EXTENDED CONJOINT ANALYSIS WITH INTENSITY MEASURES AND COMPUTER ASSISTED INTERVIEWS APPLICATIONS TO TELECOMMUNICATIONS AND TRAVEL

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Abstract

This paper reports two advances in the measurement of consumer preferences. First, a general theory extends conjoint measurement from ordinal measures (rank order only) to more effective and efficient intensity measures (interval, ratio, or hybrid). Tests are given to identify the appropriate theory to describe consumer response and procedures are given to estimate the preference functions. Second, a marketing information system (P.A.R.I.S.) is described which can automatically encode any questionnaire on an interactive computer system for computer assisted interviewing. P.A.R.I.S. has special commands for the preference measurement questions; it automatically stores all data in special files for easy access and has a subroutine for the improved conjoint analysis. The general theory as implemented through P.A.R.I.S. is illustrated with a case application to the analysis of consumer preference for new telecommunications technology. Comparisons are made to standard conjoint analysis and to preference regression.

Introduction

To design new transportation or communication services, managers and analysts must understand how consumers will react to such services and must be able to predict the subsequent usage of those services. An important component in this analysis is the measurement of consumer preferences, i.e., the measurement of how consumers value the various attributes of transportation or communications service and how they aggregate these valuations to form an overall evaluation of each alternative.

A number of techniques have been used in both marketing and in transportation to measure or estimate consumer preferences. The first set of techniques, which we will call "group-level" techniques, are used extensively in transportation demand analysis and include the "disaggregate behavioral demand models." These techniques normally represent the preference value p_{ij}, that individual i places on alternative j as a weighted sum of i's perception of j with respect to a set of attributes. If w_k is the "group" weight for attribute k, and x_{ijk} is i's perception of j with respect to k, then the model is represented by $p_{ij} = \Sigma_k w_k x_{ijk}$. Among the techniques used are logit analysis (McFadden, 1970), preference regression (Urban, 1975), and maximum score. The advantage of these models is that they are relatively easy to estimate because they are based on statistical analysis of consumers' preference or choice among existing services. Their disadvantages are that they merge individual difference and estimate group weights (w_k) rather than individual weights (w_{ik}) and that the simple linear form may not accurately represent consumer behavior (Farquhar, 1977; Hauser and Urban, 1977b, Keeney and Raiffa, 1976). Their primary use is as a preliminary screening process to identify important attributes and provide "first order" predictions.

As the design of the product or service is refined, analysts need stronger measures and an ability to better understand the mapping of perceptions into preference. Furthermore, for various segmentation strategies it is important to identify individual differences by measuring preference functions for each individual consumer. These "individual-level" techniques normally represent preference, p_{ij}, as a sum or product of non-linear functions of the attributes, i.e., $p_{ij} = \Sigma_k u_{ik}(x_{ijk})$. Among these techniques are conjoint analysis (Tversky, 1967; Green and Wind, 1973), tradeoff analysis (Johnson, 1974), direct utility assessment (Hauser and Urban, 1977b). The advantages of these models are that they provide more detailed identification of individual differences and that their non-linear forms are more sensitive to decreasing returns and risk aversion effects (Raiffa, 1970). Their disadvantages are that they are more expensive because they normally require a personal interview, that they must often expand the stimuli set to pseudo-products (products represented by their attribute levels) to get sufficient degrees of freedom for estimation, and that the consumer task is often tedious. When compared to group-level techniques the "individual-level" techniques are more accurate but more expensive. Because of their advantages, these techniques have definite use in the design of transportation services if used judiciously (Green and Wind, 1975; Market Facts, 1976), but there is a definite need for improvement to make them more efficient and cost effective.

This paper covers two parallel improvements in the measurement of individual-level preference functions. The first, evaluation theory, generalizes conjoint analysis to stronger, more efficient measures of preference. These intensity measures are shown in an empirical example to improve prediction relative to both conjoint analysis and a representative "group-level" technique--preference regression. The second improvement, interactive interviewing, provides for more cost-effective measurement and faster, less expensive analysis. The general theory and the interactive interviewing system are covered in detail in two separate papers available upon request from the authors (Hauser and Shugan, 1977; Shugan and Hauser, 1977).

Theory Based on Intensity Measures

Standard conjoint analysis is an effective technique to measure consumer preference, but the consumer task is quite tedious requiring the consumer to rank order 20-40 "products" (actual or pseudo-products) in terms of preference. As a result, many researchers have modified conjoint analysis to reduce the consumer task. For example, Green and Wind (1975) use a fractional factorial design to reduce the number of stimuli. Johnson (1974) uses tradeoff matrices that require consumers to rank order "products" where only two attributes vary at a time. Hauser and Urban (1977b) use von Neumann-Morgenstern theory to formulate indifference questions[1] that require consumers to set an attribute level of one product such that it is equal in preference to another fully-specified product. All three procedures simplify the consumer task, but applications still require 20-40 minute interviews.

[1] Indifference questions are a limiting case of rank order questions.

Furthermore, each theory measures ordinal preference, i.e., a ranking over "products,"[2] rather than intensity of preference. Although a set of conjoint models over a consumer population estimates how many people choose each product, conjoint analysis does not estimate ratio, interval or probabilistic preferences. Such intensity measures are potentially better indicators of the consumer evaluation process and more accurate predictors of behavior.

If conjoint analysis could be extended to intensity measures such as dollar metric (Pessemier, 1977) or constant sum paired comparisons (Torgenson, 1958), it is reasonable to posit that more information could be gathered per question and as a result, fewer questions need be asked. (See figure 1 for an example of a constant sum paired comparison [CSPC] question.) Furthermore, if the consumer gives consistent answers, it may be possible to measure preference functions that incorporate intensity of preference. Support for this conjecture comes from recent simulation and empirical results (Green, 1976; Carmone, Green and Jain, 1976; Cattin and Wittink, 1976; Hauser and Urban, 1977a) which show that conjoint analysis is robust with respect to the metric/non-metric assumption. In fact, there are definite indications that the metric models which treat ordinal data as interval data can outperform their non-metric counterparts. Further support comes from Silk and Urban (1976) who report tremendous success with CSPC for actual products chosen in simulated purchase environment (over 80% of the uncertainty in behavior explained). The natural extension would then be to use intensity measures directly rather than arbitrarily forming interval data from ordinal data.

FIGURE 1
An Example of Constant Sum Paired Comparison Measurement
(Respondent's answers are in *italics*.)

DIVIDE 100 CHIPS BETWEEN EACH OF THE FOLLOWING PAIRS OF HYPOTHETICAL DEODORANTS:

PRODUCT A	PRODUCT B
PUMP SPRAY	AEROSOL
HERBAL SCENT	UNSCENTED
REGULAR	ANTI-PERSPIRANT

ENTER CHIPS ...

74, 26

But conjoint theory (Tversky, 1967) as well as utility theory (von Neumann-Morgenstern, 1947) is based on ordinal preference. Before intensity measures can be used, assumptions and properties of the measures and preference functions must be identified. Tests must be developed to determine whether the consumer reacts consistently to the task and to determine what theory best explains his or her answers. This will determine whether the preference function should exhibit ordinal, interval, ratio, probabilistic, or hybrid properties.

Hauser and Shugan (1977) show that consumer reaction to intensity measures can be represented by a general equation based on property operators and measurement relations. They show that two axioms--property asymmetry and property transitivity--are necessary for consistency of the representations and a general independence property--evaluative independence--provides simple decompositions for ease of estimation. Rather than cover the detailed derivations in this paper, we will simply state the results for four special cases: ordinal, interval, ratio, and hybrid.

[2] Von Neumann-Morgenstern preference functions can handle lotteries, i.e., products with uncertain or risky attributes.

Conjoint Analysis (Ordinal Theory)

Ordinal theory is based on the standard assumption that the intensity measures give only rank order information. I.e., consider the CSPC question in figure 1. Let x_{jk} be the value of the k^{th} attribute, e.g., scent (k=2), for the j^{th} product, e.g., product A (j=1). Let $\underline{x}_j = (x_{j1}, x_{j2}, \ldots, x_{jK})$. Let a_{ij} be the number of chips allocated to product i when comparing i and j, and let $a_{ji} = 100 - a_{ij}$. Let $u(\underline{x}_j)$ be the preference function that maps the attributes into a measure of preference, i.e., $p_j = u(\underline{x}_j)$ where p_j is a scalar measure of "goodness" for product j. In this notation ordinal theory is simply stated:

$$a_{ij} > a_{ji} \text{ implies } u(\underline{x}_i) > u(\underline{x}_j) \quad (1)$$

Property transitivity is ordinary transitivity. I.e., if δ_{ij} is defined such that $\delta_{ij} = 1$ if $a_{ij} > a_{ji}$, $\delta_{ij} = 0$ if $a_{ij} = a_{ji}$, and $\delta_{ij} = -1$ if $a_{ij} < a_{ji}$ then property transitivity among three products--i, j and k--is given by:

$$\delta_{ij} + \delta_{jk} - \delta_{ik} = \delta_{ij}\delta_{jk}\delta_{ik} \quad (2)$$

Under evaluative independence (which is known in ordinal theory as pairwise preferential independence [Ting, 1971; Farquhar, 1977; Keeney and Raiffa, 1976]) it can be shown that the appropriate decomposition is:

$$u(\underline{x}_j) = u_1(x_{j1}) + u_2(x_{j2}) + \ldots + u_K(x_{jK}) \quad (3)$$

Equations 1, 2 and 3 can also be extended to handle risky alternatives, i.e., products with uncertain attribute levels by the use of von Neumann-Morgenstern theory. Equations 1 and 2 are extended to lotteries (Keeney and Raiffa, 1976; Hauser and Urban, 1977a; Hauser, 1976) and equation 3 becomes Keeney's quasi-additive form (Keeney, 1972).

Estimation is by standard conjoint estimation (Green and Wind, 1975; Johnson, 1974; Srinivasan and Shocker, 1973) or, for risky alternatives, with direct utility assessment (Hauser and Urban, 1977b).

Intensity Measures (Interval Theory)

Conjoint analysis has proven successful in the past but ordinal theory uses only part of the information in CSPC or equivalent measures. An alternative theory, based on fundamental axioms by Shapley (1975) is interval theory. This is given simply by:

$$u(\underline{x}_i) - u(\underline{x}_j) = a_{ij} - a_{ji} \quad (4)$$

The test of consistency is additive transitivity.

$$(a_{ij} - a_{ji}) + (a_{jk} - a_{kj}) = (a_{ik} - a_{ki}) \quad (5)$$

Under evaluative independence, the decomposition is again additive:

$$u(\underline{x}_j) = u_1(x_{j1}) + u_2(x_{j2}) + \ldots + u_K(x_{jK}) \quad (6)$$

If we discretize each $u_k(x_{jk})$, i.e., define $u_k(x_{jk}) = \Sigma_\ell \lambda_{\ell k}\delta_{\ell kj}$ where $\delta_{\ell kj} = 1$ if product j has attribute k at level ℓ and $\delta_{\ell kj} = 0$ otherwise, then the estimation equation is:

$$a_{ij} - a_{ji} = \Sigma_k \Sigma_\ell \lambda_{\ell k}(\delta_{\ell ki} - \delta_{\ell kj}) + \text{error} \quad (7)$$

The part-worths, $\lambda_{\ell k}$, are estimated with ordinary least squares regress (OLS) or linear programming (Srinivasan and Shocker, 1973).

Intensity Measures (Ratio Theory)

Originally CSPC is based on a ratio assumption (Torgenson, 1958). Hauser and Shugan (1977) show that the ratio assumption can be extended from comparisons over physical products to comparisons over attribute bundles. This theory is given by:

$$u(\underline{x}_i)/u(\underline{x}_j) = a_{ij}/a_{ji} \qquad (8)$$

The test of consistency is multiplicative transitivity:

$$(a_{ij}/a_{ji}) \cdot (a_{jk}/a_{kj}) = (a_{ik}/a_{ki}) \qquad (9)$$

It can be shown that the appropriate decomposition is multiplicative:

$$u(\underline{x}_j) = u_1(x_{j1}) \cdot u_2(x_{j2}) \cdot u_3(x_{j3}) \cdot \ldots \, u_K(x_{jK}) \qquad (10)$$

If we discretize $u_k(x_{jk})$ as an interval theory, then under the logarithmic transformation the estimation equation becomes:[3]

$$\log(a_{ij}/a_{ji}) = \Sigma_k \Sigma_\ell (\delta_{\ell ki} - \delta_{\ell kj}) \log \lambda_{\ell k} + \text{error} \qquad (11)$$

The part worths, $\lambda_{\ell k}$, are obtained from estimates of $\log \lambda_{\ell k}$ based on OLS or linear programming.

Hybrid Theories

Given the general form it is possible to extend the above theories. One that we have found most useful is a hybrid theory to investigate non-linearities at the extreme end of the scales. The form is a combination of the ratio and interval theories:

$$u(\underline{x}_i) - (a_{ij}/a_{ji})^\gamma u(\underline{x}_j) = \beta(a_{ij} - a_{ji}) \qquad (12)$$

Note that if $\gamma \to 0$, $\beta \to 1$ the interval theory applies, if $\gamma \to 1$, $\beta \to 0$ the ratio theory applies. In between estimation is based on non-linear estimation routines (Abelman, 1976; Cohen, 1975). Note also that if $\gamma = 0$ or $\beta = 0$, linear techniques apply.

Tests to Identify Appropriate Theory

The above four theories are representative of the possible theories that can result from the general form.[4] They illustrate the breadth of possible procedures to estimate preference functions based on CSPC questions. To proceed further we must devise a test to empirically distinguish how each consumer reacts to the CSPC questions. With this test we can first observe how the consumer responds to a given battery of questions and then based on his or her responses branch to the appropriate theory and estimation. To perform this test, consider all product triplets and define $a_{ik}{}^I$ as the closest integer such that the interval test, equation 5, holds. Define $a_{ik}{}^R$ as the closest integer such that the ratio test, equation 9, holds. These differences minimize the scale differences inherent when comparing "errors" in equations 7 and 11. Suppose that a_{ik} is the respondent's actual answer, then define the following absolute error tests:

$$T_I = (1/n) \, \Sigma_t \, | \, a_{ik}{}^I - a_{ik} \, | \qquad (13)$$

$$T_R = (1/n) \, \Sigma_t \, | \, a_{ik}{}^R - a_{ik} \, | \qquad (14)$$

where the summation is over all possible tests, t, within a design and n is the number of such tests. If $T_I < T_R$, then the consumer is more likely responding via the interval theory. If $T_R < T_I$, then it is more likely the ratio theory applies. If both T_I and T_R are above some cutoff, T_o, reject both theories. (In practice we have found $T_o = 20$ is a good cutoff. Furthermore, we have found that the root mean square error modification of equations 13 and 14 give similar results.)

Summary

This section has reviewed the results of a theory based on intensity of preference. In particular it has stated the appropriate functional forms and has given equations to estimate preference functions via each theory. Finally, it has given a test to distinguish from a set of data, which theory best describes how consumers are reacting to the CSPC scales.

As stated earlier, these theories have great potential for accuracy because they utilize more information in consumer judgments than do the existing methods of conjoint analysis and preference regression. This remains to be shown. Following a discussion of computer assisted measurement, the section on application will give empirical evidence to support this conjecture, but first we will digress to illustrate how one can practically measure such functions.

Computer Assisted Consumer Measurement and Data Analysis

The general intensity theory makes possible the estimation of preference functions based on CSPC data. Because we expect that more information is contained in this data, we expect that the general theory will lead to improved accuracy or conversely, the same accuracy but with fewer questions. But this theory depends on our ability to quickly and efficiently ask CSPC questions. To do this we developed a marketing information system, P.A.R.I.S.,[5] which can implement a general questionnaire but which has special capabilities built in to implement CSPC questions. Furthermore, P.A.R.I.S. automatically encodes the data and sets up computer files for easy access and analysis. Special subroutines access the stored CSPC data and estimate the preference functions. The details of the P.A.R.I.S. system are contained in Shugan and Hauser (1977). We will describe here some of the features as they relate to preference measurement.

Development of an Interactive Program

The P.A.R.I.S. system allows the researcher to develop an interactive questionnaire as easily as a written question might be developed. The researcher would accomplish this development in three steps.

First, the researcher constructs a questionnaire using the P.A.R.I.S. language. This language consists of simple commands to print questions, record answers, check ranges, branch based on consumer response, etc. The language, which consists of over thirty commands, is sufficiently general to implement most market research questionnaires.

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[3] The appropriate functional representation is multiplicative in the $\lambda_{\ell k}$ terms raised to the $\delta_{\ell kj}$ power.

[4] Hauser and Shugan (1977) cover other theories such as stochastic preference which includes an individual level logit model.

[5] Preference Assessment and Retrieval Information System

Second, the written questionnaire is either punched on ordinary data cards or written on-line to computer storage (tape or disc). A single command activates the P.A.R.I.S. Q-compiler which converts the human-oriented language into an alpha-numeric, machine-oriented language and sets up the appropriate files to record and decode answers and sets up a system to time and record how long it took each consumer to answer each question. The Q-compiler also checks the questionnaire for coding errors and provides a summary of each question's status, thus alerting the researcher of possible errors in questionnaire design.

Finally, the compiled version of the questionnaire is automatically input to a "mass storage" program. This program stores the questions in a format allowing efficient computer access to any question in any order. The questionnaire is now ready for implementation.

Development of a Dynamic Market Research Data Base

The actual administration of the questionnaire is accomplished either by seating a respondent at a portable terminal (e.g., Cathode-Ray tube CRT) or by allowing an interviewer to interactively record answers while obtaining them in person by telephone. In either case, P.A.R.I.S. adds the response to the data base together with the time and date when entered. The computer then provides instantaneous range-checking to insure each response is in the legitimate range allowed for that response. Illegal responses (e.g., "yes" when his/her age is asked) may be followed by a gentle computer response informing the respondent or interviewer of an error and providing a clarifying instruction. Once a legitimate response is obtained, the range of that response can determine the next question. For example, if the respondent can only evaluate three brands of deodorants, perception questions about non-relevant brands can be avoided. This branching permits very efficient questioning, minimizing the actual number of questions asked to the most relevant questions for the consumer.

When the interview is completed, summary statistics are automatically provided. Management can access all interviews to date or some selected portion of them. Statistical analysis can be performed periodically and selectively. A master file allows a researcher to determine at a glance the current sample size, progress for the entire study, and how long each questionnaire administration took. More detailed information, e.g., how long a partial question's administration took and the answer given, can be obtained from the main data-base record. A special comment file records qualitative responses for easy access and analysis. We have found record and comment information, together with the feature that all answers are recorded regardless of whether a question is reasked because of an improper response, is very valuable for the development of test questionnaires. All answers, including mistakes, can be accessed to fully pretest a questionnaire.

Special Constant Sum Paired Comparison Commands

P.A.R.I.S. is designed with special commands for preference analysis by conjoint or evaluation theory. For example, a single command "READ n CHIPS" sets up a constant sum paired comparison question with automatic range checks and tests to ensure that the consumers' responses sum to n. If the responses do not sum to n, or if negative or non-numeric answers are given, the system diagnoses the problem and informs the respondent of his or her mistake. The form for quick answers or a longer form with more explanation. See figure 1 for an example of the short form. Furthermore, the system automatically sets up a computer routine to encode the constant sum response and place it in the record file for easy access. This encoded data is input to a related subroutine which uses linear programming to estimate the preference functions. This subroutine is a modification for constant sum data of ideas expressed by Srinivasan and Shocker (1973) in LINMAP. Experience to date has shown that the constant sum paired comparison task for preference measurement is readily accepted by consumers.

Typical Questionnaire

The next section reports an empirical application of a typical questionnaire and gives an example (figure 2) of what the consumer sees. We will put off this discussion until that section.

Empirical Example: Telecommunications Innovations[6]

Previous sections presented the results of a general theory for intensity of preference and described a marketing information system to implement that theory. We present here an empirical example of the use of P.A.R.I.S. to estimate intensity of preference functions. The remainder of this section is taken from section 3 of Hauser and Shugan (1977). The entire paper is available from the authors.

The empirical problem is to design a mix of telecommunications technology for use in a small research community. Scientific research requires effective communication among scientists, but in many government laboratories cooperating scientists and managers find themselves in buildings 2-3 miles apart. Furthermore, laboratories, such as Los Alamos Scientific Laboratory (LASL) in New Mexico, do much of their work for federal agencies and there is a strong need for effective communication with managers and policy makers in Washington, D.C. Currently, the most common means of communication are telephone (39% in LASL) and personal visit (58% in LASL), with only a small percentage (3% in LASL) of the interactions using other means. The National Science Foundation would like to enhance communication among the scientists, managers, and policy makers with an improved system that is more effective than telephone for technical communication, yet more efficient than personal visit in terms of cost, time, and energy. Among the options being considered are closed circuit television, telecopiers (facsimile transfer devices or teletypewriters), and narrow-band televideo systems (an attachment to the telephone which transmits still pictures over voice-grade telephone lines). But since the laboratories have limited budgets, each laboratory would like to implement the communications system that would be most cost-effective. To do this the laboratories need to know how scientists and managers would react to the various systems.

Study Design. To address this problem we used the normative methodology described in Hauser and Urban (1977a) to identify the relevant dimensions that describe communications options and to identify the relative importances of these dimensions. These dimensions form the basis for the CSPC questions used in the estimation of preference functions.

First, consumer focus groups were run and analyzed to produce an indication of the choice process, consumer semantics, and a set of 25 attribute scales to character-

[6] The majority of this section is taken from John R. Hauser and Steven M. Shugan, "Efficient Measurement of Consumer Preference Functions: A General Theory for Intensity of Preference," Working paper, Department of Marketing, Northwestern University, Evanston, Illinois, July, 1977.

ize consumer reactions to communication technology. Based on the focus groups and on previous research in the area of communications, a mail-back questionnaire was designed and implemented in which consumers rated telephone, personal visit, and the three new communications options (1-page concept statements) on the 25 attribute scales. Factor analysis of the response revealed two perceptual dimensions labeled "ease of use" and "effectiveness." Ease of use correlates with the ability to find the right person, save time, eliminate paperwork, and get a quick response as well as saving hassle, planning, time and cost; effectiveness correlates with the ability to exchange scientific and technical information, persuade people, convey all forms of information, control the impression you want to make, monitor people, operations, and equipment, yield a high level of human interaction, solve problems, express feelings, and enhance idea development.

Scientific and managerial communication is complex and it is probable that the communications needs would vary by individual depending upon his or her requirements. Thus, to accurately analyze preferences for communications options, we need to stratify by use scenario (purpose, distance between communicators, relation of communicators, etc.) and estimate preference functions within each category. Evaluation theory is used to measure these preference functions.

Consumer Measurement. Based on the results of the mail questionnaire, a preference assessment questionnaire was designed to measure the CSPC data needed for the preference functions. This questionnaire was then implemented via P.A.R.I.S. to scientists and managers at LASL and practicing managers enrolled in Northwestern University's Managers Program (evening work toward a master's in management). The questionnaire contained six sections: (1) warmup questions, (2) questions to establish a scenario for usage, (3) consumer rating of effectiveness and ease of use for the existing options and concept statements, (4) the CSPC questions, (5) preference ranking and usage intent for the existing products and the concepts, and (6) various personal and demographic questions and comments.

Example questions of section 2 are shown in figure 2. Review figure 1 for an example of a CSPC question. Note that the "questionnaire" handles out of range responses by gently informing the respondent of his mistake and asking for a new response.

Section 3 of the questionnaire was included to acquaint consumers with the measurement scales for effectiveness and ease of use and to provide us with their perceptions of each product or concept. Section 5 provided preference measures for the actual products and concepts. These measures were used to validate predictions made by each theory based on CSPC questions.

The complete questionnaire contained 96 questions including 16 CSPC questions and took about 15-30 minutes to complete. The administration cost including on-line hookup was about $1 per respondent on a CDC-6400 ($510 per cpu hour). The comparative results reported below are based on the sample of 41 practicing managers.

Results. Figure 3 gives the perceptual maps positioning of the five stimuli based on factor scores (mail survey) and the direct measures (preference survey). The close agreement of the relative stimuli position in the two maps supports the direct measures of effectiveness and ease of use as sufficient for the preference analysis. (Note that teletype terminals, used in the mail questionnaire, was revised to facsimile transfer devices in the preference questionnaire.)

FIGURE 2
An Example of Interactive Computer Measurement by P.A.R.I.S.
(Respondent's answers are in *italics*.)

WE WOULD LIKE TO KNOW ABOUT YOUR MOST RECENT INTERACTION WITH A COLLEAGUE, OR A VENDOR, ETC., TO DISCUSS A PROBLEM ON WHICH ONE OR MORE OF YOU IS PRESENTLY WORKING. PLEASE CONSIDER INTERACTIONS ONLY WITH THOSE PEOPLE WHO DO NOT WORK IN THE SAME BUILDING AS YOU AND DON'T CONSIDER CALLS JUST TO SET UP APPOINTMENTS.

1. IN ADDITION TO YOURSELF, HOW MANY PEOPLE PARTICIPATED IN THE INTERACTION: (PLEASE TYPE IN THE NUMBER OF PEOPLE.)

?*3*

2. DID YOU USE:

1 = TELEPHONE
2 = INTEROFFICE MEMO
3 = MAIL
4 = TELETYPE OR TELECOPIER
5 = PERSONAL VISIT (YOU WENT TO HIM [THEM])
6 = PERSONAL VISIT (HE [THEY] CAME TO YOU)
7 = PERSONAL VISIT (CONFERENCE ROOM, AUDITORIUM, ETC.)
8 = OTHER
(PLEASE ANSWER WITH A NUMBER 1 THROUGH 8.)

? *10*

(PLEASE ANSWER WITH A NUMBER 1 THROUGH 8.)

?*8*

PLEASE SPECIFY

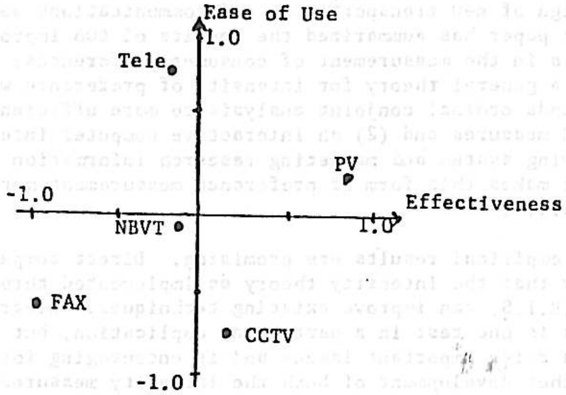
? *TELEGRAM*

The heuristic T-test with a cutoff of $T_o = 20$ indicated that 51.2% of the consumers were ratio, 31.2% interval, and 17.1% at most ordinal. The median minimum T_I, T_R was 13.1 with an interquartile range of 10.6-17.9. Based on the T-test we would expect that models based on one of the intensity of preference models would outperform standard ordinal estimation (conjoint analysis).

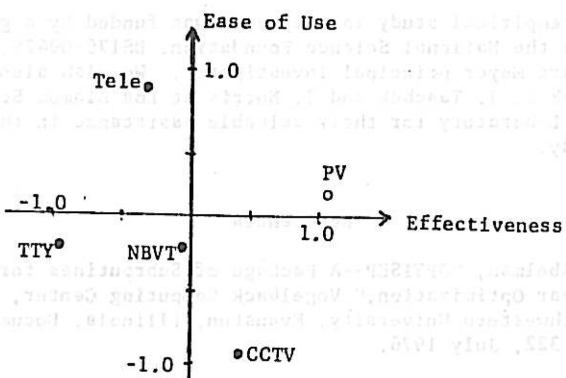
Table 1 compares first preference predictions based on linear programming estimates for the ratio, interval, and ordinal theories. For completeness, these predictions were compared to preference regression (Urban, 1975) which is an aggregate technique that assumes the same preference function for all consumers. Preference regression is widely used in the marketing literature and is representative of aggregate models such as aggregate monotonic regression (Hauser and Urban, 1977b) and logit analysis (McFadden, 1970). Recent studies have shown that predictions based on these three models are similar.

Inspection of table 1 shows that the intensity of preference theories do improve predictions over the existing models--preference regression and conjoint analysis. Furthermore, these predictions are quite good--72% of those products or concepts predicted first were indeed preferred. Detailed analysis of individual predictions reveals that the improved prediction comes primarily because the intensity of preference theories can discriminate between products that the ordinal (conjoint) theory predicted as being equal in preference. (E.g., the ratio theory might predict telephone as first preference while conjoint analysis would predict that

FIGURE 3
Perceptual Maps of Communications Options



a) Direct Measures (Standardized)



b) Factor Scores (Standardized)

Tele: Telephone
PV : Personal Visit
TTY : Teletype
NBVT: Narrow Band Video Telephone
CCTV: Closed Circuit Television
FAX : Facsimile Transfer Device

TABLE 1
Comparison of Models Based on Ability to Predict First Preference

		1st	2nd	3rd	4th	5th
Conjoint Analysis	(Ordinal)	57.1	25.8	12.0	4.3	0
Intensity Measure	(Interval)	69.1	24.8	5.3	0.8	0
	(Ratio)	71.6	22.4	5.3	0.8	0
Preference Regression		65.2	18.5	7.1	4.6	4.5

Most Preferred Product was Predicted (%)

telephone was tied with NBVT for first preference.) Thus conjoint analysis is a "correct" representation of consumer preference, but the intensity of preference theories produce preference functions that can better discriminate among products.

The comparison of preference regression and conjoint analysis is mixed. Preference regression is better at recovering first preference, but, as with any aggregate technique, it makes large errors on some individuals. Thus, table 2 compares the techniques on their ability to correctly predict market preference shares. Again the intensity of preference models provide improved predictions relative to both existing techniques. Note

TABLE 2
Comparison of Predicted Market Shares of Preference (NBVT - Narrow Band Video Telephone, CCTV = Closed Circuit Television, FAX = Facsimile Transfer Device)

	Tele.	Pers. Visit	NBVT	CCTV	FAX	Mean Absolute Error
Conjoint Analysis (Ordinal)	28.0	38.2	13.8	13.0	8.1	6.90
Intensity Measure (Interval)	32.5	39.0	13.0	10.5	4.9	4.54
(Ratio)	32.5	39.0	14.2	9.3	4.9	4.54
Preference Regression	31.7	31.9	12.8	16.5	7.1	7.72
(Actual)	(36.6)	(46.3)	(9.8)	(4.9)	(2.4)	

Predicted Market Share (%)

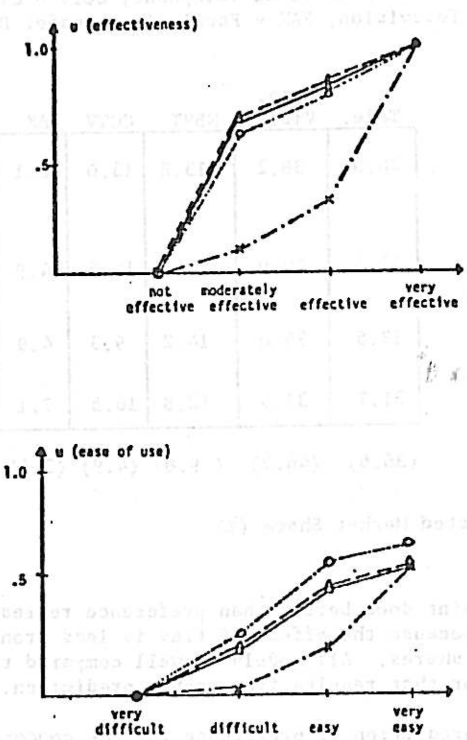
that conjoint does better than preference regression--probably because the effect of ties is less pronounced on market shares. All models do well compared to the 17.2% error that results from random prediction.

The over prediction of preference for the concepts results from the effect that consumers tend to choose an existing alternative when it is tied with a concept in predicted preference. Future research will expand evaluation theory to include this "preference inertia" effect (Neslin, 1976). Empirically when the models are applied to existing alternatives only, the mean absolute error is reduced to 1.4% for ratio. Furthermore, all relative comparisons remain the same.

Predictive accuracy is important for the evaluation of alternative products, but to improve the design of new products managers need diagnostic information to help them understand consumer preferences and thus design improved products. Although preference functions are estimated at the individual level, it is useful to present summary statistics (mean, variance, median, interquartile range) to represent the population. Figure 4 is a graph of the average preference functions. (The "utility" of effectiveness is scaled 0 to 1 for consistent comparison.) Note that the average individual functions (ratio, interval, ordinal) are quite close, although relative to the others the ordinal theory over-estimates the importance of ease of use. The interpretations are quite intuitive with decreasing returns on effectiveness and a slight threshold on ease of use. These results are consistent with the above conclusion that conjoint analysis provides "correct" representations of consumer preference and that the improvements achieved by intensity of preference theories result from improved discrimination among individual preference functions.

On the other hand, preference regression gives counter-intuitive increasing returns functions, although its estimate of relative importance (ratio of maximum utilities) is consistent with the individual level preference theories. This result coupled with the predictive results suggests that the individual level measurement can better explain the details of consumer preference and identify individual differences, but preference regression, which could be done without the second survey, is adequate for a first pass at analyzing the data.

FIGURE 4
Comparisons of Preference Functions



Δ------Δ Interval
□——□ Ratio
o.....o Ordinal (Conjoint Analysis)
x_._._x Preference Regression

The final question is whether $T_o = 20$ is a good cutoff for the heuristic error measure. If the CSPC responses from consumers with $T_I > 20$ and $T_R > 20$ are indistinguishable from ordinal preference then any theory--ratio, interval or ordinal--should give similar predictions or at best only as good as ordinal based predictions. Furthermore, we would expect the predictive capability to be similar to that for ordinal applied to the general population. Empirically for the 17% of the consumers with T_I, $T_R > 20$, we found that the predictions of each theory were almost identical giving an overall preference recovery of 57.1%, 28.6%, 14.3%, 0%, and 0%. This recovery agrees well with the ordinal theory (row 1 of table 3).

Thus the empirical evidence supports the conjecture that the intensity of preference theories can provide improved predictions and useful diagnostic information relative to existing theories such as conjoint analysis and preference regression. Existing techniques do well, as evidenced by tables 1 and 2, but the more general theory can make more efficient and effective use of consumer preference judgments. Clearly, this empirical example is a first application and test of the general theory but it does indicate that consumers can provide consistent CSPC judgments for products specified by attribute levels and that the majority of consumers give CSPC judgments that contain more extractable information than judgments based on the ordinal task used in conjoint analysis. Even for the 17% who gave at most ordinal results, the intensity measures did as well as the ordinal based conjoint analysis.

Summary

Consumer preference measurement is important for the design of new transportation and communications services. This paper has summarized the results of two improvements in the measurement of consumer preferences: (1) a general theory for intensity of preference which extends ordinal conjoint analysis to more efficient CSPC measures and (2) an interactive computer interviewing system and marketing research information system that makes this form of preference measurement more feasible.

The empirical results are promising. Direct comparisons show that the intensity theory as implemented through P.A.R.I.S. can improve existing techniques. Clearly, this is one test in a particular application, but it does raise important issues and is encouraging for further development of both the intensity measures and the interactive system.

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