Development of Survey Instruments Suitable for Determining Nonhome Activity Patterns

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Generation of travel behavior data by means of empirical surveys is an important element of transportation planning. At the same time, relatively little attention has been paid to the rules for collecting and determining the methodological quality of the data. The methodological design of such surveys is relatively complicated because of a number of influence factors that may ultimately be reflected in the validity of the results. The issue of survey instrument design is discussed in detail. A number of methodological tests are examined that were intended to improve one of the weak points in surveys of travel behavior—the design of such instruments. Initially, it was concluded that a diary-type instrument would have to be used to ensure proper recording of trip details. An ideal diary was developed that was used in several surveys. But it became evident that this instrument design, in spite of its high methodological quality, was unsuitable for large-scale surveys, such as those frequently used in transportation planning, because of organizational and cost problems. Therefore, an additional series of tests was developed to simplify these diaries and to transform them into a form suitable for large-scale mail-back surveys. Each test series was tested empirically with detailed documentation of reporting deficiencies. Thus it was possible to present in an understandable manner the development of a survey instrument of desirable quality. The final version of the instrument design, which was the outgrowth of the empirical tests, has been used subsequently in numerous large-scale applications in several countries. In the course of these applications the methodological quality of the design was confirmed, which ultimately justified the development costs.

The influence of measurement procedures and measurement (survey) instruments on measurement results has to be recognized at the outset of any empirical survey. Therefore, the survey procedure has to be included as part of the overall research approach (1). Typically, a measurement process (i.e., survey procedure) is composed of a number of elements that can be subsumed under the following categories (2,3):

1. Problem formulation, theoretical reference frame, analysis concept;
2. Base population, sampling unit, sampling procedure, weighting, population values;
3. Survey method and instrument(s);
4. Survey implementation, response rates; and
5. Data preparation, evaluation, and analysis.

The third and fourth categories are the subjects of this paper. The development and use of survey instruments designed to measure actual nonhome activity patterns are described in this paper.

Empirically measured travel behavior is the most important input to transportation planning decisions because it constitutes the basis for explanation and prediction of future travel activities. Methodological deficiencies of this measure have direct consequences for all subsequent phases of the transportation planning process.

Meanwhile, the mail-back household survey, which measures nonhome activity patterns, has become a standard component of transportation planning. Generally, the survey instruments used in this process are the result of years of developmental work. In this paper such a developmental process is retraced in terms of content and chronology on the basis of the KONTIV design (4).

Two aspects will be emphasized. First, the laborious path of such developmental work, including its accompanying setbacks, is illustrated. Second, it will be shown that basic methodological research also can produce, as by-products, fundamental and substantive analytical and theoretical insights.

EARLY DEVELOPMENTS

When preliminary developmental work toward the improvement of methods for measuring nonhome activity patterns started in Germany in 1972, the generally accepted method for empirical surveys was the personal interview. For example, in an intensive personal interview survey (5), the course of the daily trips to work or school was investigated in addition to various other aspects. Three main bases for criticism arose out of such survey efforts:

1. The survey measured average rather than actual travel behavior;
2. Information (e.g., about travel time) was estimated by the interviewee; and
3. Only a segment of the individual's mobility was investigated.

Consequently, the results of such interview information were unsatisfactory when validated on the basis of objectively measured values for travel time, distance, and cost. For example, only three-quarters of automobile drivers estimated their travel time within a tolerance level of ±25 percent. (Admittedly, the generation of objective comparative data is difficult in this instance.) On average, travel time was underestimated by 11 percent (1).

For the transit user the situation was quite different. Although the share of respondents with reports of travel time within the tolerance level of ±25 percent was greater (namely, 79 percent), the average error was substantially higher and in the opposite direction, namely an average overestimation of 36 percent [see Table 1 (4)].

The strong distortions caused by these misestimates are described in Table 2 (4), which gives a breakdown of trips into their access, egress, and travel-time components. Automobile drivers claim to have spent, on average, only a total of 6 min on access and egress, including the search for parking spaces, whereas transit users recorded 62 min for access, egress, waiting, and transfer times.

The methodologically oriented reader of such results could draw two significant conclusions. First, the reported travel behavior and characteristics deviated substantially from reality even though these respondents experienced the real values of these trip elements twice during each working (school) day. Second, the biases are of a systematic nature and apparently are related to the user's attitude toward the respective travel mode. Hence, in the case of public transit, the particularly disturbing access, egress, waiting, and transfer times are overestimated drastically.

From a conceptual point of view, these results [which were substantiated in several other studies (6)] indicated that the subjective perception of such measures constitutes an important determinant of travel modal choice. This concept has found entry into the relevant models under the terms perception and perceived values (7). The methodological analysis of these findings leads to two conclusions. First, data about travel behavior must not be collected (inquired about) in a general form

Table 1. Accuracy of travel-time estimates for automobiles and transit (4).

Item	Reported (interview) Travel Time for	
	Automobile	Public Transit
Sample size	800	520
Correct estimates (within ±25 percent error) (%)	72	79
Incorrect estimates (> 25 percent error) (%)	28	21
Index of average deviation from the correct travel time (objective time = 100)	89	136

Table 2. Reported estimates of travel-time components for automobile and transit users (4).

Item	Travel Time (min)
Automobile users (n = 800)	
Walk from residence to parking; from parking to destination	6
In-vehicle travel time	41
Search for parking at destination	1
Total	48
Transit users (n = 520)	
Walk from residence to boarding stop; from alighting stop to destination	28
In-vehicle travel time	22
Total waiting and transfer time	34
Total	84

(i.e., not in terms of average values); they need to have a concrete temporal reference. Second, activities cannot be viewed in isolation. Instead, complete daily activity patterns are needed to constitute the basis of analysis.

It could be shown, for example, that the recording of beginning and termination times of a trip is more accurate than the direct reporting of trip lengths. The implications of this for further methodological considerations are as follows. First, the data about travel behavior need to be collected for specific survey days. Second, a diary-type survey instrument should be used, which requires entries about complete daily activity sequences. Third, a written survey form is preferable to the personal interview. However, this does not indicate by what means the survey instrument should be delivered to the respondents, i.e., by mail or by means of an interviewer.

DEVELOPMENT OF AN ACTIVITIES DIARY

Based on the recognition that surveys about general (or average) travel behavior and of estimated information lead to invalid results, an activity diary (8) was developed in 1972, in which the target population (sample) was asked to record in writing its complete daily activity set for specific survey dates.

This diary (see Figures 1-4) was a brochure of about 8 x 6 in. in size, the cover of which listed the name of the target person, the day of the week, and the date of the respective survey day. On the inside cover were 12 numbered lines for trip entries, where the odd-numbered trips were designated by a different color in order to make this page of the diary visually clearer and more appealing. On this page the respondents were supposed to enter the

Figure 1. Cover of trip diary for en route use.

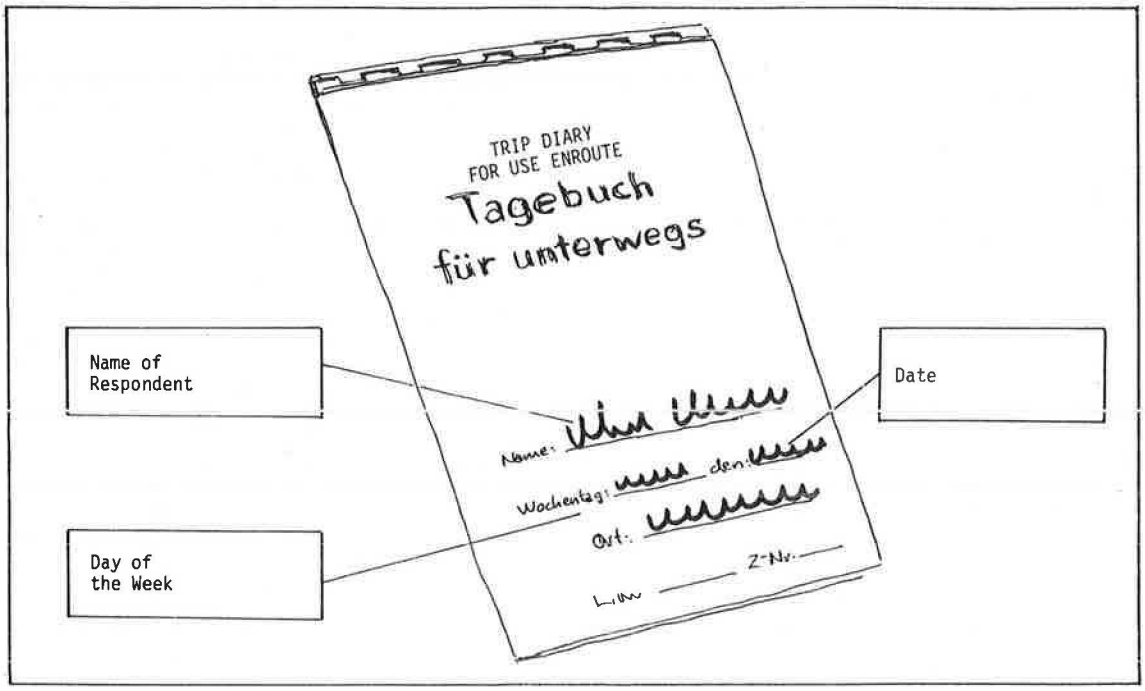


Figure 2. Inside of trip diary.

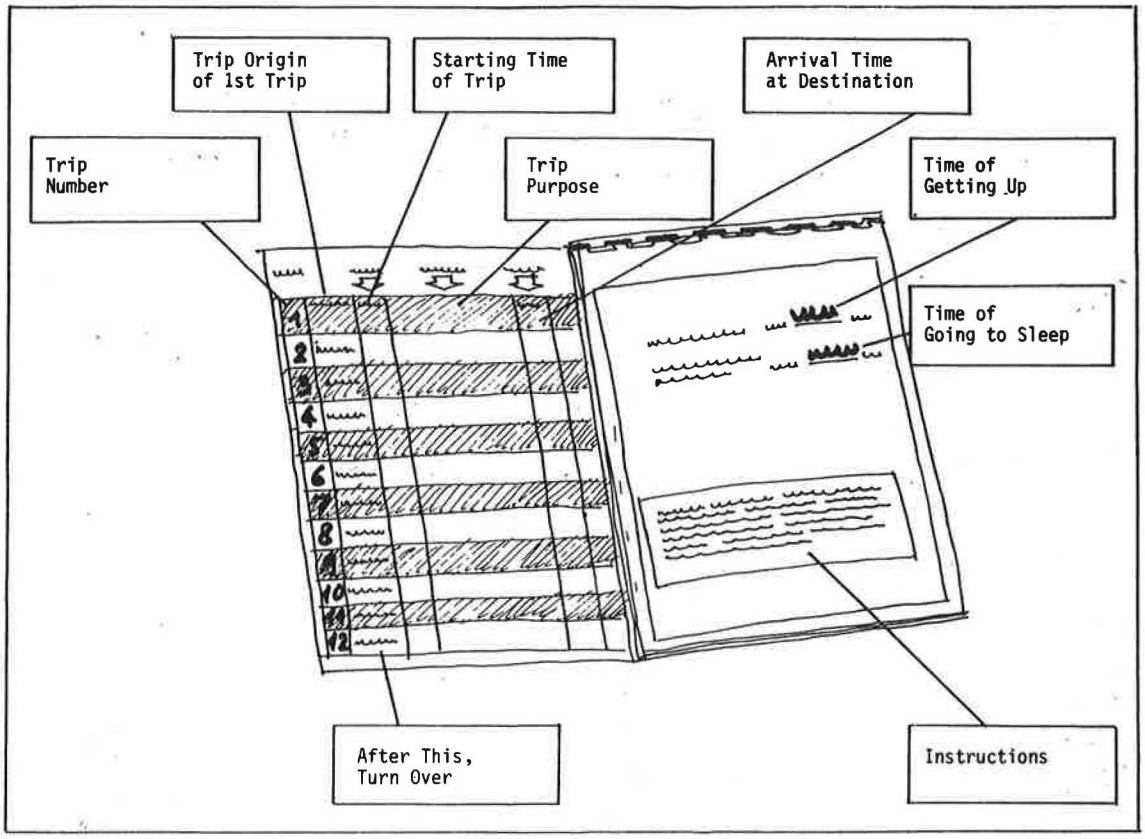


Figure 3. Trip register of diary for respondent.

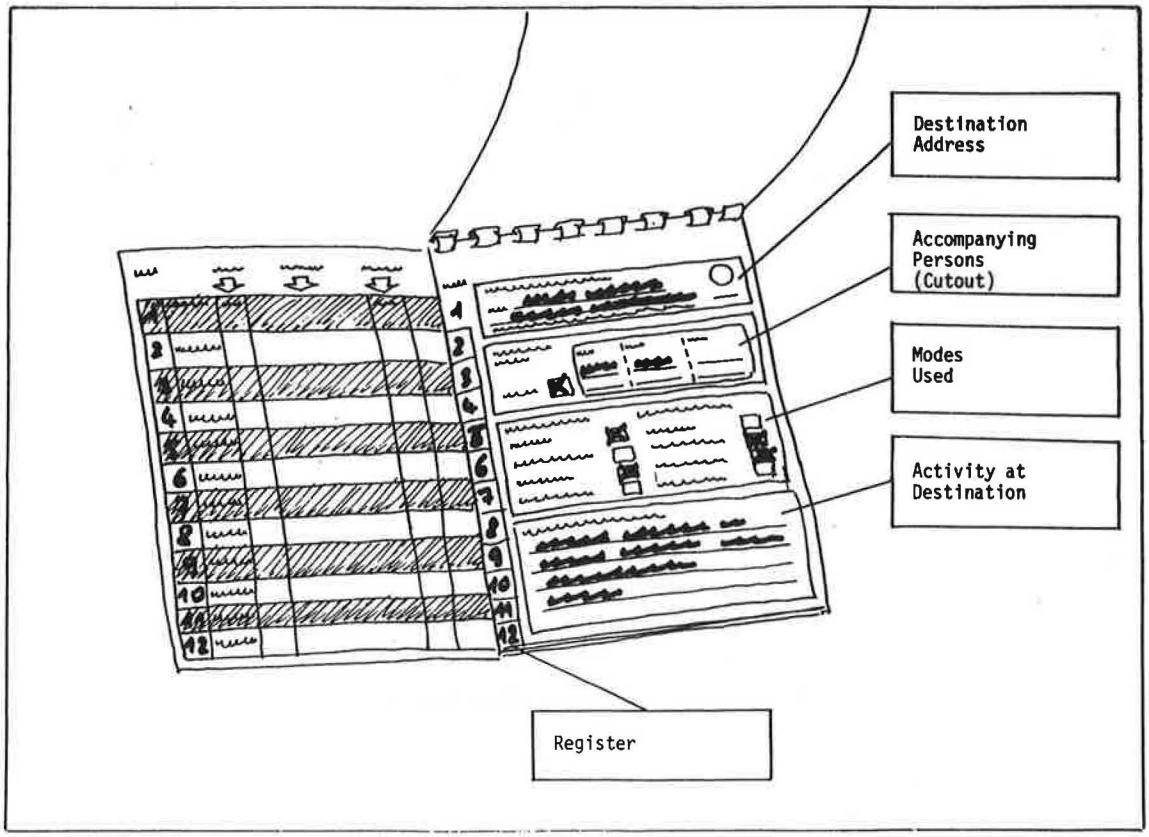
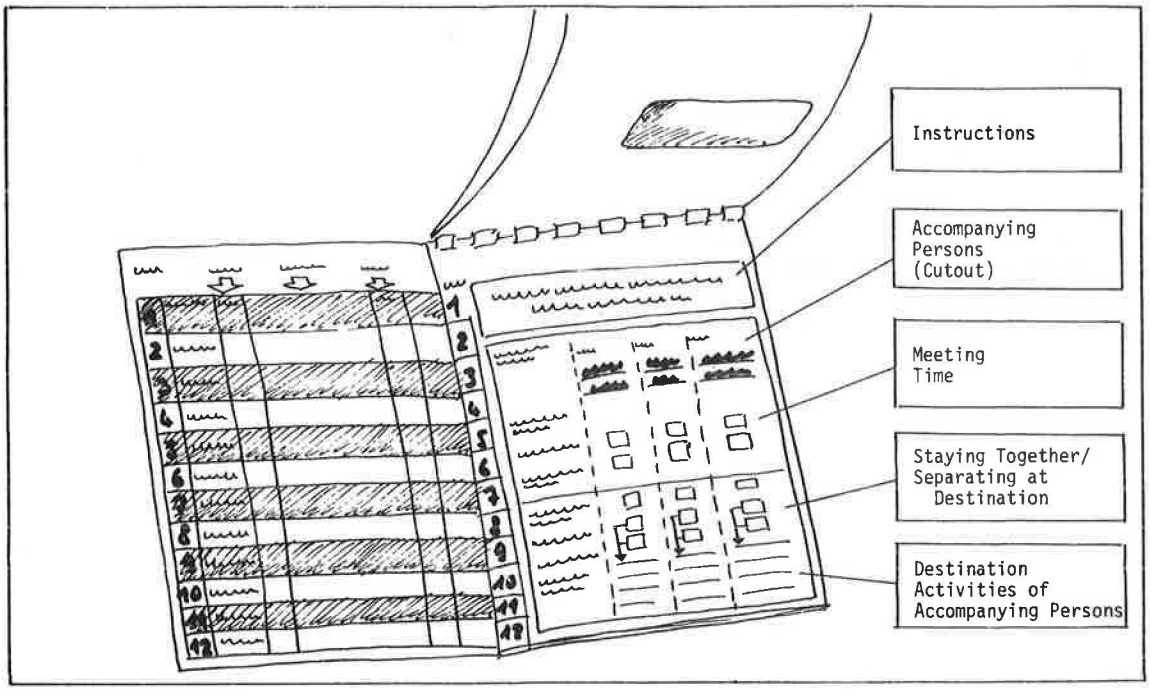


Figure 4. Trip register for accompanying person(s).



most important aspects of their sequence of activities during that day; i.e., location of the day's first activity (usually home), starting time of the first trip, activity associated with that trip (e.g., work), and time of arrival at destination.

All subsequent trips for that day were recorded according to the same pattern on the inside cover. Thus the temporal sequence of activities and the reasons (trip purposes) for the diverse nonhome activities were determined. At the same time, the format and layout of the instrument ensured that this rough record of daily activities could be outlined in the course of the day (i.e., en route, close to the time of the occurrence of any particular activity). This constituted the basis for the additional questions in the activities diary.

Separate survey sheets for each trip were afixed to the top of the inside right cover. There were two sheets for each trip; the first was to be used by the target person who was completing the diary. The second trip sheet referred to any possible accompanying traveler. These individual survey sheets were equipped with a register that made it simple to locate quickly the two sheets that belonged to any one trip. A color code was used for each trip that corresponded to the color scheme of even- versus odd-numbered trips recorded on the left inside cover.

The survey form for a specific trip performed by the respondent contained the following information:

1. Accurate address of destination,
2. Specification of up to three accompanying persons (e.g., neighbor, son, uncle),
3. All travel modes used on a particular trip, and
4. Detailed description of the destination activity.

A window was cut in the space where the specification of the accompanying person was recorded so that this specification appeared on both sheets (for the respondent and the accompanying person) without the need to record the same information twice. The form for the accompanying person contained information as to whether that person had accompanied the respondent from the start of the trip, whether the person stayed with the respondent at the destination, and, if applicable, what the person did subsequently.

ORGANIZATIONAL PROCESS FOR USE OF ACTIVITY DIARY

The diary was intended to be completed by the respondents, but the demands on the respondents both in terms of time and contents comprehension were substantial, especially for first-time use. The necessary instructions could not be transmitted easily in writing to the respondent. Hence the use of interviewers was necessary, but they played the role of advisors rather than interviewers.

The procedure went as follows. First, the interviewer conducted a preinterview with the respondent, collecting the relevant sociodemographic data. The interviewer explained the structure of the diary and helped fill in the sequence of activities for the day before the interview. Then the diaries were handed to the respondent for subsequent unassisted reporting of activities on the specified survey days.

Finally, a postinterview was arranged to discuss the respondents' experiences with the diaries, to review the completed diaries, to make any corrections or additions that came to light at that time, and to collect the completed diaries. By this technique it was possible to determine how well respondents had fared with the diaries and how complete the recorded information was.

The technique of a personal trip diary represented significant progress both in terms of content and method. With respect to content, the diary, which required the reporting of entire activity sequences, by necessity also provided information for the transportation planner about walk and bicycle trips that had been ignored typically up to that time. The high share of nonmotorized travel in total individual mobility was registered with some

Figure 5. Timetable for interview work plan.

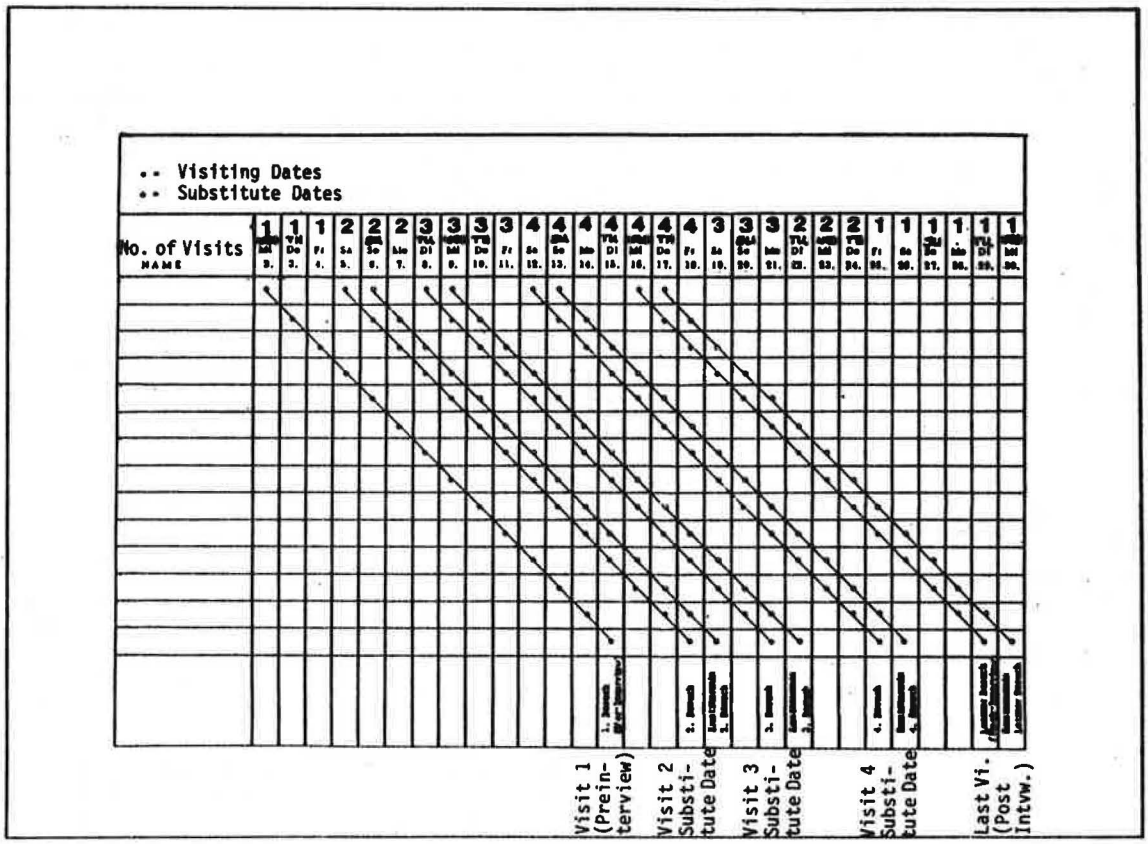


Table 3. Influence of interviewer on reported number of trips (8).

Day	Avg No. of Trips	Mobility Index (first day = 100.0)
1	5.14	100.0
2	4.90	95.3
3	4.66	90.7
Visit by interviewer		
4	5.02	97.7
5	4.66	90.7
6	4.76	92.6
7	4.43	86.2
Visit by interviewer		
8	4.82	93.8
9	4.45	86.6
10	4.67	90.9
11	4.74	92.2
Visit by interviewer		
12	4.83	94.0
13	4.52	87.9
14	4.48	87.2

surprise, at least in the Federal Republic of Germany.

From a methodological point of view, progress was achieved because travel behavior had not been recorded in general and average terms, but rather according to actual activities, and estimates had been replaced by methodologically superior techniques. Nevertheless, the problems remained that one survey day provided only a segment of an individual's mobility behavior, and that travel behavior could vary from day to day.

Based on these problems it was decided to investigate the travel activities of a population for two consecutive weeks, with each day requiring the completion of a separate diary. Because it could be expected that the motivation for completing these diaries would decrease with time, the interviewers took on the additional task of visiting the sample households and providing the respondents with renewed encouragement. Also, respondents were handed diaries for only 3 to 4 days at a time, which were then checked and exchanged against new ones for the next set of days. Only highly qualified and sensitive interviewers could be used for this difficult task. Therefore the sample was divided into several subsamples for which the survey weeks were staggered. Hence the interviewers did not have to conduct all preinterviews and postinterviews on the same days. Instead, they received a rather complicated work plan (see Figure 5) according to which they had to conduct the preinterviews, the repeat visits, and the postinterviews on specific days for specific households.

This form of survey organization permits a time-series investigation with diaries. It is clear, however, that such surveys have to be limited in terms of sample size because of organizational and financial constraints.

The evaluation of the data collected by means of these diaries indicates that the expensive advisory function performed by the interviewers was absolutely necessary. As indicated by the data in Table 3 (8), the number of trips recorded for the first day was highest, with all subsequent days showing a decline. This continuity was interrupted only for the days following a visit by an interviewer, i.e., the number of reported trips increased only to decrease again until the next visit.

FURTHER DEVELOPMENTS OF ACTIVITY DIARY

It became clear that, from a methodological point of view, this diary approach constituted the best in-

strument in the early 1970s. However, it was not suitable for use in large-scale surveys that cover large geographical or time dimensions. The objectives for further developmental work were the elimination of the interviewer (advisor) and the simplification of the diary to such a degree that self-administered, mail-back surveys would become feasible.

In the course of a new pretest series, the diaries were still delivered by interviewers. But the interviewers would only hand out an instruction sheet to the sample households, rather than providing detailed verbal explanations. The completed diaries were returned by mail, thus eliminating the possibility of checking the diaries for accuracy and completeness.

The these reasons, this pretest was subjected to a systematic error analysis of each diary, which revealed the following results:

1. About one-third of the diaries did not contain any recognizable errors,
2. About one-fifth contained mistakes that could be corrected subsequently by means of careful data preparation (e.g., missing return trips home, inaccurate destination address), and
3. Another fifth showed mistakes of such severity that the diary was unusable or only partly usable [see Table 4 (8), Version 1].

A more detailed analysis of the mistakes indicated that

1. Forty percent of the errors pertained to the trip destination address, most of which could be corrected subsequently;
2. Approximately 25 percent of the errors occurred in the trip-purpose specification, most of which could be corrected; and
3. A little less than one-quarter of the deficiencies pertained to incomplete information, mostly missing trips; only 14 percent of these could be reconstructed in the data preparation phase [see Table 5 (8), Version 1].

Table 4. Response quality for activity diary (8).

Item	Version 1[a]	Version 2[b]
Sample size	118	133
Usable diaries (%)		
Without mistakes	62	60
With small mistakes	18	20
Total	80	80
Unusable or only partly usable diaries (%)	20	20

[a]Every activity represents a trip. [b]Every mode used constitutes a trip.

Overall, about three-quarters of the recognizable errors could be corrected (Table 5). This result was considered satisfactory. In principle, it appeared feasible to conduct such surveys with purely written instructions accompanying the survey instrument. The relatively high number of unusable or only partly usable survey responses were attributable to the complexity of the required recording procedure that had not been altered up to this stage in the development of the survey instrument.

Before tackling this particular issue, another problem had to be addressed, which pertained to the content of the survey instrument, namely the definition of the term trip and the recording of travel modes. Up to this version of the diary, a trip was understood as the activity that links two geographically separate places where the respondent pursued activities. Therefore, it was necessary to record all modes of travel that were necessary to overcome the spatial separation. This aspect resulted in the following issues:

1. It was possible that respondents did not record walk trips that were necessary in conjunction with the use of individual or public transportation modes;
2. If a travel mode had to be used repeatedly (e.g., different subway, bus, or street car lines), this mode could only be recorded once; and
3. The sequence of use for the different modes was not immediately discernable from the diary entries.

The methodological solution that eliminated these issues completely could only lie in the definition of trip as comprising each individual mode used on a specific travel segment. This meant that a separate survey sheet would have to be used for each change of mode. The obvious disadvantage was the increased reporting effort required of the respondent.

The results of a test with a diary that used the trip definition just outlined were as follows.

1. The number of usable diaries did not change.
2. The number of diaries with correctable minor errors increased slightly (see Table 4, Version 2).
3. The number of recorded trips per diary increased from 4.21 to 4.79, as was to be expected. Of course, this increase was directly related to the change in trip definition. In fact, when the number of trips were compared on the basis of the same trip definition, the second, more work-intensive version of the diary led to a reduction in the number of trips by about 10 percent.
4. The total number of errors per diary decreased from 3.41 in the pretest to 3.05, which was attributable mainly to improvements in the reporting of destination addresses. This is plausible because this address now was the parking garage, the bus stop, and so forth.

Table 5. Reporting errors for activity diary (8).

	Total (n = 2,522)		Version 1[a] (n = 402)		Version 2[b] (n = 405)	
Item	Percent	Correctable Errors (%)	Percent	Correctable Errors (%)	Percent	Correctable Errors
Error in destination address	60	46	40	36	26	19
Error in trip purpose	20	16	28	24	52	45
Error in mode used	4	2	3	1	1	-
Error in specification of time	5	2	5	2	1	-
Incomplete reporting	11	6	23	14	21	8
Total	100	72	99	77	101	72

[a]Every activity represents a trip. [b]Every mode used constitutes a trip.

5. The number of incorrectable errors increased from 0.78 to 0.85 per daily diary. More than half of the errors pertained to trip-purpose information (see Table 5, Version 2).

These results suggested a return to the former trip definition because the problems that gave rise to a change in trip definition could be overcome by other means:

1. Walk trips as access and egress elements could be supplemented at the time of data preparation (verification);
2. The sequence of travel mode used and multiple use of a mode on a single trip could be constructed easily on the basis of origin-destination information, in case this is important information for a specific study; and
3. The majority of investigations that deal with explanation and prediction of, and the ability to influence, travel behavior are mainly directed toward the main mode used on a trip.

FROM ACTIVITY DIARY TO PERSONAL SURVEY FORM

From a methodological and theoretical point of view, it can be concluded that the diary met the requirements of methodological quality extremely well. Nevertheless, as stated previously, the use of a diary becomes problematic for large, possibly widely dispersed, populations. The financial and organizational costs for the necessary interviewer advice and for the instrument layout make it somewhat questionable.

This implied that a survey instrument had to be developed for large-scale surveys that maintained high methodological quality while at the same time was technically simpler and more suitable for self-administration by the respondents. With the survey content given (namely measurement of all trips during a day characterized by times, purpose, destination, and travel mode used), the following aspects gained importance in the further development of the survey instrument: formulation of questions, arrangement of questions, layout, and communications between respondents and survey administrators.

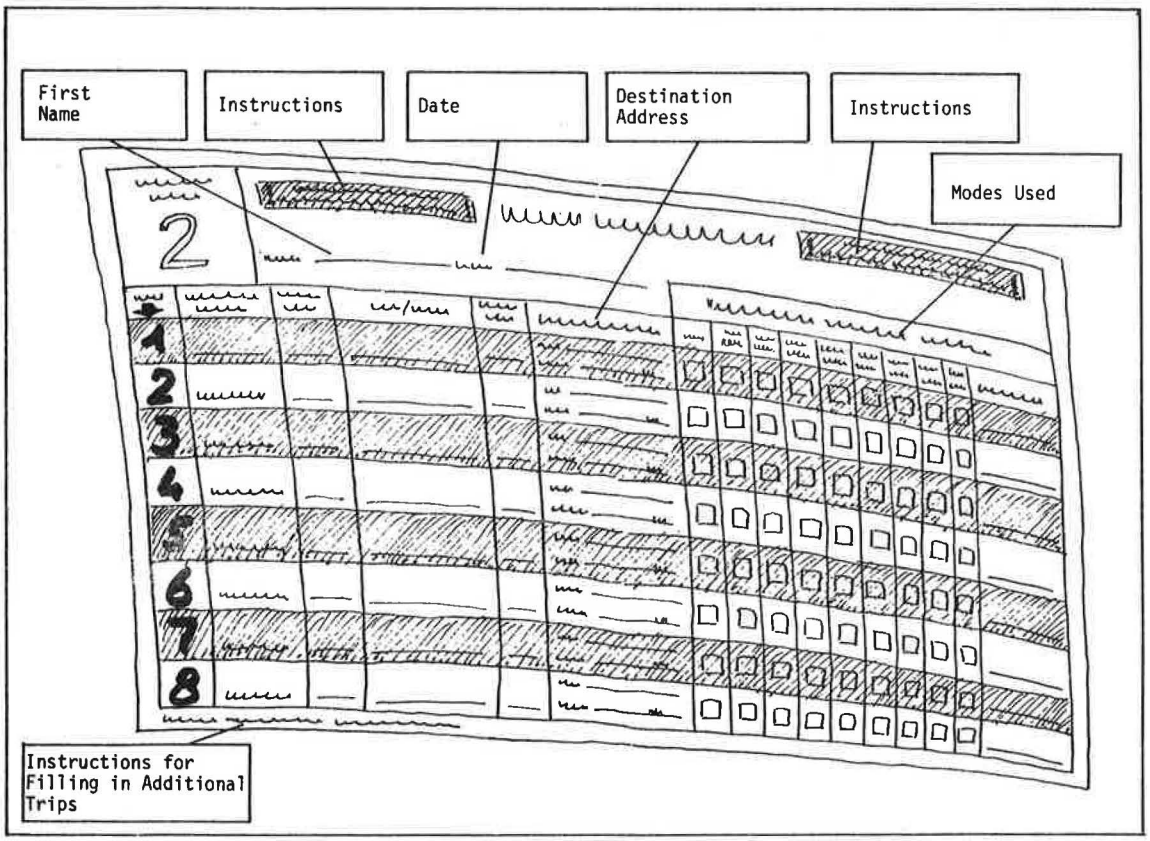
First Pretest Phase for Questionnaire Development

A multiphase pretest series was performed in order to transform the activity diary to a survey instrument suitable for large-scale surveys (9). The main effort during the first pretest concentrated on generating preferably a single-sheet questionnaire out of an extensive diary, while still being able to record all trips of a survey day. This requirement had several consequences: (a) the number of recorded trips had to be more limited, (b) the brief summary of the sequence of the day's activities (inside front cover of diary) had to be deleted, and (c) space for comments and open questions was to become limited.

Two questionnaires were developed for this first pretest that differed with respect to the formulation and arrangement of the questions and the layout. In the first questionnaire trips had to be recorded in rows. Trip purpose had to be entered in longhand rather than checked off on a preprinted listing. All trip characteristics could only be listed once. Each trip row contained fields for making longhand entries and squares for checkoff marks (Figure 6).

In the second version of this questionnaire trips had to be recorded in columns. Trip purpose had to be recorded in longhand. For each block the most frequent and obvious categories of answers were

Figure 6. Row version of questionnaire.



given for easy checkoff; all other answers had to be provided in longhand (Figure 7).

The results of this first pretest stage can be summarized as follows.

1. The percentage of usable forms for the column version of the questionnaire was higher (97 percent) than the row version (92 percent) [see Table 6 (10)].
2. Sixty-two percent of the reported trips contained incorrect or incomplete information; 46.4 percent were correctable [see Table 7 (8,10), First Pretest Phase].
3. Most deficiencies in reporting pertain to the destination address (41.9 percent of all trips), but most of them are minor problems because the majority of the addresses can be located, given the geographical aggregation level typically used in transportation planning (see Table 7, First Pretest Phase).
4. In the row version an increasing number of errors occurred with respect to trip purpose for the return trip home. This is attributable to the open form of the question used in this version.
5. The average number of daily trips measured in this pretest was 3.59 trips per person compared with

Figure 7. Column version of questionnaire.

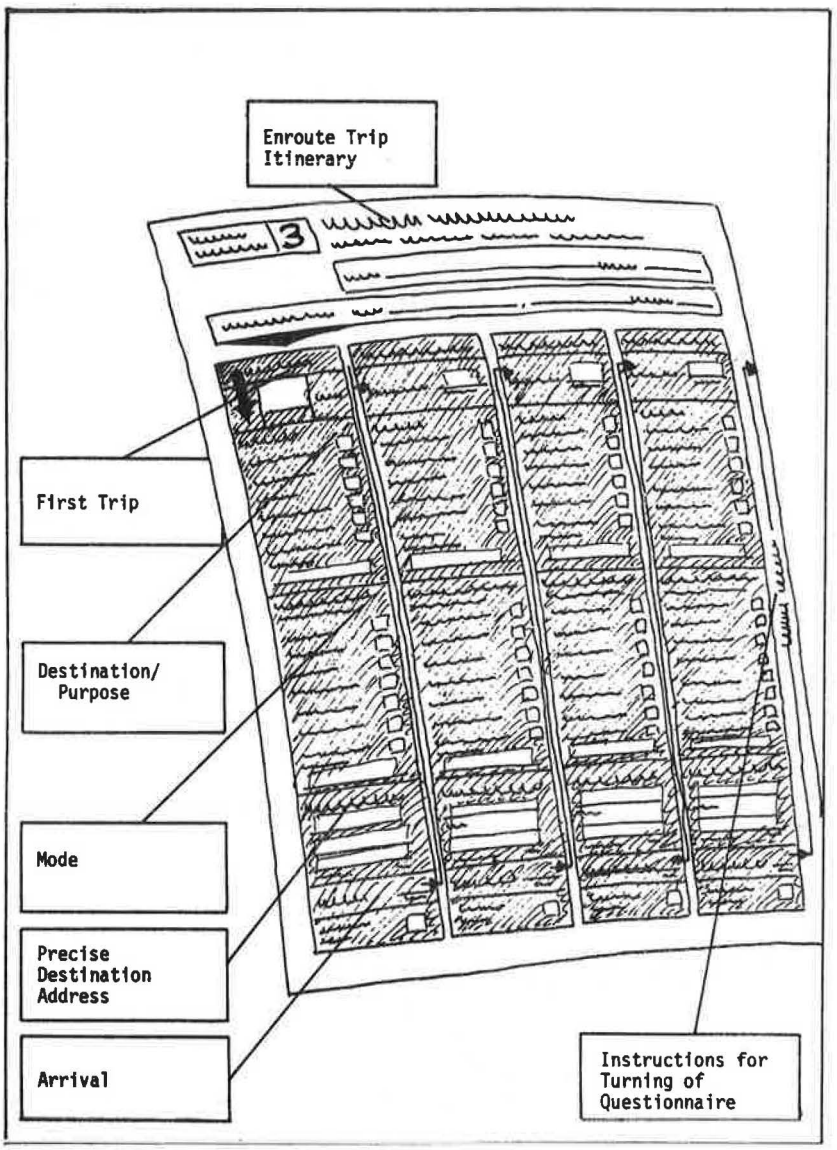


Table 6. Reporting quality for column and row versions of questionnaire (10).

Questionnaire Version	Sample Size	Usable Questionnaires (%)			Unusable or Partly Usable Questionnaire (%)
		Without Error	Correctable Questionnaire	Total	
Column layout	59	88	9	97	3
Row layout	58	89	3	92	8

Table 7. Incorrect and incomplete reporting (8,10).

Pretest Phase	Incorrect Reports per 100 Trips by Trip Characteristic								Incomplete Reports per 100 Trips	
	Destination Address		Purpose		Mode		Timing of Departure and Arrival			
	Total	Noncorrectable	Total	Noncorrectable	Total	Noncorrectable	Total	Noncorrectable	Total	Noncorrectable
First	41.9	2.9	4.4	2.6	1.6	1.0	5.5	3.6	8.6	5.5
Second	29.6	8.1	4.7	1.6	1.9	0.8	0.8	0.4	2.0	0.4

4.21 trips reported in the diary. The reasons for this lie in the absence of an interviewer providing additional motivation for responding and in the layout of the questionnaire.

Second Pretest Phase

The second pretest again made use of the row and column versions of the questionnaire (see Figures 6 and 7). However, this time the layout was improved substantially. Dual color printing made the questionnaire more readable and visually more appealing. In the column version the fields and squares for recording answers and checkmarks, and in the row version all odd-numbered trips, appeared in a different color from that used on the rest of the form. Also, emphasis of certain important information was achieved through varying letter size and thickness.

These changes in layout were supposed to improve the results of the first pretest phase in two respects. First, the clearer distinction between individual trips impresses more on the respondent that all trips for a day were to be recorded. Second, the visual emphasis was supposed to reduce the share of unanswered questions because the respondent could see immediately where entries were expected to be made.

The second pretest phase is distinguishable from the first one mainly because the questionnaires were to be tested under the conditions of a mail-back survey; i.e., respondents had to master the questionnaire responses exclusively on the basis of the written instructions provided, and the respondents had to be motivated in writing to participate in the survey.

Two variations of the column version, distinguished by their different spatial arrangements, were developed for purposes of a mail-back survey. Both variations were printed on one sheet, one of them a folded version where all trips could be recorded across that page. The other version was printed on both sides of a smaller sheet, with the implication that the sheet had to be turned over after the first four trips had been recorded on the front. This last version, of course, had a postage cost advantage.

The results of this second pretest phase were as follows.

1. The number of reported trips increased from 3.59 during the first phase to 3.97 trips, which can be attributed to the improved layout. The remaining discrepancy with respect to the 4.20 trips per person per day obtained in the diary is explainable because no control and immediate corrections function can be provided in the mail-back questionnaires.
2. The row version contained the largest number of incomplete answers (39.9 percent of all trips), whereas the front and back column version contained the fewest (37.9 percent). These differences are not dramatic, but it should be emphasized that the number of errors was successfully reduced for all questionnaire versions compared with the first pretest phase [see Table 8 (9,10)].
3. The number of mistakes with respect to the destination address decreased from 41.9 to 29.6 percent. Unfortunately, the share of noncorrectable errors increased from 2.9 to 8.1 percent (see Table 7, Second Pretest Phase). It is worth mentioning that the first pretest phase was conducted in Munich, where a greater amount of professional deciphering of address information could be provided by the administering agencies (Socialdata GmbH and Technical University Munich) than in the case of the second pretest phase, which took place in other German cities. Of course, the three questionnaire versions used were identical; i.e., the destination address had to be provided in longhand [see Table 9 (9,10)].
4. The row version had more errors in the trip purposes, as was the case in the first pretest phase. Again, the reason was because of the open answer format (Table 9).
5. The number of unusable questionnaires and noncorrectable entries increased with the age of the respondent. Older people had particular difficulties with the accurate reporting of trip purposes.
6. For complicated trip sequences (i.e., those that involve more than travel to and from a single destination or involve several intermediate activities), the number of unusable responses was high. Trip purpose and destination address appeared to cause the most difficulties.

Table 8. Incorrect and incomplete reporting of trips in relation to different questionnaire versions (9,10).

Questionnaire Version	Reported Trips	Incorrect and Incomplete Trip Reports		Incorrect and Incomplete Reports per 100 Trips	
		Total	Noncorrectable	Total	Noncorrectable
Column version with foldout	1,384	540	146	39.0	10.6
Column version with front-to-back printing	1,148	436	138	37.9	12.1
Row version	1,253	500	144	39.9	11.5
Total	3,785	1,476	428	39.0	11.3

Table 9. Incorrect and incomplete trip reports by trip characteristic and questionnaire version (9,10).

Questionnaire Version	Incorrect Reports per 100 Trips by Trip Characteristic								Incomplete Reports per 100 Trips	
	Destination Address		Purpose		Mode		Timing of Departure and Arrival			
	Total	Noncorrectable	Total	Noncorrectable	Total	Noncorrectable	Total	Noncorrectable	Total	Noncorrectable
Column version with foldout	29.7	7.8	4.0	0.9	1.9	1.1	1.4	0.8	2.0	0.0
Column version with front-to-back printing	29.7	9.7	4.0	1.0	1.1	0.4	0.6	0.1	2.5	0.9
Row version	29.5	7.3	6.1	2.9	2.7	0.7	0.2	0.2	1.4	0.4
Total	29.6	8.1	4.7	1.6	1.9	0.8	0.8	0.4	2.0	0.4

In summary it can be concluded that the column version resulted in higher reporting accuracy. The decisive impetus to use this version in future surveys, however, was provided by a second criterion that was investigated in this pretest phase--willingness to respond.

The front-to-back variation on the column version led to a better response rate: approximately 80 percent as compared with the row version of about 70 percent.

Communication Between Survey Agency and Respondent

In the previous sections a distinction was made between two forms of communication: personal delivery and pickup of the survey forms (first pretest) and self-administered mail-back surveys (second pretest). The impact of these two methods on response accuracy was investigated. However, communication still has two additional important implications: response rate and survey cost per respondent.

These two aspects were investigated in another pretest series. Eight different forms of communication were tested, including a mix of personal and postal delivery and pickup. For the case of postal service use, additional distinctions were made as to whether prior notification by postcard was provided, and whether the recipients of the survey instrument received reminders by telephone on the actual prescribed survey day.

The results of these methodological tests were clear [Table 10 (8)]. Even the simplest postal service method (method 1) resulted in a better response rate (73 percent) than the most costly personal attention method (method 7) by means of interviewers (70 percent response rate). A response rate of 81 percent was achieved by means of the most expensive postal method [i.e., including notification and reminder by telephone (method 4)]. Even this method is less expensive than the least-expensive personal method (method 5).

On the basis of these results it was decided to conduct such surveys in writing by the mail-back process and to ensure as good a response rate as possible by written notification and reminder notices (8).

Further Aspects of Survey Instrument Design

Three additional aspects of questionnaire design that often are relevant in specific practical applications are as follows: (a) ease of coding for computer analysis, (b) consistency of questionnaire contents, and (c) surveys for foreign nationals.

Questionnaire Design for Computer Processing

Frequently, questionnaires were and are designed such that they meet the demands of researchers in the best possible manner. These demands and standards, however, often run counter to the needs of the survey respondent. Outstanding examples for this are the attempts to design the survey questionnaires in machine-readable form. A comparison of two substantially identical questionnaires, one in machine-readable format and the other with a normal layout, produced the following results (11):

1. The machine-readable form produced 10 percent fewer activities,
2. The number of deficient questionnaires was almost 3 times as high,
3. The number of unusable questionnaires was almost 4 times as high, and
4. With identical strategies for increasing the response rate, the machine-readable form produced a 66 percent rate and the normal layout a 79 percent rate.

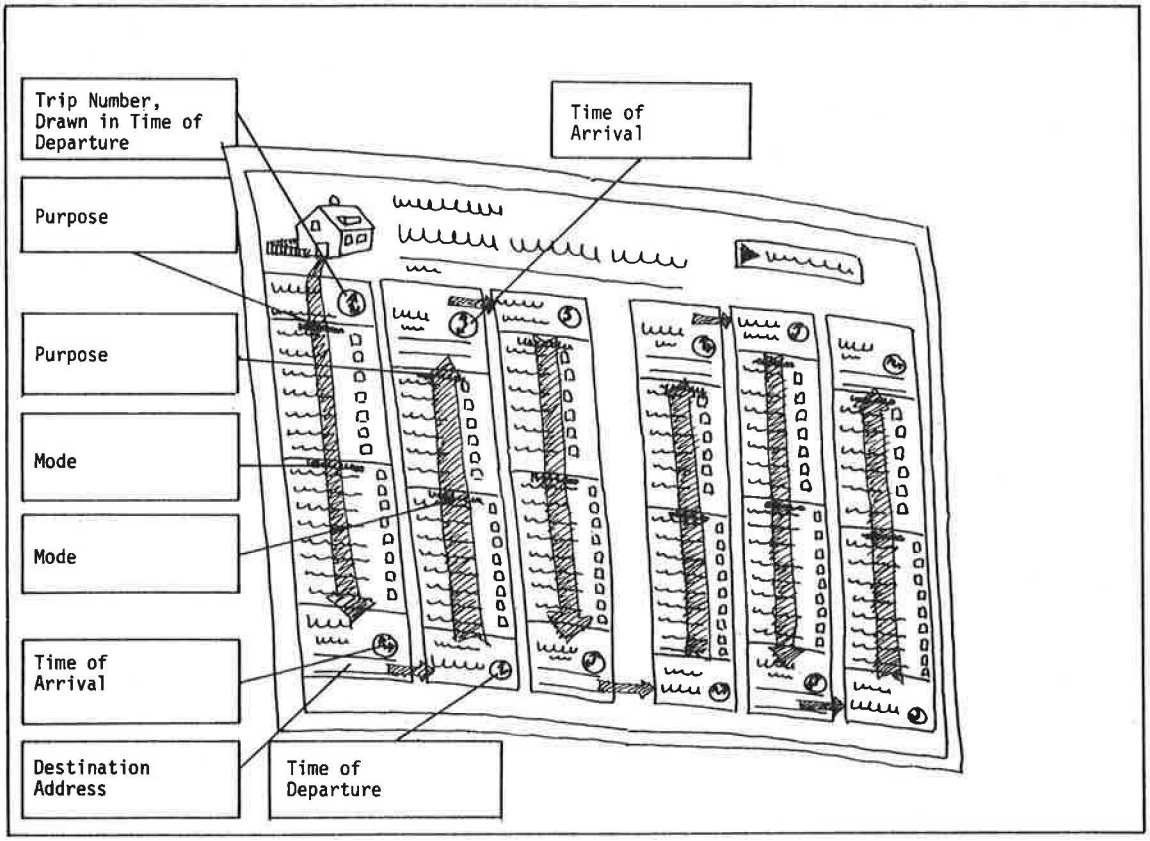
Consistency of Questionnaire Content

In addition to the design and layout, the questionnaire content has a significant effect on the willingness to respond. The logic of the questionnaire content (as perceived by the respondent) rather than the length is important. In this context it can be shown that it is feasible to transmit to the respondent the necessity of answering related and internally consistent sets of questions, but that the respondent's comprehension and willingness to respond is reduced markedly when this rule is violated.

Table 10. Response rates and survey cost as a function of questionnaire distribution and collection methods (8).

Distribution and Collection Method	Response Rate (%)	Cost-Index per Response	Sample Size (households)
Method 1-postal distribution and return	73	100	1,188
Method 2-notification, postal distribution and return	78	101	1,196
Method 3-postal distribution, reminder on survey day, postal return	77	104	1,193
Method 4-notification, postal distribution, reminder on survey day, postal return	81	113	1,191
Method 5-postal distribution, personal pickup	64	188	544
Method 6-personal delivery, postal return	63	215	517
Method 7-personal delivery, personal pickup	70	278	1,071

Figure 8. Column version of questionnaire for foreigners.



This point is illustrated in the following table on the basis of three surveys (4) with different degrees of internally logical sets of questions:

	Version		
Item	1: Complete Internal Logic	2: Partial Internal Logic	3: No Internal Logic
Sample size	55,107	19,380	12,091
Response rate (%)	81	77	67

Version 1 contained questions about demographics and nonhome activities (i.e., the internal logic was fully recognizable). Version 2 included additional, somewhat related questions (i.e., a logical unit was present, in part). Finally, in version 3 sets of questions of entirely different content were added (i.e., the logical unity was lost). The data in the table indicate that the response rate was affected quite substantially.

Surveys for Foreign Nationals

In several countries with sizable groups of foreign nationals it is sometimes necessary to survey this population segment of a specific study area. Typically, one of the following survey techniques is used. Either the foreigners receive the standard local-language form as it is distributed to the domestic population sample in the hopes that they have acquired sufficient local-language facility, or they receive a version prepared in their native language.

The second method obviously is the better approach, but it is not sufficient to generate adequate response in terms of numbers and quality. Because foreigners do not only differ in their native language but also in terms of mentality (e.g., perception of time), forms of expressions, and communications, a straight technical translation of the survey instrument cannot suffice to provide them with a survey form adequate for their needs (see Figure 8). In order to generate a questionnaire of equal content it was necessary to conduct similar types of pretest series as were described for the development of the local-language questionnaire in earlier sections of this paper. Different techniques and presentations had to be tested.

Such a questionnaire was developed for Turkish and Yugoslav residents of Berlin, Germany, and it was used in the context of a large-scale survey in that city (12). A meaningful comparison of the response quality between the German and foreign-language versions of the questionnaire can be made for the reporting of trip destinations because that aspect was probably most difficult for foreigners to answer accurately. The results indicated that the difference in response accuracy was insignificant, and it was certainly much better than had been observed in other surveys involving foreign residents [see Table 11 (12)].

Table 11. Example of response quality for German and Turkish and Yugoslav residents of Berlin, Germany (12).

Item	German Residents	Turkish and Yugoslav Residents
Sample size	19,000	2,000
Reporting quality of destination address (%)		
Directly usable	78	72
Usable with extra effort	20	18
Not usable	2	10
Response rate (%)	77	71

The questionnaire design for foreigners also has a direct impact on the response rate. A 13 percent difference in response rates could be observed between a straight technical translation and a specially designed survey form. According to the data in the following table (12), an additional increase of 9 percent was possible by means of special foreign-language telephone and written assistance and information:

Survey	Sample Size	Response Rate (%)
Straight technical translation	3,000	49
Specially designed survey form	1,084	62
Specially designed survey form with special assistance provided	2,712	71

CONCLUSIONS

The details of the developmental process involved in generating a survey instrument that meets criteria of high methodological quality, high expected response rates, suitability for large-scale surveys into travel behavior, and relatively low costs have been described. Through a number of real-world tests it was demonstrated that a variety of design aspects can have substantial influence on one or more of the preceding criteria. Each test series was tested empirically, with detailed documentation of reporting deficiencies.

The tests revealed how important methodological research into improved survey design can pay off in terms of better and more complete survey results and, hence, in terms of more reliable and valid inputs into travel modeling and transportation planning. Uncritical use of unproven survey instruments can have a profound influence on the efforts by transportation planners and policy decision makers.

In this paper the evolution of better travel survey instruments based on diary-generated information through research performed in Germany has been discussed. It should be made clear that many of the methodological insights gained in the course of these developments have been implemented in sophisticated travel data-collection efforts in the United States. Excellent examples of such efforts have been presented in two recent papers (13,14).

REFERENCES

1. A.H. Meyburg and W. Brög. Validity Problems in Empirical Analyses of Nonhome Activity Patterns. TRB, Transportation Research Record 807, 1981, pp. 46-50.
2. W. Brög. Mobility and Lifestyle--Sociological Aspects. Report of the 8th International European Conference of Ministers of Transport Symposium on Theory and Practice in Transport Economics (ECMT Publications Department of the Organization for Economic Cooperation and Development), Istanbul, Sept. 1979.
3. M.J. Wermuth. Effects of Survey Methods and Measurement Techniques on the Accuracy of Household Travel Behavior Surveys. In New Horizons in Travel Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), Lexington Books, Lexington, Mass., 1981, Chapter 28.
4. Sozialforschung Brög. KONTIV 75-77: Continuous Survey of Travel Behavior (Kontinuierliche Erhebung zum Verkehrsverhalten), Summary Vols. 1-3. Ministry of Transport, Munich, Germany, 1977 (in German).
5. W. Brög and W. Schwerdtfeger. Considerations on the Design of Behavioral Oriented Models from the Point of View of Empirical Social Research. In Transport Decisions in an Age of Uncertainty (E.J. Visser, ed.), Kluwer Academic Publishers, Hingham, Mass., 1977.
6. W. Brög. Latest Empirical Findings of Individual Travel Behavior as a Tool for Establishing Better Policy-Sensitive Planning Models. Presented at World Conference on Transport Research, London, England, April 1980.
7. W. Brög. Application of Situational Approach to Depict a Model of Personal Long-Distance Travel. TRB, Transportation Research Record 890, 1982, pp. 24-33.
8. Sozialforschung Brög. Travel Behavior in Connection with the Munich Commuter Train System (Verkehrsverhalten im S-Bahn-Bereich). Urban Development Office, Munich, Germany, Jan. 1973 (in German).
9. Sozialforschung Brög. Comprehensive Transportation Plan for Nuremberg (Gesamtverkehrsplan Nürnberg). Government of Middle Franconia, Munich, Germany, Preparatory Studies, Vol. 3, 1974 (in German).
10. M.J. Wermuth and G. Meerschalk. Representativeness of Written Mail-Back Household Surveys (Zur Repräsentanz Schriftlicher Haushaltsbefragungen). German Ministry of Transport, Munich, Germany, 1981 (in German).
11. Sozialforschung Brög. Investigation of Work and School Trips (Studie zum Berufs-und Ausbildungsverkehr). German Ministry of Transport, Munich, Germany, 1976 (in German).
12. Sozialforschung Brög. Transport Development Plan for Berlin [Verkehrsentwicklungsplan (VEP) Berlin]. Senator for Construction and Housing, Berlin, Germany, Final Rept., 1977 (in German).
13. P.R. Stopher and I.M. Sheskin. Toward Improved Collection of 24-H Travel Record. TRB, Transportation Research Record 891, 1982, pp. 10-17.
14. P. Rai, P.R. Stopher, and C. Brown. Origin-Destination Travel Survey for Southeast Michigan. TRB, Transportation Research Record 886, 1982, pp. 1-8.

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