Interactive Measurement Methods: Theoretical Bases and Practical Applications

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A new approach to collecting data on travel behavior by using interactive survey techniques is presented. The general background of empirical measurement of human behavior is discussed, and the different steps of interactive measurement for the empirical study of complex determinants of behavior are shown. Examples are given of practical applications of interactive measurement methods for use in the area of transportation planning, as well as the results that can be obtained by using a complete survey design constructed according to the principles of interactive measurement.

Since empirical measurements are of basic importance in nearly all branches of science, the process of measurement is a fundamental concern in scientific research. However, although physical scientists take this for granted when using methodologies appropriate to the study of physical phenomena, persons engaged in social research frequently overlook it.

Measurement seems to be made especially carelessly when researchers specializing in the physical sciences employ the empirical research techniques of the social sciences. Many examples of inaccurate measurement can be found in transportation research, a field in which surveys of the population--i.e., empirical measurements of the behavior of a part of society--have often been taken by economists or engineers. The risk of slipshod measurement tends to be particularly great here because these researchers inevitably ignore, or are perhaps unaware of, the theoretical framework within which sound social research methodology should be planned and results interpreted. Basic premises of scientific measurement--including the premise that the result of the measurement is influenced by the phenomenon to be studied and by the method of measurement used--are thus overlooked (1).

The social researcher must never ignore the fact that measurements of behavior can never be exact and thus can never be treated as exact replicas of reality. The degree of distortion can be greater or lesser, depending on the method of measurement used and how well the method is adapted to the problem being studied (2).

PROBLEMS IN EMPIRICAL MEASUREMENT OF BEHAVIOR

Explaining present behavior and forecasting future behavior have always been major concerns of applied empirical social research. However, the history of applied empirical social research shows that the fundamental problems have never been properly understood.

Since the question of "representativity" has been so thoroughly discussed (3), questions concerning the reliability and especially the validity of data should be of central importance. A new approach is called for that takes the following factors into consideration.

1. Many basic studies on methodology show that simply questioning individuals on their behavior measures only the individual's subjective appraisal of his or her behavior. Thus, data collected in this manner tend to be inaccurate (4).
2. The history of applied empirical research also shows that asking individuals to explain their behavior leads to even greater distortions. These data are also inaccurate (5).
3. The information that individuals give on their planned future behavior is frequently refuted by their actual behavior. Thus, the usefulness of the popular "what if. . ." games, used as an aid in determining future behavior, is problematic (6).

The present method of data collection in the area of empirical social research suggests that the interviewee is considered to be little more than a data bank that can be relied on to report all relevant variables. Thus, the survey instruments tend to become ends in themselves rather than means to an end. This instrumental orientation is of doubtful accuracy, for the survey contents are then adapted to the few survey methods that are frequently used. As a result, the interviewee is frequently depersonalized and is not accepted as a partner in the process of communication.

However, when data are collected by means of interviews or questionnaires, communication is indeed taking place--a very special form of communication. In this case, communication does not take place between the interviewer and an amorphous mass; rather, there are as many individual acts of communication taking place as there are persons who are questioned.

Lasswell's definition of communication is useful here (7). Lasswell says that the communicatory act is composed of five factors that explain not only the process, but also the meaning of communication: "WHO says WHAT to WHOM using what MEDIUM with which EFFECT?" This formula can be readily applied to the survey situation if one rephrases the question to ask, "Who formulates what kind of survey questions for whom and using which methods for which desired end?"

These five factors stand in a reciprocal relationship to one another. Changing only one variable in the survey process inevitably has an effect on the results of the survey, even though the other variables remain constant. This means that if one uses only a limited number of methods the number of problems that can be studied is also limited (8). When the interviewees are treated as active partners in the act of communication and the survey method is adjusted accordingly, however, results are radically improved. But before one can attempt to describe survey methods developed with the above considerations in mind, it is necessary to study more closely the interviewee and his descriptive variables.

BEHAVIOR MEASUREMENT IN A SITUATIONAL CONTEXT

The attempt to view the interviewees as individuals, rather than simply as the bearers of certain behavioral characteristics that make it possible to aggregate them, is not new (9).

Conventional transport modelers now use a "disaggregate" approach that is theoretically concerned with understanding the individual as a unique entity or behavioral unit. In practice, however, individuals are merely viewed as the bearers of certain (socioeconomic) characteristics. No theoretical reformulation reflects the disaggregate approach. In particular, not enough attention is paid to the fact that individuals have a certain flexi-

bility with which they can react to different circumstances. The degree of flexibility is influenced by the material environment, the constraints and options affecting the individual, and social values, norms, and opinions (10).

Each individual perceives "objective" situations differently; therefore, perceptions are either incomplete or distorted or both. The degree of distortion depends on the individual. Since individual decisions are made subjectively, it is these individual decisions that are relevant for explaining behavior in subjective situations (11).

Therefore, if one wishes to understand behavior, it is necessary to reenact the chain of "objective circumstances--personal perception--subjective situation--individual decision--behavior" (12). (This is ignored in conventional disaggregate or econometric models, which assume that there is a direct relationship between socioeconomic characteristics and behavior.)

The above general approach can be applied to different forms of behavior, including the behavior of interviewees. The fact that the behavior of the interviewees is determined by their unique situations must be reflected in the choice of survey method, since the method affects the interview situation and, consequently, influences the behavior of the interviewee and his or her answers. Although the survey method always influences the survey results, the more the interviewee is isolated from his or her "normal" situational context, the more the method affects the results. In empirical research, this phenomenon is known as "reactive measurement" (13) and has been repeatedly validated. The phenomenon is closely related to our confidence in behavioral transportation measures and models that are now in use.

A classic example of the debate on the validity of empirical measurements is attitudinal research. Attitude has been defined in many different ways. Here attitude refers to those opinions and ways of thinking that are socially acquired. Although it is debatable to what degree opinions actually influence behavior, it seems logical that opinions do indeed affect behavior. However, empirical data frequently do not support this theory, since only a fraction of different behavior can be explained by attitudes (14).

Although it might thus seem that researchers could ignore attitude in their forecasting, this conclusion is incorrect for a number of reasons. First, existing methods of measuring attitudes are generally inaccurate because they only consider the target person's account of his or her own attitudes. It would be important to determine what the target person's attitudes, per se, really are. It is also possible that the relationship between behavior and attitudes is relevant only in specific groups and that these groups can be identified by indicators independent of attitude. If such is the case, it would be possible to limit measurement of attitude to these latter groups.

Traditional research on attitude has not adequately dealt with the fact that an individual's account of his or her own attitudes is subjective and not necessarily reliable. Other important factors must also be considered. For instance, interviewees frequently show a tendency to acquiesce. They wish to make a good impression. Furthermore, the actual object of study can only be indirectly examined, since it is necessary to rely on the verbal account of the interviewee in order to collect data. Empirical research must counteract this problem by designing new methods of measurement.

If one wants a more precise empirical explanation of factors that influence behavior related to mobility, then one must use the most appropriate survey instruments. Because mobility is a highly complex subject, the number of questions that must be asked is extensive; therefore, face-to-face interviews must be used since such interviews make it possible to study all factors that might be relevant to the subject. This survey instrument, however, must deal with a variety of problems:

1. In the interview situation, the interviewee must be made aware of his or her daily routine, which has become habitual and of which he or she is, therefore, not totally conscious. Unfortunately, face-to-face interviews do not serve as an adequate memory aid, for they do not help give the interviewee a complete picture of all factors--including nonrealized options--that influence his or her behavior.
2. Decisions concerning manner, scope, and type of transportation are not always individual decisions. Others, especially other household members, frequently influence individual transit behavior. The factors that influence behavior must be empirically reconstructed. It is of utmost importance that the interviewee respond within a real-life context rather than in an isolated interview situation. This means that the whole household should, if possible, take part in the interview.

When questions are asked that pertain only to the individual, such as questions relating to away-from-home activities, written questionnaires can be used that are later read aloud.

When specific questions are asked that are aimed at the household as a whole, empirical methods must be used that realistically depict the group's decision-making process. For this purpose, real-life situations must be simulated as accurately as possible. Visual displays of real-life situations and games are useful, for these help one to identify options and constraints that influence behavior. Factors that subjectively and objectively influence behavior can thus be identified in the context that is actually relevant for decision making. This method makes it possible to forecast, for example, the use of a new subway route.

DEVELOPMENT OF A COMPLETE STUDY DESIGN

So far, we have primarily dealt with the methodology that pertains to the survey instruments of empirical studies. Although this is important as a first step in the development of a complete survey design, empirical data collection methods are not ends in themselves but rather means to collect information that is as accurate as possible. The method with which the most accurate results can be obtained depends on the nature of the problem to be studied. The broader the contents of the data to be collected and the greater the differences between the target groups studied, the more flexible one must be in the choice of methodological instruments.

When information needs are broad and differentiated, a combination of different methods should be used. Each method is best suited for a special information need. This means that

1. All methods of direct questioning can be used to gather sociodemographic data for persons and households;
2. The diary technique is necessary to establish activity patterns (otherwise, respondents report either their "typical" activities or their personal perceptions of their activities);
3. Data on the objective environment and the

infrastructure should be taken from official statistics or gathered by personal observation (15);

4. If one needs data on subjective perceptions, face-to-face interviews are useful since they encourage spontaneity;

5. Spontaneous, explorative questioning can be used for the analysis of individual personality and psychological makeup (in attitude measurements, the value of purely psychometric methods is questionable);

6. In order to analyze the internal household organizational structure, data should be collected indirectly, e.g., in group discussions, rather than directly, since the households are often unaware of their own organizational structures (the more pertinent the issue is for the given family, and the better the interviewer, the better indirect questioning works) (16); and

7. Forecasting the behavioral changes caused by changed circumstances is especially difficult, for the interviewees are frequently incapable of predicting their own behavior and do not take the complexity of the situation into account and, for this reason, their responses are frequently incorrect.

It is useful to confront the household with simulated situations and to make it respond to the given situation by discussing the possibility that specific circumstances will cause changed behavior (17). This gives one a good idea of the decision-making process, constraints, and options and shows many variables of which the interviewees themselves are unaware.

Depending on the given situation, data are thus collected by observation, written questionnaires, personal interviews, or interactive measurement. The latter two have a number of similarities, including the measurement of psychological structures, perceptions, and interactive procedures. In this case, it is necessary to use interactive measurement methods. But it should be noted that it is necessary to use methods of observation and written questionnaires before interactive measurement methods can be used.

All relevant aspects of the given research problem should be studied, step by step, using the different methods to study the perceptions of the interviewees, the objective and subjective constraints that influence their behavior, and their unconscious decision-making processes.

SPECIAL REQUIREMENTS FOR DATA COLLECTION AND CODING PROCEDURES

Anyone who wishes to construct a data collection design in accordance with the interactive measurement method described above needs long years of experience and a broad knowledge of empirical methodology. Multilevel, broad-spectrum pilot tests designed to study the effectiveness of data collection methods are an absolute must.

Furthermore, the quality of the interviewer and his or her experience in interviewing are very important. Interviewers must be trained in the goals and techniques of the interview. In order to guarantee effective communication, the interviewers should be split up into small working groups, each of which is supervised by an experienced group leader.

Finally a problem-oriented coding of the questionnaire cannot simply consist of a quantitative enumeration of an enormous quantity of data. No software package can reconstruct the individual or household from more or less isolated data fragments. The purpose of the research concept is very different. It rejects any mechanistic classification that has to be based on a prepared hierarchy of variables. Rather, all collected data are considered to be of equal importance; each datum must be analyzed individually in order to determine which factors influence behavior and how they influence it. In addition, the whole research design is based on the need to identify contradictions. The "logic" of standardized software packages, however, does not usually allow classification of such contradictions and could not make use of the resulting data.

Consequently, every household interview has to be coded and the data analyzed as a unique case study, based on all available information. Since the survey instrument is designed to be flexible, the range of factors to be taken into consideration can be changed from case to case.

The design of the interactive measurement method described above is much broader than that of various "gaming techniques." The individual steps are more diverse and, therefore, the methods and variables are also broader. Also, the measurement procedure ensures that important information is collected before the specially designed game is used. The final step--the game--is only one of the steps in collecting data for analysis and forecasting.

Comparable methods have been in use for some years in different areas of empirical research, in social research, and in marketing research. What is new, and perhaps unique, in interactive measurement is the step-by-step combination of methods and the use of perceptions and interaction to explain hidden correlations between organizational structures and decision-making patterns.

POSSIBLE APPLICATIONS OF INTERACTIVE MEASUREMENTS

As has been shown earlier, interactive measurement techniques are not simply special instruments for measurement. Rather, they reflect a whole empirical philosophy. Basically, there are four classic areas for the application of interactive measurement. Interactive measurement helps one to

1. Obtain more accurate information by studying interaction in a social context,
2. Break through the barrier of the interviewee's perceptions by making him or her interact with the interviewer,
3. Study the reorganization of activity patterns, and
4. Study the mechanisms of group decision making.

For each of the areas mentioned above, an example from the field of transportation research will be given.

Interaction in a Situational Context

Interactive measurement methods allow controlled collection of information in a situational context. Three control mechanisms are used to minimize the potential for bias on the part of the interviewer and interviewee:

1. The very presence of the entire decision-making group serves as a control.
2. The members of the group can correct one another when responses conflict; this is a substantive control.
3. The interviewer acts as a control mechanism since, if contradictions occur, he or she can alert the group to these contradictions.

This allows the researcher to identify objective alternatives and constraints in the interviewee's

choice of transit. The general availability of individual or public modes of transportation can thus be seen in light of objective alternatives.

In order to collect the necessary data on the availability of vehicles, the interviewer asks the whole household to play the Vehicle Availability Game (18). A label representing each type of vehicle in the household is placed on a large game board. The interviewer notes the model, type, year, and owner of each vehicle and the number of persons who either have or plan to get a driver's license. Then the general availability of each vehicle for each member of the household is studied. Each person uses labels to show which vehicle he or she can use for which purposes and notes whether his or her use of this vehicle is practically unlimited, somewhat restricted, or severely curtailed. The interviewer keeps a record of explanations and discussions that result from the game. (Figures are also kept on the number of persons who walk or are passengers in automobiles.)

By using negative selection, it is possible to identify those persons for whom specific modes are not workable alternatives in specific situations.

In the next part of the game, the routes that were actually traveled (as determined by a previously completed questionnaire) are studied, and the various options that were available to the target persons are noted. Each target person is given a form to fill out for each route for which he or she had reported travel in the prior mail-back questionnaire. These forms are sorted according to reason for travel. (The interviewer has access to all pertinent information.)

On each form, the interviewer is to note why the alternative modes were not used for the specific routes traveled. Although general constraints may repeatedly be given as reasons ("Don't have a license"), previously unidentified constraints might also be brought to light ("My husband was using the car" or "One can't walk to X"). Thus, all alternatives for reaching one's destinations are analyzed from the target person's point of view.

When this part of the interview has been completed, it is possible to determine (again by means of negative selection) which persons had no alternative options available to them and why.

Interaction with the Interviewer

Interactive measurement methods allow one to analyze the degree to which the answers given by the interviewees are correct. This was shown in a study in which the interviewee's perception of monthly driving costs were studied (19). The price estimates were studied in four different stages. In each stage, the interviewee was given more information than had been given in the preceding stage. Thus, while the first estimate was simply a rough guess, the last estimate was based on factual information. The last estimate was 22 percent higher than the first.

The interactive measurement method used was as follows: First, the interviewee was asked to guess, as accurately as possible, how much his or her car costs per month. No bills, etc., could be used. Next, the interviewee was asked whether he or she had not perhaps forgotten some of the expenses involved in keeping an automobile and was then asked for a new estimate. In the third step, the interviewer reminded the interviewee of some of the expenses that he or she had forgotten to calculate. The interviewee was again asked to give a new estimate. In the final step, the car budget was viewed within the framework of the household's entire monthly budget. The interviewees used documents of various sorts to make their estimates; i.e., they could use receipts for gas, repairs, maintenance, etc.

This interactive measurement technique makes it possible to nonverbally measure complex perceptual connections. It can also be used to determine price sensitivity.

Although monetary considerations alone do not make valid forecasting possible, if they are seen in relationship to the interviewee's anger toward or acceptance of increased fares, they can be important factors that suggest how much financial latitude the interviewees have about the costs of keeping their cars. It then becomes possible to determine more or less precisely the objective interest of the interviewees in cost-conscious behavior aimed at keeping automobile expenses within economically feasible limits.

Controlled Reorganization

Interactive measurement is especially important if a realistic, controlled reorganization of the activity pattern of the household is called for. The actual activity pattern (as determined by previous written surveys) that is to be reorganized as a result of changed circumstances is used as a basis.

Constraints that affect the household's reaction to changed conditions can then be identified. The control mechanisms mentioned above ensure that the reorganization is realistic. The group being interviewed mutually constructs the reorganization, and the interviewer can interrupt if contradictions occur.

The example given below illustrates the potential reorganization of the household's outdoor activity pattern. It can be useful for forecasting demand if changes in the urban public transit system are to be made (20).

The household is shown a game that includes data pertaining to actual activity patterns. While the interviewer explains how to play the game, the information that has been collected is checked, and it is then symbolically represented in the figures that are used to play the game.

Those playing the game are told that the supply of the urban public transit system has been changed and that they must therefore try to reorganize their activity patterns (depicted on the game board) so that all trips are made by using an alternative mode. The alternatives are symbolized by new figures. The interviewer must

1. Make sure that the interviewees give realistic answers concerning their options for reorganizing their activities,
2. Check to see whether the changed activity patterns of the individuals are mutually compatible within the given household structure,
3. Note the constraints that partly or totally influence the household's activity pattern,
4. Keep a protocol of the reorganized activity pattern, and
5. Explore the household's general alternatives for reorganization, e.g., substitute modes for the specific routes traveled.

(It should be noted that the use of maps generally confuses the households more than it helps them.)

The Household Decision-Making Process

Interactive measurement methods can also be used to reconstruct the decision-making process of the households as they are confronted with various

constraints, since situations can be simulated and the reactions of the respondents can be studied. (The interviewer is nothing more than a kind of supervisor.) The decision-making process is as important as the actual results.

In the example given below, the importance of the automobile for the household was studied by simulating a situation in which the household budget was reduced over a long period of time (21). First, the net income of the household was determined and this sum was then subdivided according to the family's spending habits. For this purpose, the available funds were distributed among 18 different boxes that symbolized different categories of expenditure.

The interviewees were told that they must support (for a long stretch of time) a family member living away from home who had run into financial difficulties through no fault of his or her own. The family was told to assume that its budget had therefore initially been reduced by 15 percent, and then, in five further stages, by an additional 5 percent, until the total reduction in income was 40 percent.

The interviewees had to try to save the given amounts by reducing their expenditures in the different categories. Both initial budget distribution and all subsequent changes in the budget distribution were noted by the interviewer. Furthermore, the interviewer was responsible for making sure that certain minimal sums were allotted to specific categories--such as the food budget. Basically, though, the interviewer only intervened if the interviewee contradicted himself or herself.

However, the accuracy of even this apparently simple approach was problematical, since households know surprisingly little about their actual financial situations. Of the households studied, only 18 percent could give accurate figures for the budgets and another 23 percent could quote sums that were more or less accurate. Thus, although approximately 41 percent of the households could be more or less accurately assessed by using such traditional methods as attitude questionnaire techniques, in some 59 percent of all households interactive measurement techniques made it possible to collect data that could not have been collected if interactive measurement had not been used.

The game described above ends when the household decides to give up a car or when the budget has been reduced by 40 percent.

The purpose of the budget game is to simulate as realistically as possible a relative increase in prices, although the absolute price remains the same. Since households cannot be very flexible in regard to such items as rent and insurance, they are forced to respond to a reduced budget by restricting their demand for goods that are not considered to be basic necessities. Therefore, the priorities of the different households become apparent, since the importance of individual items for a specific household is reflected in the proportion of the total budget spent on these items. By broadening or narrowing the different categories of expenditure, it is possible to identify those categories that need to be more closely studied.

Since the importance of automobiles for households was the central issue in the above study, expenses related to driving automobiles were subdivided into various categories. This makes a number of interpretations possible. The car budget can be interpreted absolutely and relatively, and changes in the car budget can be analyzed in relation to the reduction of the total household budget.

FORMATION OF A COMPLETE SURVEY DESIGN

A complete survey design that takes the conceptual design of interactive measurement into consideration was constructed to study how and whether price changes in the urban public transit system would affect demand for public transportation (22).

By using this research design, which included a variety of different survey methods, it was possible to derive a model of price sensitivity that would provide the policymaker with much more substantive behavioral data than that offered by conventional indexes of elasticity (23). This means that

1. It was possible to pinpoint those trips made by means of the urban public transportation system for which options were available on the day of random sampling,
2. The price thresholds at which mode of transportation would change were determined,
3. Those conditions that make it possible for people to react to increased fares by changing their mode were identified,
4. Situations were identified in which people could react to increased fares by reducing the number of trips made by public transportation,
5. Thresholds at which changed behavior could actually be expected were determined,
6. Socially desirable thresholds were identified, and
7. Probable "atmospheric" reactions to price increases were determined, not taking actual de facto reactions and price sensitivity into consideration.

OTHER AREAS OF APPLICATION

As has already been pointed out, interactive measurement and gaming techniques are far from new in empirical social research. In the area of transportation, this means that the specific applications of different games is new--not the general idea of using games.

There are a great number of possible applications for these techniques. In recent years, our institute has found interactive measurement useful to study such varied topics as

1. Price sensitivity in the use of public transportation,
2. Marketing strategies aimed at increasing the demand for public transportation,
3. The effects of a new subway route,
4. Preference for bus or streetcar as opposed to the subway system,
5. Possibility of connecting the intercity train system directly with the airports in Germany,
6. Mode-choice problems in daily commuting needs,
7. Mode-choice problems in future long-distance travel,
8. Knowledge and perception of costs related to the use of private automobiles,
9. The decision-making process of households in choosing their place of residence,
10. Social policies aimed at improving the quality of life of handicapped persons living at home with their families,
11. The decision-making process of families planning to purchase durable goods for the household, and
12. The decision-making process of companies making investments of various kinds.

ACKNOWLEDGMENT

We gratefully acknowledge the support of the German Ministry of Transport, the Integrated Transport Systems of Munich and Stuttgart, and the German Automobile Association. Special thanks are also extended to Peter Jones and Martin Dix for their extensive and constructive contributions in reviewing a first draft of this paper; to Hans Fechtel, Otto Förg, and Wilfried Schwerdtfeger for their help in developing the methodological instruments described in this paper; and to Monica Gora for translating the German version of this paper into English.

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Experience with Household Activity-Travel Simulator (HATS)

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Ways in which the Household Activity-Travel Simulator (HATS) has been used in a research context to investigate aspects of household travel behavior and its more recent application as a policy tool and an educational aid are described. Use of the equipment as a laboratory simulation exercise in which students or practitioners take on the roles of household members and simulate their responses to proposed policy measures is also discussed.

The Household Activity-Travel Simulator (HATS) was developed as an exploratory research tool to investigate the role of travel in people's daily lives and the ways in which households adapt to various changes. It is an interactive