus. A judgment is relative to the referent used by the subject. Each of these values is assumed to be defined on a commensurate underlying psychological continuum. The standard acts as a psychological yardstick against which the stimuli are compared.

The Random Walk Model

When a stimulus (S_i) is presented to a subject, a psychological value of the stimulus (X_i) is compared to the internal referent (X_r) by subtraction. These randomly sampled variables, X_i and X_r, can be assumed to be normally distributed with means μ_i and μ_r respectively, to have common variance σ^2 and to be fixed during a trial. The subtractive process produces a new difference random variable with mean $\mu_i - \mu_r$ and variance $2\sigma^2$. On a trial, these discrepancies between X_i and X_r are accumulated sequentially until one of the two response thresholds if reached. The comparison process during small time units of size Δt result in a stationary random variable, $d_i = X_i - X_r$. For the k^{th} time unit, this difference random variable will be denoted d_{ik} and the sum of these differences at the n^{th} time interval is $D_{in} = \sum_{i=1}^{n} d_{ik}$. This accumulation process is characterized as a random walk between two response barriers A and -A (Figure 5).

The accumulation of the d_{ik} continues until the value of D_{in} is either greater than A or less than -A. If it exceeds barrier A, then response R_A occurs or if it is less than -A, then the response R_B is emitted.

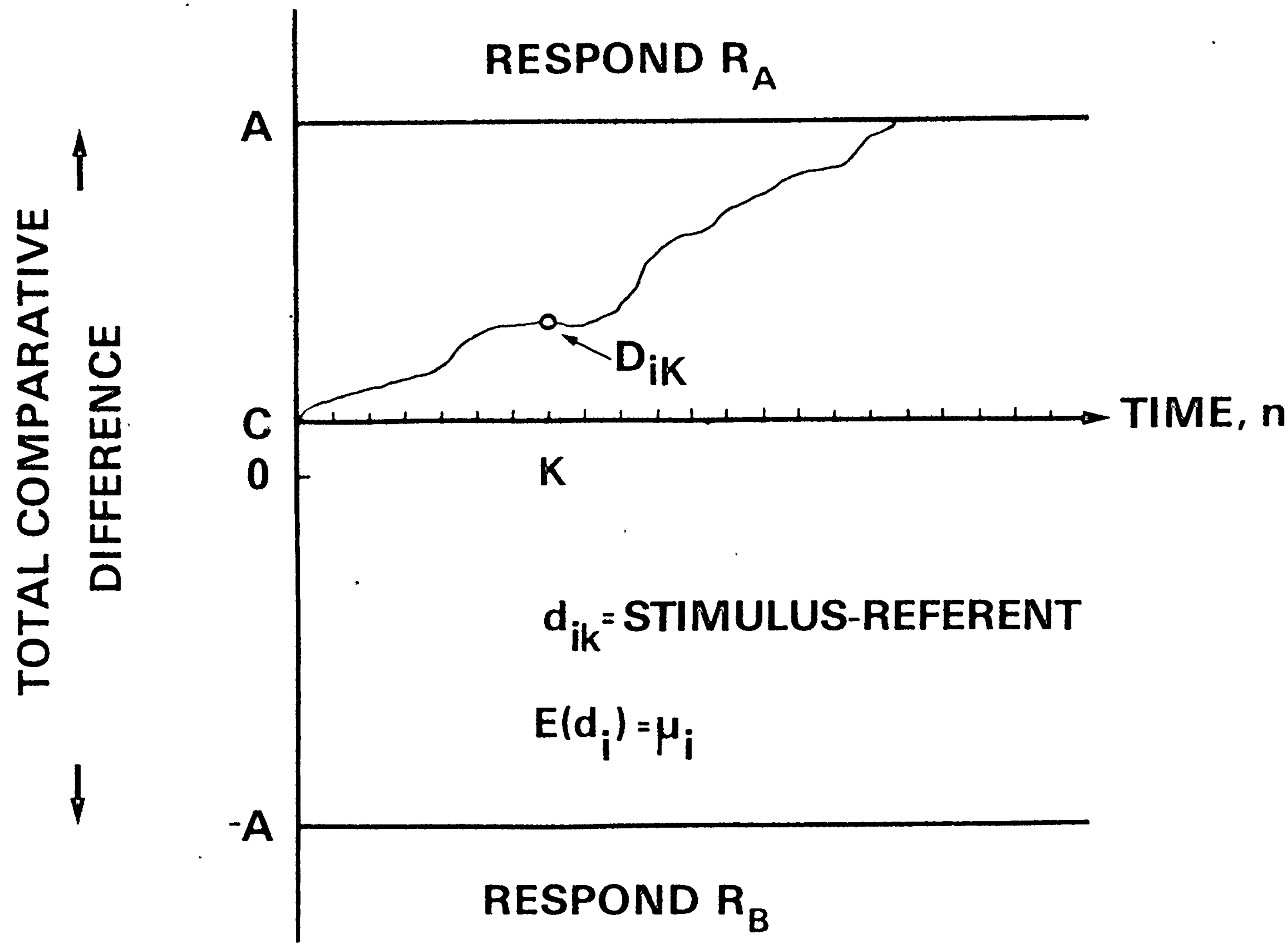
The size of A is assumed to be under the subject's control and determines the amount of information required for a discrimination. If A is increased, a larger total discrepancy is required for a response. Since the process accumulates the discrepancies sequentially, an increase in A will also lead to an increase in the expected decision time.

The mathematical derivation of relative judgment theory is based on the well known Wald Identity (Link, 1978).

$$E(e^{-D_{in}} f_i(\upsilon)^{-N}) = 1$$

where N is the value of k when the random walk exceeds one of the response thresholds and $f_i(\upsilon)$ is the moment generating function (m.g.f.) for d_i.

Figure 5. A representation of the random walk process.


TOTAL COMPARATIVE DIFFERENCE
RESPOND R_A
A
C
0
-A
D_{iK}
TIME, n
K
d_{ik} = STIMULUS-REFERENT
$E(d_i) = \mu_i$
RESPOND R_B

Theoretical Predictions

I. Probability

The general forms of the prediction equations were derived by Link and Heath (1975); however, the forms used here are taken from a later paper (Link, 1978).

Assuming an unbiased starting point (C=0), the probability of responding R_A given stimulus S_i is

$$P_{Ai} = \frac{e^{\upsilon_i A} - 1}{e^{\upsilon_i A} - e^{-\upsilon_i A}} \qquad (1)$$

where υ_i is a nonzero solution to $f_i(\upsilon) = 1$. Rewriting this equation gives

$$P_{Ai} = \frac{1}{1+e^{-\upsilon_i A}} \qquad (2)$$

which is the standard form for a logistic distribution evaluated at $-\upsilon_i A$. The logit of this probability is a maximum likelihood estimator of $\upsilon_i A$:

$$\ln\left(\frac{P_{Ai}}{1-P_{Ai}}\right) = \upsilon_i A. \qquad (3)$$

II. Response Time

The response time is the sum of the decision time (DT) and non-decision components which are assumed to be constant (K). The mean decision time is the average distance to the response barrers divided by the drift rate,

$$DT_i = \frac{[A(P_{Ai}) + (-A)(1-P_{Ai})]}{\mu_i}$$

$$= \frac{A(2P_{Ai} - 1)}{\mu_i}$$

where the drift rate $\mu_i = E(X_i - X_r)$ is the mean difference between the mental values of S_i and the referent. The predicted mean response time to stimulus S_i (with zero response bias assumed) is

$$RT_i = \frac{A}{\mu_i}(2P_{Ai} - 1) + K \qquad (4)$$

Thus, when μ_i is known, mean RT_i is a linear function of $(2P_{Ai}-1)/\mu_i$ with slope A and intercept K. Link (1975, 1978) showed that the relative judgment theory predictions provide a very reasonable account of the data in a variety of psychophysical discrimination experiments.

More recently, Link (1980) demonstrated the general applicability of relative judgment theory by conducting an experiment to measure the seriousness of various crimes. This was a direct extension of Thurstone's (1927b) study of crimes reported above.

In this case, however, Link argued that people may not make judgments about the seriousness of crimes directly, but rather the amount of punishment (in years of imprisonment) which is attributable to each crime may form the basis of the judgment. To investigate this hypothesis, Link devised a technique called the method of compared-comparisons to collect data.

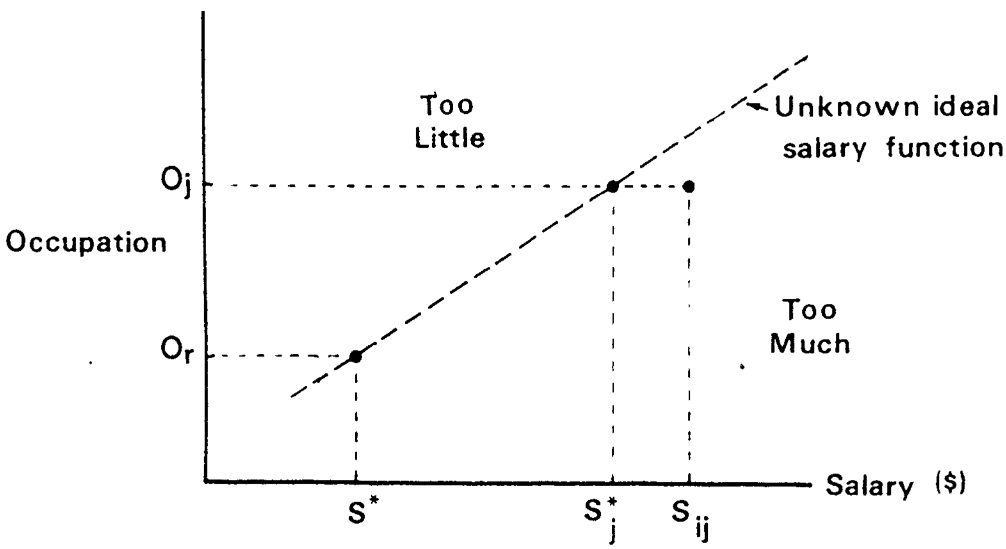
The Method of Compared-Comparisons

In this procedure, a subject makes judgments considering jointly two psychological dimensions. In Link's study, these two dimensions were the seriousness of a crime and the severity of a punishment; in the present study, they are occupations and salaries. In the present experiment, the subject is given a standard salary-occupation pair, S*, which has an internal salary representation s* with mean μ*. The subject compares the salary-occupation stimulus pairs, S_{ij} (i = salary levels; j = occupations) against S*. Through this comparison, the subject constructs an ideal salary for occupation O_j which is defined to be S^*_j that is normally distributed with mean μ^*_j. The set of all ideal salaries defines the ideal salary function relating occupation and income.

When a stimulus S_{ij} is to be compared against S*, the subject compares the internal representation of S_{ij}, that is s_{ij}, against the ideal salary for occupation O_j, that is against s^*_j. When given a stimulus S_{ij} the subject first treats occupation O_j as a stimulus for comparison against S*. The subject determines, on the basis of his or her ideal salary function, a value s^*_j which represents the ideal salary for occupation O_j. Having determined the ideal salary, the subject now compares the internal representation of the salary paired with O_j, that is, s_{ij} against s^*_j to obtain a comensurable comparative difference. The comparative difference $s_{ij}-s^*_j$ equals d_{ij}, a normally distributed random variable with a mean equal to $\mu_{ij}-\mu^*_j$.

The discrimination process is the same random walk accumulation of discrepancies over small time units Δt with response barriers A and -A as represented in Figure 5. If the accumulation of differences is positive, that is $s_{ij} > s^*_j$ as shown in Figure 6, then the response TOO MUCH (R_M) will occur. If the accumulation is negative, the result will be a TOO LITTLE response (R_L). The difference obtained during time interval k is $d_{ijk} = s_{ij} - s^*_j$. The accumulation of these discrepancies drives the random walk process toward the response threshold A or -A.

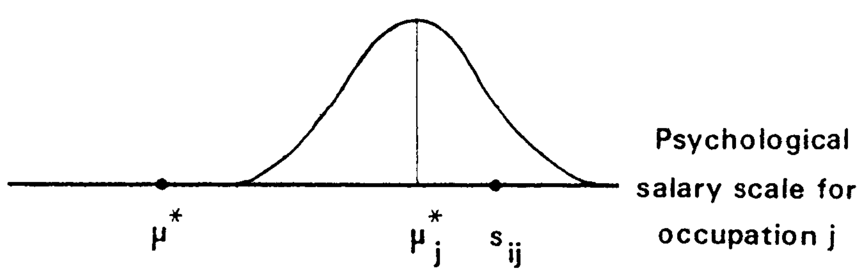
Figure 6. A graphical illustration of the experimental standard, the subject's referent and a stimulus pair along the punishment continuum for a given crime (i).



s^* - given standard salary/occupation pair

s_j^* - constructed ideal salary for occupation j

s_{ij} - stimulus probe, salary i/occupation j



To examine this model in the context of crime and punishment, Link gave 42 undergraduate university students a standard crime and punishment of 6 years for counterfeiting. The subjects were asked to judge whether a stimulus crime-punishment pair was more or less severe than the standard. The object of the experiment was to obtain scale values for the crimes and to determine the ideal sentence for each crime which was used by the subjects in making their judgments. For the stimuli, Link used 15 crimes (14 of which were used by Thurstone, 1927b). The punishment set consisted of 1 to 13 years in prison. The stimulus pairs consisted of all distinct pairings of the 15 crimes with 1 to 13 years giving a total of 195 pairs. The standard pair of 6 years for counterfeiting was not compared with itself. Both the response and response time were collected for each trial for every subject, then averaged over all of the subjects.

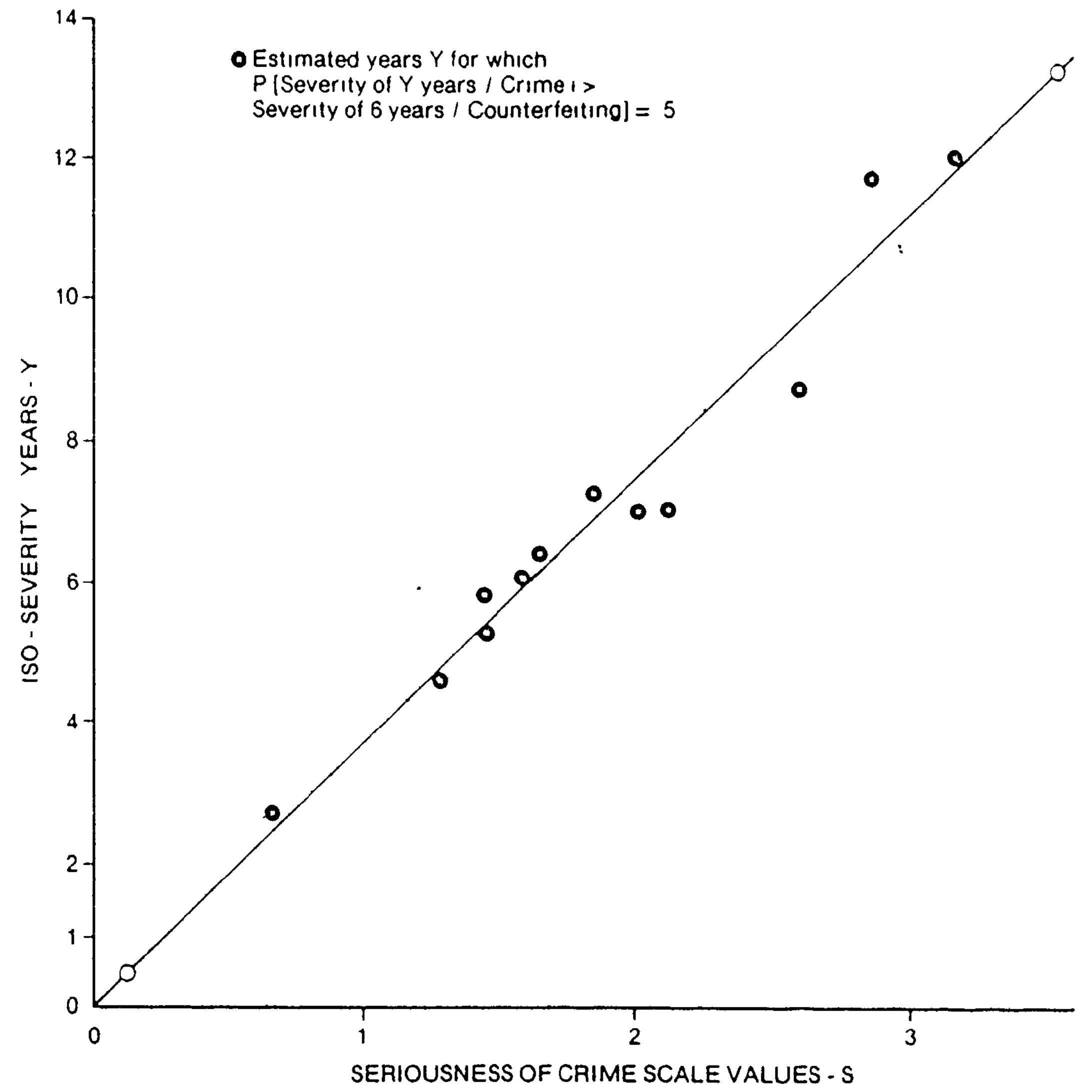
As discussed above for salaries and occupations, when a standard pair, such as 6 years for counterfeiting in the crime and punishment context, is presented to the subject, he or she will use that standard to establish ideal punishment levels for the other crimes, based on the perceived seriousness of each crime. Therefore, the discrepancy between the standard punishment and the ideal punishment for crime C_i is due to the difference between the seriousness of the standard crime and crime C_i.

Considering the scale values for the crimes, a measure of the difference of crime C_i from the standard crime is $\mu_i^*-\mu^*$. An expression involving this difference which is derived from the moment generating function is $\upsilon_i = (\mu_i^* - \mu^*)/\sigma^2$. Therefore, υ_i is a measure of the difference of crime C_i from the standard except for multiplication by a constant. The probability that crime C_i and the standard punishment is judged greater than the standard crime-punishment pair is used in Equation 3 to obtain values of $\upsilon_i A$, which is a measure of the difference in seriousness between the crime C_i and the standard crime.

The problem is to determine values for the adopted referent punishment for each crime, that is, the values which for each crime were equivalent to the standard punishment. When a sentence exactly corresponds to the subject's referent, there is no difference between the stimulus and the standard, that is $\mu_i - \mu^* = 0$. There is nothing to be discriminated in this case, so υ_i (and $\upsilon_i A$) equals zero. The point where $\upsilon_i A$ is zero corresponds to the point where half of the subjects judged the sentence more severe and half judged it less severe than the referent. Thus, to obtain an estimate of the number of years corresponding to the adopted referent, the point where $\upsilon_i A$ equals zero is either found in the data or is estimated by interpolation.

The relation between the subjects' perception of the seriousness of crime and severity of punishment is shown in Figure 7. The scale values for the crimes in Figure 7 have been adjusted so that the best fitting line passes through the origin of both axes. Thus a crime on this line with a seriousness value of zero would also have a zero severity of punishment value. Using the original, unadjusted, data, the best fitting linear equation describing the relation was

Figure 7. The relationship between seriousness of crime and severity of punishment from Link's (1980) experiment.


Estimated years Y for which
P [Severity of Y years / Crime i >
Severity of 6 years / Counterfeiting] = .5
ISO - SEVERITY YEARS - Y
SERIOUSNESS OF CRIME SCALE VALUES - S
0
1
2
3
4
6
8
10
12
14

$$\text{Severity} = (3.775)\ \text{Seriousness} + 5.90\ \text{years}.$$

The second experiment of this study uses Link's methods to obtain data on the relation between salary and occupations. The scale values that are obtained can be compared with those from experiment 1. More important, however, the ability of relative judgment theory to predict the relation between latency and response probability will be examined.

EXPERIMENT 2

Measurement of Occupation vs. Income Using the Compared-Comparison Technique.

Method

Subjects: Seventy-seven first year psychology students, 26 males and 51 females, received partial course credit for taking part in the experiment. Each subject participated in one session of about one hour duration. None of these subjects had participated in Experiment 1.

Stimuli:

The occupations used in this experiment were the same as those used in the paired-comparison study in Experiment 1 except that two jobs, Nurse and Airplane Pilot, were omitted thereby reducing the number of occupations to sixteen. The list was reduced to accommodate limited memory space in the computer and to decrease the time to run the complete session. The Nurse and Airplane Pilot occupations were removed rather arbitrarily but jobs at the extremes or near the median on the estimated-salary scale were not considered for removal. The final list of 16 occupations was:

1. Accountant	9. Lawyer
2. Bartender	10. Physician
3. Bus driver	11. Policeman
4. Chemist	12. Programmer
5. Dentist	13. Psychologist
6. Engineer	14. Secretary
7. Farmer	15. Teacher
8. Flight Attendant	16. Welder

A set of salary values also was generated with reference to data from Experiment 1. Again, computer memory space and the overall time of a session were taken into consideration in determining the number of salary levels chosen as stimulus values. Since the inter-job salary increment in Figure 4 was not constant but increased at the higher salary end of the scale, it was decided that a constant incremental value would not be as appropriate as an increment which was smaller at the low salary end and larger at the high salary end. A set of 15 values were chosen starting at the minimum of $10,000. The increment for the lowest five levels was $2,000, $3,000 for the next five levels and $4,000 for the highest five, resulting in the following values:

SALARY LEVEL	SALARY VALUE
1	$10,000
2	$12,000
3	$14,000
4	$16,000
5	$18,000
6	$21,000
7	$24,000
8	$27,000
9	$30,000
10	$33,000
11	$37,000
12	$41,000
13	$45,000
14	$49,000
15	$53,000

The standard comparison pair of $21,000 for a Programmer was chosen by selecting an occupation which was close to the median in the data from Experiment 1.. The Programmer category had a mean rank of 9.5 out of the original 18 jobs and a paired-comparison scale value of -0.12. The marginal probability of judging a Programmer greater than any other occupation was .487, the closest value to the .5 level. The mean estimated salary for a Programmer was $21,160 which corresponds closely with the sixth salary level of $21,000.

The total number of salary/occupation pairs was 15 x 16 = 240. Each subject was given ten practise trials followed by 239 experimental trials (the $21,000/Programmer pair was not presented as a stimulus pair).. The trials were presented in a random order which was different for every subject.

Procedure: To standardize the concept of each of the occupations subjects first read the instructions (see Appendix B) plus a list of brief definitions of the occupations. They were then asked to complete a questionnaire in which the definitions were listed in a different order and without the occupation label. Their task was to fill in the correct label for each description.

Next, a subject was seated facing the display terminal of a PDP-11/34 computer which controlled all of the stimulus displays and collected the responses and response times. The first part of the computer controlled presentation asked the subject to judge whether each of the fifteen occupations was paid more or less than a Programmer. To record a judgment, the subject depressed either the M or the L button on the terminal's keyboard as each occupation-Programmer pair appeared on the screen. The subject was asked to complete the set of 15 comparisons twice for a total of 30 trials. These trials were used to familiarize the subjects with the location of the response keys and gave them experience with the process of comparing each of the occupations to a Programmer.

The second and major part of the computer-controlled session was the compared-comparison trials. Full instructions on the stimulus configuration and method of responding were given in the previously read instructions and these were available at all times for the subject's reference. The subject's task was to compare the stimulus, a salary/occupation pair, to the standard pair of $21,000 for a Programmer and to judge whether the stimulus salary was too much or too little relative to the standard. If the subject judged that the salary was "too much," then the response was the M key and if the salary was judged "too little," the response was the L key. Each time a response button was pushed, its value was registered by depressing the space bar on the keyboard. An error could be corrected by typing an X following the original response and then depressing the space bar. The subject then entered the correct response. The response time for such a corrected trial was recorded as a negative value so that it could be excluded from the response time analyses.

The response time was the interval between the appearance of the stimulus on the display screen and the depression of the M or L response key.

The stimulus configuration appeared on the screen as shown below:

IS $12,000 FOR A(N) ENGINEER
TOO MUCH (M) OR TOO LITTLE (L)
COMPARED TO $21,000 FOR A PROGRAMMER?

Once a response was entered, the next trial commenced with a new salary/occupation pair appearing on the screen along with the rest of the display.

About fifteen minutes into the session, a message appeared on the screen asking the subject if he/she would like a short break. The subject was allowed (and encouraged) to take up to 5 minutes to walk about and stretch, and then resume the task. The session was re-initiated by the subject's typing the X key. Subsequent breaks were given at 15 minute intervals.

When the subject completed the compared-comparison task, a message appeared on the screen asking the subject to complete a final section. This last part asked the subject to estimate the annual salary of each of the occupations. The occupation label appeared on the screen and the subject entered the estimated salary to the nearest $1,000. This was parallel to the final section of Experiment 1.

At the completion of the session, the experimenter explained the essence of the study using the printout of the subject's data to illustrate important features of the experiment.

Results:

Preliminary analyses of the data were conducted to identify subjects who made frequent errors and to get a frequency analysis of response times in order to set up upper and lower censoring values. Upper and lower censoring values of 20 seconds and 1 second respectively were used to exclude response times that were either very long or very short. About 1.9% of the response times were less than one second and about 0.6% of the response times were over 20 seconds. Data for 17 of the original 77 subjects, 12 females and 5 males, were excluded from the analyses. Fifteen of these subjects were rejected because they had more than five inconsistencies in their judgments of the stimulus pairs. Two subjects were excluded because more than half of their response times were too fast, that is, less than one second.

Data for the remaining 60 subjects were processed and summarized into a single table containing mean response probabilities and mean response times for each salary/occupation pair as well as response probabilities and response times for the M (too much) and L (too little) response categories (Appendix B).

Two important tables were extracted from this main summary table. Table 5 contains the marginal probability, P_{Mij}, of responding "too much" (M) for job j and salary i given the referent $21,000/Programmer pair. Table 6 contains the mean response times for each of the salary/occupation pairs and Table 6a contains the between subject standard deviations of the Table 6 response times. Within subject variability was not available since each subject made only one response to each stimulus pair.

The probability in each cell in Table 5 is denoted by P_{Mij}. For example, $P_{M6,1}$ is .338 which indicates that 33.8% of the subjects judged that $21,000 (row 6) was too much for a Teacher (column 1). As a second example, $P_{M13,3}$ is .754 which shows that 75.4% of the subjects judged that $45,000 was too much for a Lawyer.

The first step in analysing these data was to calculate the adopted or ideal salary value (ISV) for each occupation. The ISV for occupation O_j is defined as the point where P_{Mij}=.50. The ISV is the salary value for which half of the subjects judged that it was too much and half judged that it was too little, consequently $\upsilon_{ij}A = 0$, since $\upsilon A = \ln (P/1-P)$. Because the exact 50% point occurred in Table 5 for only one occupation (Teacher), an interpolation technique was used to estimate the ISV for each of the occupations. For each job, O_j, the best linear fit between the salary values (SV_{ij}) and $\upsilon_{ij}A$ was computed using only those probabilities greater than .05 and less than .95.

TABLE 5. Probability matrix for Experiment 2 compared comparison method containing the probability that the row-salary was judged "too much" for the column-occupation.

Salary Level	TEACHER	POLICEMAN	LAWYER	FARMER	FLIGHT ATTENDANT	PHYSICIAN	PROGRAMMER	WELDER	ENGINEER	PSYCHOLOGIST	SECRETARY	DENTIST	BARTENDER	ACCOUNTANT	BUS DRIVER	CHEMIST
$10,000	0	0	0	0	.050	0	0	0	0	0	.017	0	.101	0	.053	0
$12,000	.016	0	.016	.051	.051	0	0	.083	0	0	.100	0	.137	.016	.070	.016
$14,000	.016	.034	0	.017	.189	0	0	.103	0	0	.203	0	.372	0	.220	0
$16,000	.017	.067	.035	.152	.362	0	0	.222	0	0	.423	0	.596	0	.425	.016
$18,000	.150	.101	0	.362	.631	0	0	.385	.016	.033	.745	0	.844	.017	.714	.101
$21,000	.338	.288	.016	.568	.896	.016	0	.762	0	.050	.932	.033	.866	.120	.949	.122
$24,000	.500	.482	0	.714	.982	0	.933	.800	.050	.216	.983	.017	.982	.288	.966	.233
$27,000	.728	.706	.084	.864	1.000	.034	1.000	.900	.140	.338	.983	.100	1.000	.433	.983	.389
$30,000	.915	.775	.155	.833	.983	.035	1.000	.931	.237	.448	1.000	.192	1.000	.550	.983	.508
$33,000	.949	.827	.266	.862	.982	.116	1.000	.983	.372	.614	1.000	.315	.982	.689	1.000	.689
$37,000	.949	.932	.428	.950	.965	.338	1.000	.983	.603	.793	1.000	.500	1.000	.810	.983	.931
$41,000	1.000	.948	.627	.962	1.000	.456	1.000	.983	.830	.900	1.000	.694	1.000	.807	1.000	.948
$45,000	.983	.966	.754	.950	1.000	.542	1.000	1.000	.862	.898	.982	.736	.982	.890	1.000	.949
$49,000	.983	.983	.793	.966	1.000	.661	1.000	1.000	.883	.931	1.000	.810	1.000	.859	.981	1.000
$53,000	1.000	.983	.894	.983	1.000	.775	1.000	.982	.982	.931	1.000	.915	1.000	.966	1.000	.982

TABLE 6. Mean response times (in seconds) for Experiment 2 compared comparison method.

Salary Level	TEACHER	POLICEMAN	LAWYER	FARMER	FLIGHT ATTENDANT	PHYSICIAN	PROGRAMMER	WELDER	ENGINEER	PSYCHOLOGIST	SECRETARY	DENTIST	BARTENDER	ACCOUNTANT	BUS DRIVER	CHEMIST
$10,000	3.10	2.61	2.71	3.07	3.38	2.81	3.48	3.45	2.95	2.81	3.21	2.61	3.99	2.75	2.84	2.93
$12,000	2.89	2.98	2.48	3.35	4.28	2.86	4.39	3.42	2.97	2.98	4.27	2.79	4.36	2.81	4.07	2.72
$14,000	3.36	3.38	2.52	3.26	4.91	2.55	3.64	3.97	2.84	2.91	4.19	2.88	5.65	3.00	4.71	3.22
$16,000	3.39	3.62	2.94	4.67	4.50	2.72	3.80	3.73	2.92	3.63	5.12	2.67	6.43	3.07	4.78	3.22
$18,000	4.74	4.39	2.82	4.55	5.58	2.80	5.41	5.74	2.93	3.06	6.26	2.70	5.00	3.47	5.62	4.10
$21,000	5.45	5.05	2.81	5.18	4.34	3.21	--	5.82	3.43	4.10	4.80	3.52	4.12	4.32	4.35	4.17
$24,000	5.58	5.13	3.26	4.48	4.00	3.65	5.17	4.13	4.10	3.82	3.72	3.70	3.39	3.92	3.62	5.02
$27,000	5.22	4.76	4.65	4.03	3.23	4.08	4.98	3.93	4.37	4.27	3.09	4.40	3.21	4.73	3.11	4.83
$30,000	4.66	4.15	4.28	3.87	3.26	4.15	3.93	3.92	5.15	4.93	3.10	4.81	2.70	5.32	2.86	5.24
$33,000	3.75	3.82	5.47	3.27	2.93	4.89	4.08	4.04	5.23	5.05	3.06	5.24	2.95	4.90	3.03	5.50
$37,000	3.70	3.15	5.76	3.28	2.80	5.18	3.52	3.21	5.03	4.20	2.70	5.25	2.70	5.06	2.65	4.34
$41,000	3.58	3.69	4.35	3.03	2.83	4.79	3.39	3.25	3.99	3.68	3.05	4.27	2.51	3.26	2.75	3.99
$45,000	3.21	3.58	4.20	2.76	2.88	5.14	3.42	3.21	3.97	3.39	2.89	4.48	3.00	3.83	2.78	3.59
$49,000	3.12	2.85	4.24	3.28	3.12	4.92	3.42	2.86	4.31	3.29	3.09	3.45	2.56	3.60	2.67	2.83
$53,000	2.43	3.36	3.58	2.59	2.70	4.14	3.60	2.76	3.64	3.28	2.50	3.52	2.33	3.20	2.69	3.58

TABLE 6a. Standard deviations (in seconds) for response times in Table 6.

Salary Level	TEACHER	POLICEMAN	LAWYER	FARMER	FLIGHT ATTENDANT	PHYSICIAN	PROGRAMMER	WELDER	ENGINEER	PSYCHOLOGIST	SECRETARY	DENTIST	BARTENDER	ACCOUNTANT	BUS DRIVER	CHEMIST
$10,000	1.79	1.13	2.02	1.43	2.79	1.69	1.78	2.40	2.06	1.94	1.70	1.57	2.30	1.27	1.46	1.75
$12,000	1.76	1.65	1.06	2.33	2.69	1.67	3.25	2.43	2.08	2.00	3.59	2.14	3.18	2.38	3.20	1.47
$14,000	2.34	2.39	1.27	1.89	3.44	1.35	1.66	2.98	1.39	1.52	2.50	1.59	4.22	1.88	3.36	2.21
$16,000	2.30	2.39	2.14	3.98	3.02	1.47	2.39	2.08	1.51	2.93	3.17	1.43	4.33	2.00	3.14	2.09
$18,000	3.30	2.80	1.64	3.04	3.36	1.38	3.69	3.93	1.73	1.92	3.69	1.28	2.39	2.45	3.62	3.33
$21,000	4.13	3.35	1.35	3.99	2.40	1.90	--	4.56	1.85	2.36	3.14	2.44	2.58	3.41	2.56	2.50
$24,000	3.83	3.23	1.92	2.67	3.27	2.25	3.43	2.55	3.23	1.79	2.87	2.94	1.78	2.44	2.00	3.27
$27,000	3.60	2.14	3.71	2.07	1.59	2.84	3.47	2.10	2.89	2.79	1.64	3.05	2.47	3.12	1.33	3.16
$30,000	3.12	2.69	2.61	2.77	2.48	2.59	2.42	3.66	3.28	3.61	1.99	3.42	1.45	4.09	2.07	3.29
$33,000	2.22	2.59	4.30	1.87	1.55	3.61	2.60	3.23	3.18	3.54	2.24	3.54	1.92	3.60	2.09	3.67
$37,000	2.30	1.85	4.08	2.33	1.74	3.93	1.72	2.14	3.26	2.19	1.54	3.82	1.87	3.18	1.61	3.31
$41,000	2.63	2.80	2.43	1.70	1.50	3.27	1.98	2.25	2.48	2.68	2.67	2.42	1.21	2.32	1.86	2.87
$45,000	2.33	3.10	2.60	1.42	2.62	3.74	2.11	2.81	2.10	2.17	2.53	3.17	2.42	2.73	1.89	3.08
$49,000	2.07	1.59	2.67	2.33	1.95	3.29	2.31	2.08	3.29	2.28	2.68	2.18	1.54	1.84	1.78	1.66
$53,000	1.36	2.47	2.16	1.26	1.53	2.82	3.12	1.67	2.96	2.52	.99	2.57	1.24	2.05	1.41	3.02

Using this best fitting linear equation, the salary value was calculated for $\upsilon_{ij}A=0$. This was the ISV for occupation O_j.

As an example, the calculation of the ISV for occupation 2 (Policeman) is presented.

i	$SV_{i,2}$ (x $1000)	$P_{Mi,2}$	$\upsilon_{i,2}A$
4	16	.067	-2.634
5	18	.101	-2.186
6	21	.288	-0.905
7	24	.482	-0.072
8	27	.706	0.876
9	30	.775	1.237
10	33	.827	1.565
11	37	.932	2.618

(Data from Table 5, column 2; remember that $.05 < P_{Mij} < .95$).

The best fitting linear equation for these data is $\upsilon A = .2482$ (SV) - 6.329. At $\upsilon A=0$, SV = 6.329/.2482 = 25.50. Therefore, the estimated ISV for a Policeman is $25,500.

The second step in this analysis was to determine a scale value for each occupation. This was done by considering row 6 of Table 5, the row containing the probability of judging that $21,000 (the standard salary) was too much for each occupation. Using Equation (3), a value υ_jA can be calculated for each job using the mean probability P_{Mij} where $i = 6$, which will now be denoted as P_j. Since the probability must be greater than zero in order to calculate υ_jA, interpolation was used to obtain an estimate of P_j in cases where the observed probability value was less than .05.

The value $\upsilon_j A$ is then an estimate of the discriminability of each occupation, O_j, from the referent occupation (Programmer). Table 7 contains the estimates of the ideal salary, ISV_j and the occupation scale values, $\upsilon_j A$ for all sixteen occupations ordered from the highest ISV to the lowest. The best fitting linear equation is

$$ISV_j = 3.62\ (\upsilon_j A) + \$23,630$$

with a standard error of 2.73. Figure 8 shows a plot of the data compared to the best fitting line. The correlation between ISV and υA is $r = .958$ ($df=14$, $p < .001$).

The main prediction, Equation (4), is the relationship between response time and response probability measures:

$$RT_i = \frac{A}{\mu_i}(2P_{Mi}-1) + K$$

where A is the slope of the predicted line, μ_i is the amount of deviation from the ideal salary value for job i and K is a constant, mean non-decision component of the response time.

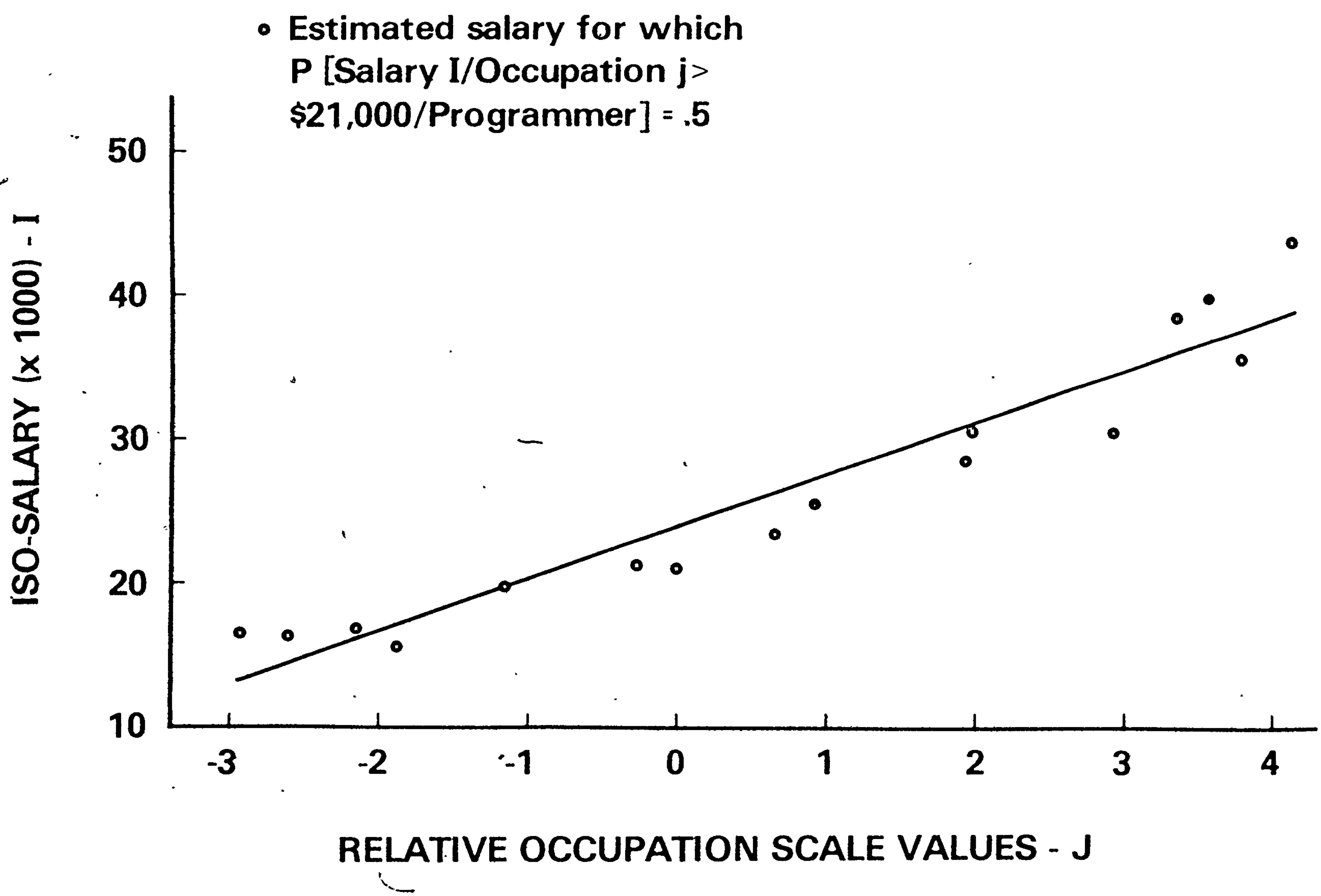
To accumulate the data for this analysis, the ISV for each value was taken from the previous analysis (Table 7) and, choosing a "standard deviation" of size $4,000, the response probability was computed for each deviation interval above and below the ISV for each job. For instance, the ISV for Policeman is $25,500. Therefore, one deviation below is $21,500 and two deviations below is $17,500. The probabilities from Table 5 which fall into these deviation intervals or "bins" are .482 in the first and .288 plus .101 in the second. This process was

Table 7

Estimates of the scale values ($\upsilon_j A$) and "ideal" salary values (ISV_j) for the 16 occupations in Experiment 2.

j	Occupation	P_j	$\upsilon_j A$	Observed ISV_j	Predicted ISV_j
1	Physican	.016	4.119	$43,909	$38,545
2	Engineer	.022	3.794	$35,639	$37,368
3	Lawyer	.028	3.585	$39,578	$36,611
4	Dentist	.034	3.378	$38,442	$35,862
5	Psychologist	.053	2.944	$30,518	$34,290
6	Accountant	.136	1.992	$30,298	$30,842
7	Chemist	.139	1.974	$28,527	$30,777
8	Policeman	.288	0.905	$25,499	$26,905
9	Teacher	.338	0.672	$23,421	$26,061
10	Programmer	.500	0.000	$21,000	$23,628
11	Farmer	.568	-0.274	$21,177	$22,635
12	Welder	.762	-1.164	$19,810	$19,412
13	Bartender	.866	-1.866	$15,409	$16,870
14	Flight Attendant	.896	-2.154	$16,930	$15,827
15	Secretary	.932	-2.618	$16,268	$14,146
16	Bus Driver	.949	-2.924	$16,413	$13,038

Figure 8. The relationship between income and occupation estimated from Experiment 2 data.



Estimated salary for which P [Salary I/Occupation j> $21,000/Programmer] = .5
ISO-SALARY (x 1000) - I
50
40
30
20
10
-3
-2
-1
0
1
2
3
4
RELATIVE OCCUPATION SCALE VALUES - J

performed for each job. The response choices and response times of all observations within an interval were averaged across all occupations. Also, the differences between the ISV and the various salary levels falling into an interval were averaged across all occupations. A schematic representation of this procedure is shown in Appendix B.

This accumulation process yielded the data presented in Table 8. There are nineteen intervals with mean deviation values ranging from -$33,910 to $36,750. These deviation values correspond to the subjective distance between the given salary levels and the subjects' adopted ideal salary function. Figure 9 graphically illustrates these results, showing the corresponding plots of the probability and response time data versus the average deviation from the ideal salary. The figure clearly shows the expected increase in response times as the deviation from the ideal salary value decreases. The plot of the probabilities versus the deviation values closely resembles the well known psychometric function. Also as expected, the peak of the response time function and the .50 point of the psychometric function are found very close to the zero deviation point.

The final analysis used the data from Table 8 to examine the Equation (4) predictions. The probability and deviation data were combined to form the $\frac{(2P-1)}{\mu}$ variable. Each deviation corresponds to a value of μ and an associated probability and response time. Using regression analysis, the best fitting line proved to be

$$RT = 16.77 \frac{(2P-1)}{\mu} + 2.28 \text{ seconds}$$

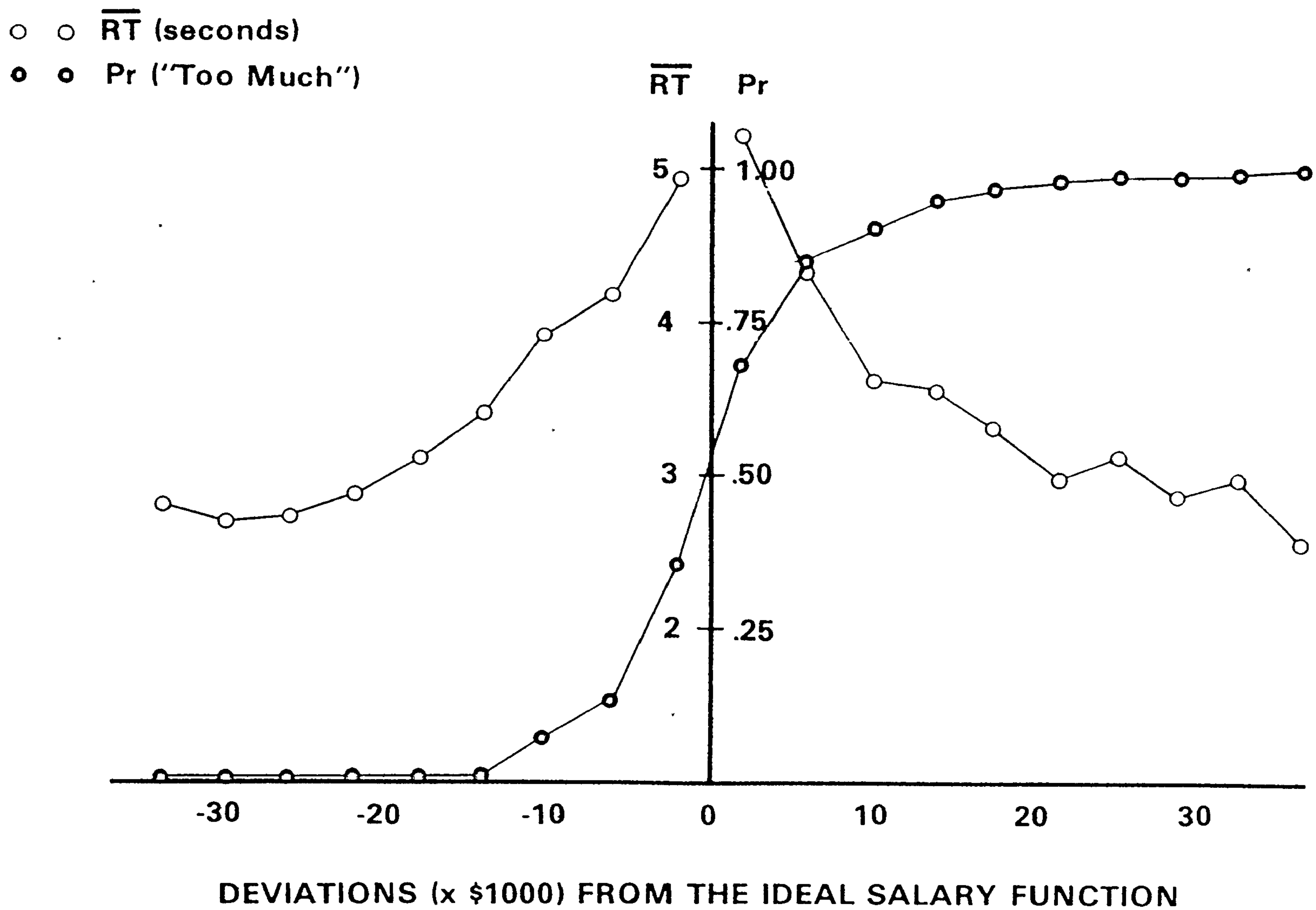
The data for this analysis appears in Table 9 and the expected linear

Table 8

The distribution of the distances (μ) of the probability of response M and the mean response time from the ideal salary values averaged across all occupations.

Deviation	Pr("Too Much")	RT (sec.)	N
-33.91	.000	2.81	1
-29.96	.000	2.68	4
-26.21	.002	2.73	7
-21.89	.005	2.86	9
-17.90	.011	3.11	12
-13.88	.015	3.40	14
-10.11	.068	3.91	18
- 6.04	.135	4.17	25
- 2.03	.359	4.94	24
1.85	.675	5.22	18
5.87	.854	4.33	21
10.03	.907	3.61	18
13.87	.948	3.55	15
17.55	.969	3.31	13
21.56	.979	2.97	12
25.35	.992	3.12	10
29.20	.993	2.86	8
32.70	.994	2.97	6
36.75	1.000	2.55	4

Figure 9. Mean response time and probability of response $M(P_M)$ as a function of the distance from the "ideal" salary.



RT (seconds)
Pr ("Too Much")
RT
Pr
5
4
3
2
1.00
.75
.50
.25
-30
-20
-10
0
10
20
30
DEVIATIONS (x $1000) FROM THE IDEAL SALARY FUNCTION

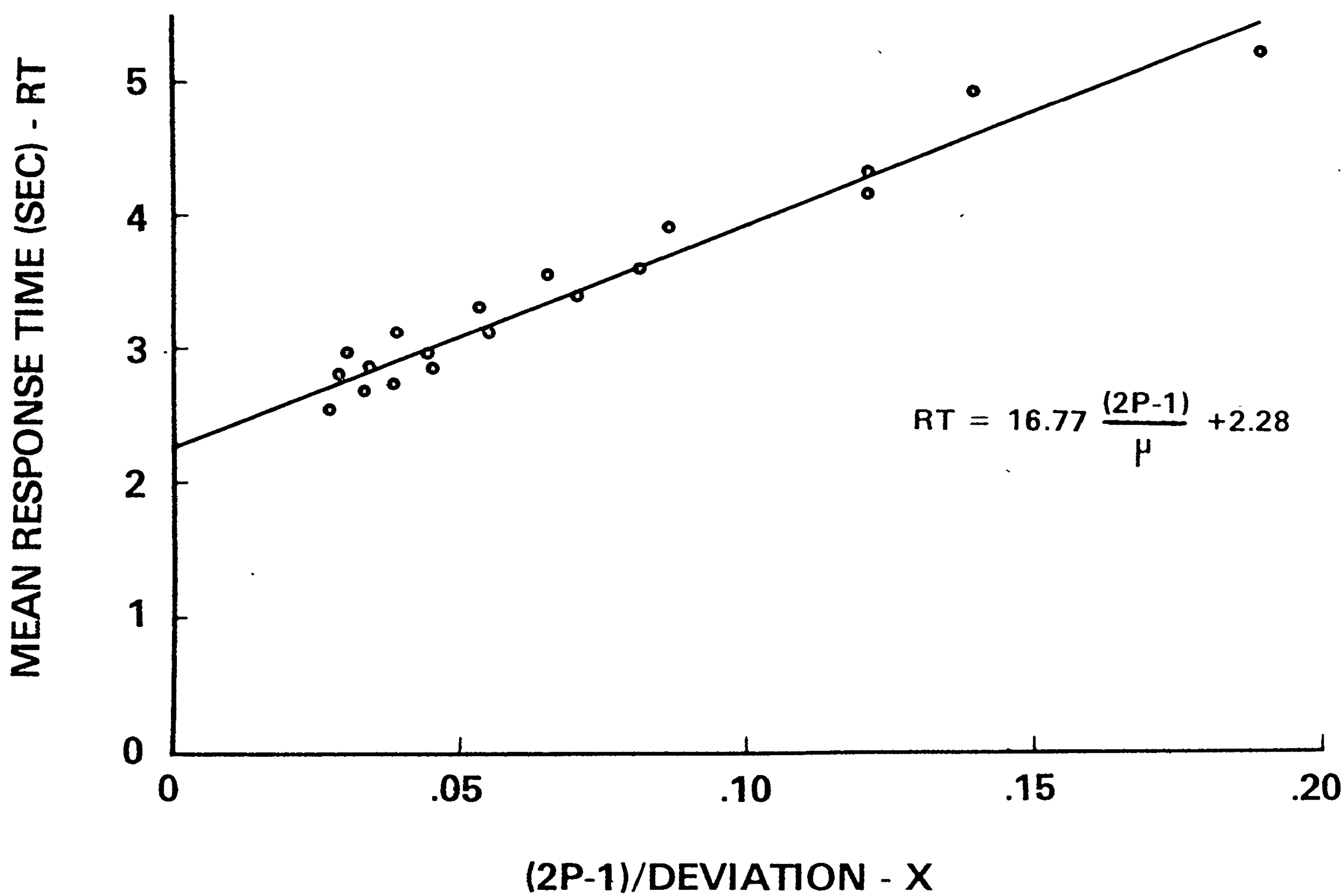
Table 9

Estimates of the probability variable $(2P_{Mi}-1)/\mu$, observed mean response time and predicted mean response time.

$\frac{2(P_M-1)}{\mu}$	Observed RT	Predicted RT
.029	2.81	2.77
.033	2.68	2.83
.038	2.73	2.92
.045	2.86	3.03
.055	3.11	3.20
.070	3.40	3.45
.086	3.91	3.72
.121	4.17	4.31
.139	4.94	4.61
.189	5.22	5.45
.121	4.33	4.31
.081	3.61	3.64
.065	3.55	3.37
.053	3.31	3.17
.044	2.97	3.02
.039	3.12	2.93
.034	2.86	2.85
.030	2.97	2.78
.027	2.55	2.73

relationship is clearly illustrated in Figure 10. The correlation of RT and $\frac{(2P-1)}{\mu}$ is .977.

Figure 10. The relationship between mean response time and $(2P_M-1)/\mu$.


MEAN RESPONSE TIME (SEC) - RT
5
4
3
2
1
0
0
.05
.10
.15
.20
RT = 16.77 (2P-1)/μ +2.28
(2P-1)/DEVIATION - X

Discussion

The problem addressed in this paper is the scaling of subjective values which have no obvious physical correlate. In psychophysics, scaling is often the assignment of numbers to sensory values of objects that can be physically measured. The present study applies the techniques used in psychophysical measurement to the scaling of social values.

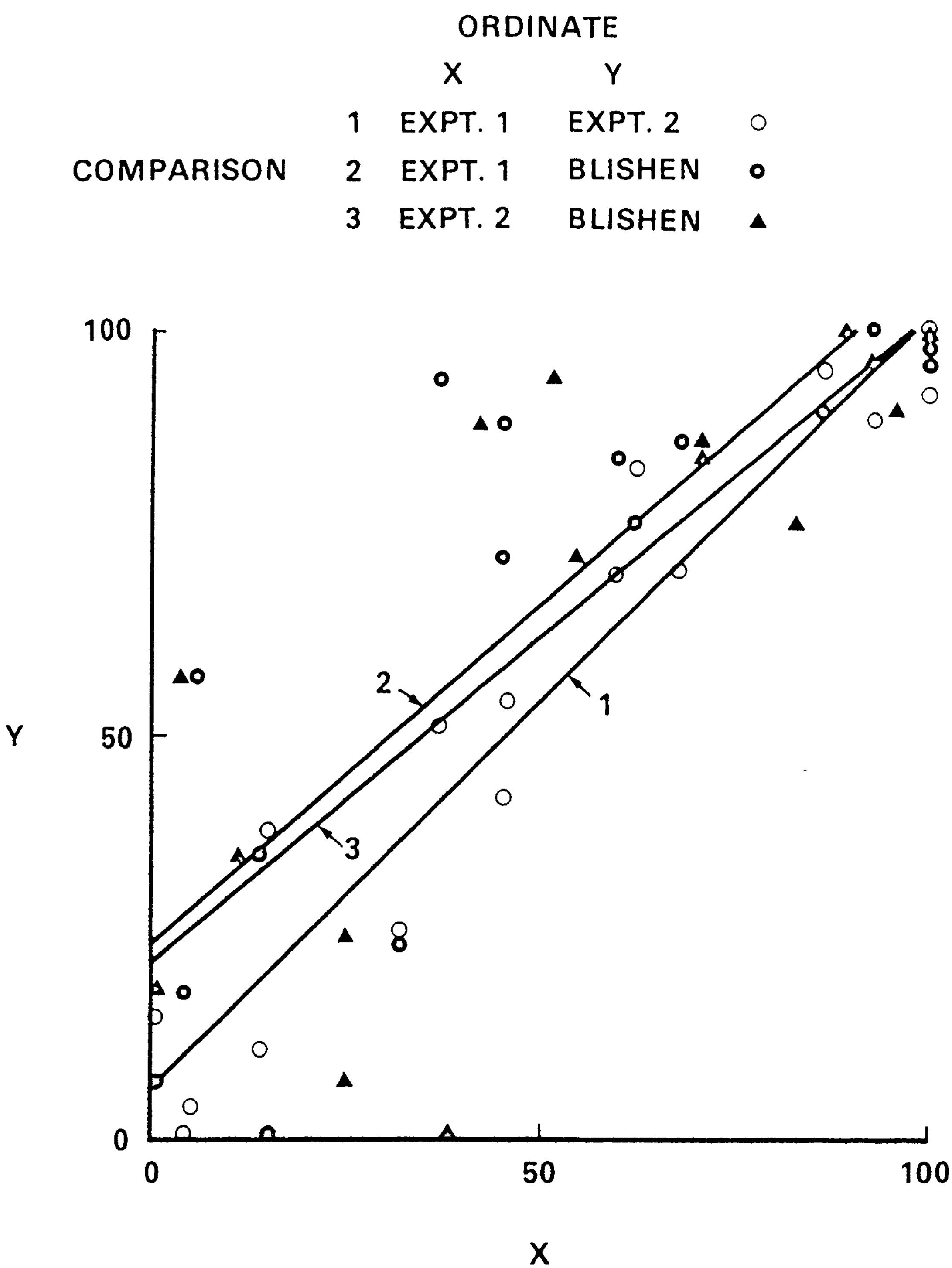
The first experiment applied Thurstone's law of comparative judgment to the problem of scaling occupations. Subjects judged pairs of occupations on the basis of which merited higher salary. As a check on the external validity of the resultant scale values, the subjects in experiment 1 were also asked to rank-order the occupations according to their salary and, finally, to estimate the annual salary of each occupation. The Thurstonian scale was in very close agreement with these alternative methods.

While the Thurstonian model is useful in the measurement of social values such as crimes and occupations, it does not invoke any underlying decision processes. Furthermore, it uses only one of several measures of a subject's performance in a discrimination task (i.e., probability). Other measures such as response latency and confidence are not considered. A more recent model, called relative judgment theory, extends the basic concepts of Thurstone's theory. Relative judgment theory assumes that in a two choice experiment; information necessary for a decision is accumulated over small units of time until one or another of the response thresholds is exceeded. This process is characterized by a sequential random walk between two absorbing barriers. The model assumes three parameters: the distance to the barriers (A or -A); the starting position of the random walk process (C); and a measure of the discriminability of the stimuli (θ). This process not only provides sensory scale values for stimuli, but also makes testable predictions about the well known relation between response time and response probability. In general, this relation, is that choice response time decreases as the psychological distance between two sensory values increases.

A study by Link (1980) showed that relative judgment theory gives scale values for the seriousness of various crimes which agreed very well with other measures of seriousness. The second experiment of this thesis tested the ability of relative judgment theory to provide scale values for occupations. In order to compare scale values between experiments, the values were standardized by transforming the data from each to a 0 to 100 scale.

In Figure 11, a comparison of the scale values for sixteen occupations obtained from experiment 1 and experiment 2 show the high general correlation between the results of the two methods. As an additional comparison to the results of the present study, Figure 11 includes values (transformed to the 0-100 scale) from the Blishen socioeconomic index for each of the occupations. The Blishen index is generated by substituting values for three variables (income, education, and prestige) into a regression equation. This scale is included for interest only since the data used to determine the index values were

Figure 11. A comparison of the relative positions of occupations from scales found by Experiment 1, Experiment 2, and Blishen & McRoberts.


ORDINATE
X
Y
COMPARISON
1 EXPT. 1 EXPT. 2
2 EXPT. 1 BLISHEN
3 EXPT. 2 BLISHEN
100
50
0
Y
X
2
1
3

collected in the 1971 census and as Blishen and McRoberts (1976) point out, significant changes in the three regression variables are likely over a ten year period such as were noted between 1961 and 1971.

Furthermore, results from a study by Burton (1972) were derived from the rank order of the occupation names according to income. Burton used an incomplete paired-comparison design to collect the data but the resulting scale values were not reported. Of the eleven occupations in common to the Burton study and experiment 2, the rank orders showed good agreement (Spearman's rho = .836, $p < .01$).

The results from experiment 2 also show the predicted linear relation between mean response time and a function of response probability. Link previously demonstrated this relationship for a variety of psychophysical experiments as well as for the crime and punishment study data. An indication of the robustness of the model is that, while most of the response time data from the psychophysical experiments ranges from 250 to 700 milliseconds, the mean response times in the social value studies are about ten times longer, that is, from 2.5 to 6.5 seconds.

One point of interest in the results of experiment 2 is the relation shown in Figure 8 between occupation scale values ($\upsilon_i A$) and the perceived ideal salary for each occupation (ISV_i). Rather than being linear as would be expected under assumptions of equal variance; this relation is distinctly curvilinear. It is likely that the variance of the ideal salary values increases with the magnitude of the mean for each occupation as suggested by Stevens (1966). For example, the ideal salary for a physician fluctuates more at the $45,000 to $50,000 level than that of a bartender at about $13,000. The range tends to be more restricted at the lower levels. If the variance increases with salary level, then the inappropriate assumption of equal variance may cause the method of computing σA used here to generate a curvilinear relation.

Other recent studies show suport for the random walk model. Link (1978) showed that the psychometric function can be derived from the model. Noreen's (1979) thesis demonstrated that the random walk model predicted more accurately than Signal Detection Theory (Green & Swets, 1966) or Choice Theory (Luce, 1959) the interdependence of sensitivity and bias. In a lexical decision study, Kames (1980) found support for the model in experiments involving "same-different" judgments for words and non-words. These studies, along with the present study, provide support for the broad applicability of relative judgment theory in the investigation of decision processes.

In conclusion, this paper demonstrates a technique for jointly measuring values on two cognitive dimensions, in this case, salary and occupation. The cross-dimensional nature of the compared comparison procedure provides a method of collecting a subject's judgments about the joint distribution of two related subjective dimensions. In experiment 2, the subjects' perception of salaries for various occupations was measured. In psychophysics, the comparison of two sets of stimuli was typically cross-modal, that is, a subject was asked to make judgments about values on two distinct sensory continua, such as the perceived intensity of a tone and of a light. The new technique, however, reveals a subject's perception about two mental dimensions considered simultaneously. It provides scale values in a twodimensional cognitive space by hypothesizing that subjects form an ideal relation between these dimensions, as illustrated for the occupations and salaries results in Figure 8. The ideal relation permits comparisons to be made on a single subjective dimension. Thus relative judgment theory and the compared-comparison technique provide a framework for exploring the relations between one mental concept and another.

References

Baird, J.C. & Norma, E. Fundamentals of scaling and psychophysics. New York: Wiley, 1978.

Blishen, B.R., & McRoberts, H.A. A revised socioeconomic index for occupations in Canada. Canadian Review of Sociology and Anthropology, 1976, 13, 71-73.

Bock, D.R., & Jones, L.V. The measurement and prediction of judgment and choice. San Francisco: Holden-Day, 1968.

Burton, M. Semantic dimensions of occupation names. In A.K. Ronney, R.N. Shepard & S.B. Nerlove (Eds.), Multidimensional Scaling: Volume II. New York: Seminar Press, 1972.

Coombs, C.H. A theory of data. Psychological Review, 1960, 67, 143 - 159.

Coombs, C.H. A theory of data. New York: Wiley, 1964.

Coombs, C.H. Thurstone's measurement of social values revisited forty years later. Journal of Personality Social Psychology, 1967, 6, 85-91.

Coombs, C.H., Dawes, R.M. & Tversky, A. Mathematical psychology. Englewood Cliffs: Prentice Hall, 1970.

David, H.A. The method of paired comparisons. New York: Hafner Press, 1969.

Engen, T. Psychophysics II. Scaling Methods. In J.W. Kling and L.A. Riggs (Eds.), Experimental Psychology (3rd edition), New York: Holt, Rinehart and Winston, 1971.

Festinger, L. Studies in decision: I. Decision time, relative frequency of judgment and subjective confidence as related to physical stimulus difference. Journal of Experimental Psychology, 1943, 32, 291-306.

Green, D.M., & Swets, J.A. Signal detection theory and psychophysics. New York: Wiley, 1966.

Helson, H. Adaptation level theory. In S. Koch (Ed.), Psychology: A study of a science. New York: McGraw-Hill, 1959, 565-621.

Henmon, V.A.C. The relation of the time of judgment to its accuracy. Psychological Review, 1911, 18, 186-201.

Horst, P. A method for determining the absolute affective value of a series of stimulus situations. Journal of Educational Psychology, 1932, 23, 418-440.

Johnson, D.M. Generalization of a scale of values by the averaging of practice effects. Journal of Experimental Psychology, 1944, 34, 425-436.

Kames, A.J. Same-different comparison processes for words and non-words: a random walk model. Ph.D. Thesis, New York University, 1980.

Kellogg, W.N. The time of judgment in psychometric measures. American Journal of Psychology, 1931, 43, 65-86.

Link, S.W. Applying RT deadlines to discrimination reaction time. Psychonomic Science, 1971, 25, 355-358.

Link, S.W. The relative judgment theory of two choice response time. Journal of Mathematical Psychology, 1975, 12, 114-135.

Link, S.W. The relative judgment theory of the psychometric function. In J. Requin (Ed.), Attention and Performance VII. Hillsdale: Erlbaum, 1978, 619-630.

Link, S.W. Crime versus punishment. Thirteenth Annual Mathematical Psychology Meetings, Madison, Wisconsin. August, 1980.

Link, S.W. & Heath, R.A. A sequential theory of psychological discrimination. Psychometrika, 1974, 40, 77-105.

Luce, R.D. Individual choice behavior. New York: Wiley, 1959.

Miller, G.A. Mathematics and psychology. New York: Wiley, 1964.

Noreen, D.L. Analysis of some mathematical models for choice and decision. Ph.D. Thesis, Rockefeller University, 1979.

Stevens, S.S. A metric for the social concensus. Science, 1966, 151, 530-541.

Thorndike, E.L. Handwriting. Teachers College Record. 1910, 11, 93.

Thurstone, L.L. A law of comparative judgment. Psychological Review, 1927a, 34, 273-286.

Thurstone, L.L. The method of paired comparisons for social values, Journal of Abnormal and Social Psychology, 1927b, 21, 384-400.

Thurstone, L.L. The measurement of values. New York: Wiley, 1959.

Torgerson, W.S. Theory and methods of scaling. New York: Wiley, 1958.

List of Appendices

Appendix A

Experiment 1

Descriptions of Occupations

ACCOUNTANT plans and administers accounting systems for organizations and private persons to provide records of assets, liabilities and financial transactions, and advises on accounting problems.

AIRPLANE PILOT pilots airplanes to transport passengers, mail and freight: prepares or examines prepared flight plan.

BARTENDER mixes and serves alcoholic and non-alcoholic drinks to patrons of bar, following standard recipes.

BUS DRIVER operates gasoline, diesel or electric-powered bus to transport passengers over established or other routes.

CHEMIST conducts basic research to extend knowledge of the science of chemistry, and/or conducts applied research to develop new or improved materials, compounds and substances for commercial purposes.

DENTIST diagnoses and treats diseases, injuries and malformations of teeth, gums and related oral structures and prescribes and administers preventive procedures.

ENGINEER prepares design proposals and advices on works and facilities such as roads, railways, bridges, dams, sewage and waste disposal systems and building structures, and coordinates their construction and maintenance.

FARMER operates a farm to grow one or more specific crops such as fruit, tobacco, grain or vegetables.

FLIGHT ATTENDANT performs a number of duties to give personal service t passengers on airliner to make their trip safe and enjoyable.

LAWYER prepares and pleads cases in courts of justice, draws up legal documents, advises clients and practises other aspects of law.

NURSE gives nursing care to patients in hospitals, nursing homes, extended care facilities and other establishments.

PHYSICIAN conducts medical examinations, makes diagnoses, prescribes medicines and gives other medical treatments for disease, disorders and injuries of the human body.

POLICEMAN patrols assigned areas on foot or using motor vehicle or motor boat to enforce federal or provincial statutes and municipal laws and regulations.

PROGRAMMER writes programs in computer-process language to provide data for mana ent and to resolve business problems.

PSYCHOLOGIST collects, interprets and applies scientific data relating to behaviour and mental processes: Studies human actions and mental processes and investigates and recommends or provides treatment for psychological problems.

SECRETARY schedule appointments, provide information to callers, take dictation and relieve employer of clerical work and administrative and business details.

TEACHER teaches academic subjects in a secondary school: specializes in one or more subjects in the academic field such as languages and literature, mathematics, science and social studies.

WELDER welds metal parts together to fabricate or repair parts and equipment, using arc welding equipment.

INSTRUCTIONS

The purpose of this study is to collect the opinions of several groups of people about the relationship between jobs and salaries. On the first 3 pages of this booklet you will find the definitions of 18 jobs. Please read them carefully and then turn to the next 2 pages where you will find the definitions listed by not labelled. The names are at the bottom of the pages and we ask that you match the definition with the appropriate label in the space provided. You should then check your answers with the full list on pages 1 to 3.

INSTRUCTIONS PART A

Now, on the remaining pages you will find all 18 jobs arranged in pairs. Your task is to decide which of each pair is paid more money (i.e. has a higher annual income) and to underline it.

Example:

MAILMAN ----- FIRE FIGHTER

You would underline fire fighter if you thought it paid a higher income.

If you find a pair of jobs that you think earn about the same salary, be sure to underline one anyway, even if you have to make a sort of guess.

Remember, be sure to underline one in each pair and complete each page before starting the next one. Once a page is completed, do not turn back to it again.

INSTRUCTIONS PART B

Your task in this part is to arrange the 18 jobs in descending order so that the one that earns the highest annual income is at the top and the lowest is at the bottom.

If you think that two jobs earn about the same salary, place one below the other even if you have to make a kind of guess.

INSTRUCTIONS PART C

In this final section, your task is to estimate the annual income of each of the 18 jobs. Please place your answer to the nearest thousand dollars in the space.

Once you have completed a page, go on to the next; do not look back to any of the completed pages.

Random order for the 153 pairs of
occupations used in Experiment 1.

1	DENTIST	CHEMIST
2	PSYCHOLOGIST	SECRETARY
3	WELDER	TEACHER
4	NURSE	PHYSICIAN
5	FLIGHT ATTENDANT	LAWYER
6	ACCOUNTANT	AIRPLANE PILOT
7	BUS DRIVER	BARTENDER
8	FARMER	ENGINEER
9	POLICEMAN	PROGRAMMER
10	PSYCHOLOGIST	POLICEMAN
11	ACCOUNTANT	BARTENDER
12	ENGINEER	CHEMIST
13	PROGRAMMER	TEACHER
14	BUS DRIVER	AIRPLANE PILOT
15	FLIGHT ATTENDANT	NURSE
16	WELDER	SECRETARY
17	DENTIST	FARMER
18	PHYSICIAN	LAWYER
19	AIRPLANE PILOT	BARTENDER
20	BUS DRIVER	ACCOUNTANT
21	DENTIST	ENGINEER
22	WELDER	PROGRAMMER
23	POLICEMAN	SECRETARY
24	PHYSICIAN	FLIGHT ATTENDANT
25	PSYCHOLOGIST	TEACHER
26	NURSE	LAWYER
27	CHEMIST	FARMER
28	POLICEMAN	FLIGHT ATTENDANT
29	BARTENDER	ENGINEER
30	TEACHER	SECRETARY
31	AIRPLANE PILOT	DENTIST
32	PSYCHOLOGIST	NURSE
33	LAWYER	PROGRAMMER
34	CHEMIST	ACCOUNTANT
35	BUS DRIVER	FARMER
36	WELDER	PHYSICIAN
37	BARTENDER	FARMER
38	ENGINEER	BUS DRIVER
39	PHYSICIAN	TEACHER
40	PROGRAMMER	FLIGHT ATTENDANT
41	LAWYER	POLICEMAN
42	DENTIST	ACCOUNTANT
43	AIRPLANE PILOT	CHEMIST
44	SECRETARY	NURSE
45	PSYCHOLOGIST	WELDER

46	TEACHER	NURSE
47	BUS DRIVER	DENTIST
48	CHEMIST	BARTENDER
49	LAWYER	SECRETARY
50	FARMER	AIRPLANE PILOT
51	FLIGHT ATTENDANT	PSYCHOLOGIST
52	PROGRAMMER	PHYSICIAN
53	POLICEMAN	WELDER
54	ENGINEER	ACCOUNTANT

55	PROGRAMMER	PSYCHOLOGIST
56	TEACHER	LAWYER
57	NURSE	WELDER
58	DENTIST	BARTENDER
59	AIRPLANE PILOT	ENGINEER
60	SECRETARY	FLIGHT ATTENDANT
61	BUS DRIVER	CHEMIST
62	FARMER	ACCOUNTANT
63	PHYSICIAN	POLICEMAN

64	SECRETARY	ENGINEER
65	FARMER	TEACHER
66	PROGRAMMER	CHEMIST
67	BUS DRIVER	POLICEMAN
68	WELDER	LAWYER
69	DENTIST	PSYCHOLOGIST
70	NURSE	AIRPLANE PILOT
71	BARTENDER	PHYSICIAN
72	FLIGHT ATTENDANT	ACCOUNTANT

73	AIRPLANE PILOT	PHYSICIAN
74	POLICEMAN	CHEMIST
75	DENTIST	SECRETARY
76	NURSE	BARTENDER
77	ACCOUNTANT	LAWYER
78	TEACHER	FLIGHT ATTENDANT
79	BUS DRIVER	PROGRAMMER
80	WELDER	FARMER
81	ENGINEER	PSYCHOLOGIST

82	PHYSICIAN	BUS DRIVER
83	ACCOUNTANT	NURSE
84	WELDER	FLIGHT ATTENDANT
85	FARMER	SECRETARY
86	PSYCHOLOGIST	CHEMIST
87	AIRPLANE PILOT	LAWYER
88	PROGRAMMER	DENTIST
89	ENGINEER	TEACHER
90	POLICEMAN	BARTENDER

91	CHEMIST	SECRETARY
92	NURSE	BUS DRIVER
93	ENGINEER	PROGRAMMER
94	LAWYER	BARTENDER
95	DENTIST	WELDER
96	TEACHER	POLICEMAN
97	AIRPLANE PILOT	FLIGHT ATTENDANT
98	PHYSICIAN	ACCOUNTANT
99	FARMER	PSYCHOLOGIST

100	NURSE	FARMER
101	ENGINEER	LAWYER
102	PSYCHOLOGIST	BARTENDER
103	PHYSICIAN	SECRETARY
104	POLICEMAN	ACCOUNTANT
105	CHEMIST	WELDER
106	PROGRAMMER	AIRPLANE PILOT
107	DENTIST	FLIGHT ATTENDANT
108	TEACHER	BUS DRIVER

109	ENGINEER	NURSE
110	FLIGHT ATTENDANT	CHEMIST
111	BARTENDER	TEACHER
112	PROGRAMMER	ACCOUNTANT
113	FARMER	POLICEMAN
114	LAWYER	DENTIST
115	PHYSICIAN	PSYCHOLOGIST
116	WELDER	BUS DRIVER
117	AIRPLANE PILOT	SECRETARY

118	NURSE	DENTIST
119	ENGINEER	POLICEMAN
120	WELDER	BARTENDER
121	PROGRAMMER	SECRETARY
122	TEACHER	AIRPLANE PILOT
123	BUS DRIVER	FLIGHT ATTENDANT
124	PHYSICIAN	FARMER
125	ACCOUNTANT	PSYCHOLOGIST
126	LAWYER	CHEMIST

127	DENTIST	PHYSICIAN
128	PROGRAMMER	NURSE
129	ENGINEER	WELDER
130	PSYCHOLOGIST	BUS DRIVER
131	FARMER	LAWYER
132	SECRETARY	ACCOUNTANT
133	BARTENDER	FLIGHT ATTENDANT
134	POLICEMAN	AIRPLANE PILOT
135	CHEMIST	TEACHER

136	TEACHER	ACCOUNTANT
137	BARTENDER	PROGRAMMER
138	POLICEMAN	DENTIST
139	AIRPLANE PILOT	WELDER
140	PHYSICIAN	ENGINEER
141	FARMER	FLIGHT ATTENDANT
142	PSYCHOLOGIST	LAWYER
143	CHEMIST	NURSE
144	SECRETARY	BUS DRIVER

145	BARTENDER	SECRETARY
146	PHYSICIAN	CHEMIST
147	ACCOUNTANT	WELDER
148	LAWYER	BUS DRIVER
149	DENTIST	TEACHER
150	FLIGHT ATTENDANT	ENGINEER
151	AIRPLANE PILOT	PSYCHOLOGIST
152	POLICEMAN	NURSE
153	FARMER	PROGRAMMER

Appendix B

Experiment 2

INSTRUCTIONS

The purpose of this study is to ascertain the opinions of several groups of people about the relationship between jobs and salaries. Your first task is to learn the definitions of the professions and then fill in the questionnaire which follows. You should not spend more than 10 minutes learning the definitions and answering the questionnaire. Please do not memorize, just be sure you understand the definition of each job. When you are finished, inform the experimenter and he will show you how to operate the computer terminal so you can begin to make judgments about jobs and salaries.

When you are working on the computer terminal, you will be required to make only two kinds of responses; either a more (press the M key) or a less (press the L key). The stimuli that will appear on the screen is a pair of job-salary couplets. The question we want answered is the following:

IS $12,000 FOR A(N) FIRE FIGHTER
TOO MUCH (M) OR TOO LITTLE (L)
COMPARED TO $21,000 FOR A PROGRAMMER?

In this case, if you think that $12,000 for a fire fighter is too little (considering that a programmer earns $21,000), you would press the "L" key. Otherwise, you would press the "M" key, if you think, that $12,00 is too much for a fire fighter.

The stimuli will remain on the screen until you make your choice; M or L. After pressing either M or L, depress the space bar to enter your response and to initiate the next trial. If you make an error but have not yet pressed the space bar, simply press the X key and then the space bar. This will allow you to enter the correct response. If you have entered an incorrect answer, write down the pair of stimuli and the correct response so that it can be corrected later.

At a certain time, the screen will print a message asking if you would like a short break. If you do (it is recommended) you may take as long as you wish up to 5 minutes. You are free to walk about and stretch if you like; then resume your task. The whole procedure should not take more than 50 minutes.

Please work quickly but be sure to consider your responses carefully.

Thank you

Experiment 2 - Raw data

			TCH	POL	LAW	FAR	FLT	DOC	PSG	WLD	ENG	[illegible]	SEC	FEM	BAR	ARC	BUS	CHM
$53,000																		
	MORE	PR	1000	[illegible]	17	0	17	102	123	273	390	508	690	[illegible]	[illegible]	[illegible]	1000	983
		RT	269	[illegible]	460	0	503	915	635	685	581	458	508	412	572	302	295	361
	LESS	PR	0	1000	983	1000	983	898	877	767	610	492	310	69	52	51	0	17
		RT	0	293	268	322	319	353	386	446	421	613	644	728	881	853	0	191
	MARG	RT	269	293	271	322	322	410	417	502	483	524	550	434	398	358	283	358
$49,000																		
	MORE	PR	860	966	34	70	220	426	714	949	967	983	983	1000	[illegible]	1000	[illegible]	[illegible]
		RT	331	[illegible]	249	714	573	493	595	434	768	304	281	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	LESS	PR	140	34	966	930	730	574	286	51	33	17	17	0	[illegible]	0	0	[illegible]
		RT	543	377	286	384	442	468	477	461	203	722	602	0	1057	0	0	189
	MARG	RT	361	321	294	407	471	479	562	435	362	311	286	303	265	275	279	268
$45,000																		
	MORE	PR	982	1000	1000	0	17	0	0	18	121	298	433	550	[illegible]	810	807	891
		RT	290	256	233	0	168	0	0	950	749	410	508	521	494	505	31	[illegible]
	LESS	PR	18	0	0	1000	983	1000	1000	982	379	712	567	450	510	190	193	109
		RT	857	0	0	275	283	300	307	337	388	385	447	545	490	507	353	591
	MARG	RT	300	256	233	275	281	300	307	346	432	392	473	532	490	506	326	383
$41,000																		
	MORE	PR	695	737	810	915	102	138	373	596	945	867	982	1000	1000	983	1000	1000
		RT	424	420	306	332	729	830	699	757	489	377	343	321	270	289	270	261
	LESS	PR	305	263	190	85	898	862	627	404	155	133	18	0	0	17	0	0
		RT	432	526	511	563	362	373	486	474	557	639	119	0	0	619	0	0
	MARG	RT	426	448	345	352	399	436	565	643	500	412	339	321	270	295	270	261
$37,000																		
	MORE	PR	1000	1000	982	1000	1000	0	0	0	0	0	33	18	100	193	316	500
		RT	270	305	292	309	250	0	0	0	0	0	1007	1014	843	670	642	511
	LESS	PR	0	0	18	0	0	1000	1000	1000	1000	1000	967	982	900	807	684	500
		RT	0	0	134	0	0	261	279	298	267	270	330	358	395	476	470	540
	MARG	RT	270	305	289	309	250	261	279	298	267	270	353	370	440	481	524	525
$33,000																		
	MORE	PR	614	793	900	898	931	931	17	100	203	424	746	932	983	983	1000	1000
		RT	512	396	361	321	322	291	152	520	616	625	657	432	353	310	310	306
	LESS	PR	386	207	100	102	69	69	983	900	797	376	254	68	17	17	0	0
		RT	494	509	429	501	417	834	324	417	368	428	536	457	221	258	0	0
	MARG	RT	505	419	368	339	329	328	321	427	418	511	626	480	372	309	310	306
$30,000																		
	MORE	PR	237	373	603	931	862	883	983	0	0	0	0	33	51	217	339	448
		RT	630	531	470	391	386	374	344	0	0	0	0	584	558	496	415	522
	LESS	PR	763	627	397	169	138	117	17	1000	1000	1000	1000	967	949	793	661	552
		RT	479	518	553	438	462	862	1550	281	298	291	363	297	402	351	433	469
	MARG	RT	515	523	503	399	396	431	365	281	298	291	363	307	410	382	427	493
$27,000																		
	MORE	PR	900	931	983	983	983	1000	1000	982	0	0	0	0	17	0	51	140
		RT	401	389	387	316	310	321	286	278	0	0	0	0	273	0	590	669
	LESS	PR	100	69	17	17	17	0	0	18	1000	1000	1000	1000	983	1000	[illegible]	[illegible]
		RT	324	435	1405	630	1225	0	0	137	295	297	284	292	294	343	400	[illegible]
	MARG	RT	393	392	404	321	325	321	286	276	295	297	284	292	294	343	410	437

Experiment 2 - Raw data (continued)

$24,000																	
MORE	PR	933	1000	1000	1000	1000	1000	1000	1000	1000	0	83	103	222	386	763	800
	RT	503	498	393	408	352	339	342	342	360	0	530	536	495	689	570	436
LESS	PR	67	0	0	0	0	0	0	0	0	1000	917	897	779	614	237	200
	RT	705	0	0	0	0	0	0	0	0	345	325	381	339	502	618	320
MARG	RT	516	498	393	408	352	339	342	342	360	345	342	397	374	574	581	413
$21,000																	
MORE	PR	17	0	34	35	117	339	456	542	661	776	0	0	0	0	0	0
	RT	151	0	526	500	512	628	542	465	454	390	0	0	0	0	0	0
LESS	PR	983	1000	966	965	883	661	544	458	339	224	1000	1000	1000	1000	1000	1000
	RT	324	366	404	412	486	461	427	573	567	497	348	439	364	330	541	0
MARG	RT	321	366	408	415	489	518	479	514	492	414	348	439	364	330	541	0
$18,000																	
MORE	PR	632	897	983	1000	983	983	966	1000	1000	1000	1000	0	0	0	0	0
	RT	575	424	385	323	327	292	280	293	288	312	270	0	0	0	0	0
LESS	PR	368	103	17	0	17	17	34	0	0	0	0	1000	1000	1000	1000	1000
	RT	529	527	1238	0	255	326	282	0	0	0	0	281	286	255	272	280
MARG	RT	558	435	400	323	326	293	280	293	288	312	270	281	286	255	272	280
$16,000																	
MORE	PR	153	362	569	714	864	833	862	950	963	950	966	983	51	52	190	362
	RT	400	538	473	396	413	334	308	327	293	275	324	251	341	611	717	576
LESS	PR	847	638	431	286	136	167	138	50	37	50	34	17	949	948	810	638
	RT	479	407	577	578	339	648	420	335	577	287	444	696	338	418	438	378
MARG	RT	467	454	518	448	403	386	328	327	304	276	329	258	333	428	191	450
$14,000																	
MORE	PR	0	35	0	17	0	85	155	267	429	627	754	793	895	0	52	17
	RT	0	249	0	123	0	814	429	717	545	426	412	389	349	0	908	326
LESS	PR	1000	965	1000	983	1000	915	845	733	571	373	246	207	105	1000	948	982
	RT	252	295	282	284	326	433	428	486	598	451	443	556	443	307	304	326
MARG	RT	252	293	282	281	326	465	428	548	575	435	420	424	359	307	335	326
$12,000																	
MORE	PR	0	34	68	102	288	483	707	776	828	932	948	966	983	983	0	17
	RT	0	977	509	459	462	310	474	386	355	315	343	361	295	312	0	414
LESS	PR	1000	966	932	898	712	517	293	224	172	68	52	34	17	17	1000	983
	RT	298	315	351	436	523	516	481	518	513	322	855	299	315	1703	271	250
MARG	RT	298	338	362	438	505	513	476	416	382	315	369	359	295	336	271	248
$10,000																	
MORE	PR	0	17	17	18	150	339	500	729	915	949	949	1000	983	983	1000	0
	RT	0	164	1616	493	670	659	507	454	469	364	355	358	323	315	243	0
LESS	PR	1000	983	983	982	850	661	500	271	85	51	51	0	17	17	0	1000
	RT	310	291	314	337	439	486	609	703	433	568	638	0	183	149	0	261
MARG	RT	310	299	336	340	474	545	558	522	466	374	369	358	321	312	243	261

Illustration of the accumulation of response time and probability data into deviation intervals for Figure 9.

DEVIATIONS FROM IDEAL SALARY (x $1000)

		-30			-20		-10			0		10			20		30
SALARY LEVELS	TEACHER					. .	. .	. .	.	. .	.	.	.	.	.	.	.
	POLICEMAN					. .	. .	.	.	.	. .	.	.	.	.	.	
	LAWYER	.	. .	. .	.	. .	.	.	.	.	.	.	.				
$PR(R_M)$	TEACHER					.000	.016 .016	.017 .150	.338	.500 .728	.915	.949	.949	1.0	.983	.983	1.0
	POLICEMAN					.000 .000	.034 .067	.101 .288	.482	.706	.775 .827	.932	.948	.966	.983	.983	
	LAWYER	.000	.016 .000	.035 .000	.016	.000 .084	.155	.266	.428	.627	.754	.793	.894				
MEAN RF	TEACHER					310	289 336	340 474	545	558 522	466	374	369	358	321	312	243
	POLICEMAN					261 298	338 362	438 505	513	476	416 382	315	369	359	286	336	
	LAWYER	271	248 252	293 282	281	326 465	428	548	575	435	420	424	359				