Survey Data Collection Using Complex Automated Questionnaires

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Abstract

Since the early 1980s, researchers in the federal statistical community have been moving complex surveys from paper questionnaires to computer-assisted interviewing (CAI). The data collected through such surveys cover a variety of needs, from critical information on the health of the economy to social issues as measured by statistics on health, crime, expenditures, and education. This paper covers some of the key issues involved in developing applications used primarily by a middle-age, part-time workforce, which uses the software in a variety of situations, while interacting with an occasionally uncooperative public.

Introduction

Government surveys provide critical information on a variety of topics of importance to the well-being of the U.S., including data about consumer expenditures, health, crime, education, and employment – just to name a few.

Compared to other disciplines, the history of survey research is relatively new, with most major advances occurring since the 1930s (Brick, 2002). Although desired information is sometimes available from existing administrative records or through simple mail surveys, more detailed information can only be obtained through direct interviews with representative samples of Americans. For example, one of the better known, largest, and longest continuing surveys in the United States is the Current Population Survey or CPS. The CPS is a monthly sample survey of about 60,000 households that has been conducted since 1940, and which provides information on labor force activity. This survey is the source of the monthly national unemployment rate, a key economic indicator. In addition, the CPS provides rich demographic detail that can be used to analyze the U.S. labor force, including age, sex, race, Hispanic origin, educational attainment, marital status and family attributes, foreign-born status, veteran status, and other demographic characteristics.

The CPS is conducted by a workforce of about 1,500 interviewers scattered across the U.S. who conduct interviews in respondents' homes and, occasionally, on doorsteps, porches, lawns, etc., or over the telephone from either an interviewer's home or from a centralized telephone interviewing facility. Although the composition of the interviewer workforce has undergone some changes in recent years with the increased hiring of retirees, historically, the majority of interviewers have been women between the ages of 45 and 55, who work part-time, and who lack many of the computer skills taken for granted in younger populations. Many interviewers tend to work on a single, primary survey, but are available to work on others (some continuous, some one-time). Depending on the survey, annual rates of attrition or interviewer turnover can range between 18 and 31 percent (Mockovak, 1981), so recruitment and training are ongoing activities.

To collect survey data, interviewers use a computer-assisted interviewing (CAI) program, called an instrument, which is loaded on a laptop computer (PCs are used in centralized phone centers). This application displays the question that the interviewer should ask, the valid answers (or answer types) for the question, special instructions to the interviewer, and any associated help information. In addition, case management software exists to help the interviewer manage her work assignment, receive and transmit cases to headquarters, provide security, and other useful functions (e.g., data backup). Although a keyboard is most frequently used, some applications also allow an interviewer to enter survey responses using a mouse or pointing device, or some combination of the preceding. In past, as well as in many existing instruments, navigation is accomplished most often using function keys (F keys) to allow specific actions such as backing up or jumping to another section or to obtain help. However, Windows-based applications are allowing increased use of the mouse and tab and arrow keys, along with the use of graphical features to accomplish the same goals.

 The opinions expressed in this paper are solely those of the author and do not reflect official positions of the Bureau of Labor Statistics.

Computer Assisted Telephone Interviewing, or CATI, was first conducted by Chilton Research Services in 1971 (Couper and Nicholls, 1998). This technology involves calling respondents from a centralized telephone interviewing facility. The purported benefits of CATI compared to paper included the management of very large telephone samples, randomization of question and response category order, on-line and automatic arithmetic, access to on-line databases, increased timeliness of data, and reduced costs.

Computer Assisted Personal Interviewing, or CAPI, was first introduced in government surveys in the early 1980s to replace paper questionnaires used in face-to-face interviews, where interviewers traveled to a respondent's home. Its initial objectives were to reduce post-interview data processing, to use data from previous interviews to speed up and improve the quality of current interviews, to allow more complex questionnaire routing and tailoring of questions (for example, the use of branching logic to ask tailored questions of respondents with selected characteristics), to allow "last minute" changes to questionnaires, and to produce statistics more quickly. Except for the ability to incorporate last-minute changes, these objectives have been widely achieved. It was also hoped that lower costs and higher quality data would result, but these objectives have been more elusive.

In addition to CATI and CAPI, the acronym CASIC (Computer Assisted Survey Information Collection) is also used frequently in survey research to describe any effort to use computers for survey data collection, data capture, data preparation, and any activities that support these tasks (Couper and Nicholls, 1998). Recent CASIC efforts have focused on use of the Internet for survey data collection.

From 1988 to 1994, the use of computer-assisted interviewing grew rapidly, to the point where now most face-to-face government surveys use it to collect data. Early CAPI applications often placed tremendous demands on interviewers. For example, the first CAPI survey required interviewers to carry 25 pound computer terminals into respondents' homes, connect them to a telephone line, and dial in to a connection on a mainframe (Rothschild and Wilson, 1988). Modern-day applications use light-weight laptop computers, pad computers, or PDAs, although hardware issues like screen size, screen readability, and battery life continue to pose important operational problems, especially for PDAs.

The size and complexity of CAI instruments can vary widely. For some surveys, the CAI program can be quite simple and straightforward. However, for lengthy, complex surveys, such as the Bureau of Labor Statistic's Consumer Expenditure Quarterly Interview Survey, an average interview lasts 65 minutes, and some small number can last much longer (for example, 2-4 hours). Besides being expensive, the nature of these interviews places extraordinary demands on the interviewer. She must introduce herself and the survey, gain a respondent's cooperation, collect the data under less than ideal conditions (for example, on the doorstep, in the yard, in a noisy kitchen with children running around, when the respondent is doing other tasks, etc.), follow proper interviewing procedures, and take as little time as possible, since many surveys are longitudinal and require multiple visits.

Although respondents have used computers to complete survey questionnaires without the assistance of an interviewer, for example, self-administered questionnaires using touchtone phones or voice recognition (Clayton and Harrell, 1989; Appel and Cole, 1994), these types of applications tend to be short and simple with very minimal branching. Similarly, although a great deal of excitement and experimentation exists about using the Internet for survey data collection, for the most part, these applications have also focused on simple, self-completed questionnaires, and obtaining a representative, scientific sample using this mode remains a major concern. In addition, problems with respondent cooperation that are so common in interviewer-mediated data collection are even more pronounced in surveys done over the web.

Accordingly, the focus of this paper is on the use of complex computer-assisted interview instruments for interviewer-mediated data collection. These interviews can be conducted either face-to-face or over the telephone. The key challenge facing the survey methodologist is designing an automated interviewing tool that does not make the interviewer's already very challenging job even more difficult. As mentioned previously, an interviewer must interact with the computer-assisted interviewing program, while interacting with the respondent at the same time. As one might expect, not all respondents readily agree to an interview, and when they do agree to cooperate, many frequently want to give information in a different order or form from that required by the automated questionnaire. These constraints pose unusual demands on the interviewer and the software. The interviewer must negotiate with occasionally hostile respondents and apply sound interviewing techniques, while interacting with the software used to collect the survey data.

Instrument and Interface Design Challenges

The challenges facing CAI instrument designers are the same facing any large-scale software development effort. Even if a paper questionnaire already exists, data requirements are sometimes ambiguous or legacy processing systems are poorly documented, subject-matter experts and survey program managers often have a hard time making the transition from paper-based to automated data collection (for example, a common reaction is to try to duplicate a paper questionnaire on a computer), and developers (programmers) often lack experience developing interactive software that must adhere to strict standards of interviewer usability, as well as program documentation.

In addition to these more general problems, computer-assisted interviewing (CAI) faces other specific challenges. One of the most basic decisions facing managers of CAI projects is the choice of a software development tool. Special purpose development tools, designed specifically for computer assisted interviewing have been created. For example, Blaise and CASES are the two most commonly used packages for large, complex government surveys, but some survey managers have decided not to use these and have opted for more common tools such as Visual Basic instead. Packages like CASES and Blaise were originally developed so that non-programmers would be able to develop survey instruments and supporting case management functions, but at least in the U.S., this goal has not been widely achieved. Instead, the complexity of questionnaires has resulted in the continued heavy involvement of programmers, even for basic instrument development.

One key advantage of tools like CASES and Blaise is that they handle common screen formatting, response selection, branching, storage, input, retrieval, and data checks (called "edit checks") with only minimal programming. Another important benefit is that they also handle complex navigation among the questionnaire items, so that in more modern CAI systems, interviewers are given almost as much flexibility of movement as they had on paper questionnaires. For example, in a well-designed instrument, interviewers are able to move freely among the questions and different sections, change answers, and then resume where they had left off. Or, they might be able to jump ahead to a later section of the questionnaire, complete items there, then return to the main interview. This navigational flexibility adds complexity, however, since the program logic must allow for this type of movement and protect variables such as counters and flags. Other standard navigation options include the ability to exit an interview at any point, and to resume at that point when the respondent is available and ready to complete the interview. A drawback to these packages is that they use proprietary databases and special programs to control input and output. As a result, they add an extra step in any processing system and require special training. In addition, survey designers are never satisfied with the functionality provided by these packages. As a result, each has a long list of desired enhancements that has been developed in response to changing user requirements. From a human resources perspective, use of these packages has another drawback. Since programmers are generally required to field complex surveys, they play a critical role, but some programmers believe that specializing in the use of these specialized tools is a dead-end to their career progression and flexibility, since the survey research market is so limited in size.

What causes questionnaire complexity?
Complex questionnaires often contain hundreds, or sometimes thousands of potential questions, usually presented in at least two languages. In addition, complex logic is used to tailor questions for selected subgroups of the population (for example, women who have had a miscarriage, unemployed workers, Hispanic adults, etc.), and for edits, or data checks, that are used to ensure that answers provided by respondents are reasonable for single questions, as well as consistent across multiple questions. For example, a person who reported that he had only used gas for heating and cooking would be asked to verify a later answer that revealed he had spent money on fuel oil.

As a result of tailored questions, built-in edits, and the flexibility given to interviewers to move among questions, the potential number of paths through a questionnaire is huge. Therefore, the iterative process of testing, debugging, and revising an automated questionnaire is labor-intensive, extremely time consuming, and expensive. Because of the difficulty of debugging CAI instruments, bugs or "work arounds" often remain in the application that have to be addressed in interviewer training. One strategy that has been pursued by survey managers to address this problem is to involve programmers in the development of CAI applications by requiring them to work on teams with subject-matter specialists and survey specialists. These teams help develop and refine programming specifications, develop prototypes, and conduct testing. This approach requires the programmer to communicate frequently with team members and, therefore, helps to speed up the instrument development process. Despite these attempts, the testing and debugging process remains the **single** most important problem facing the development of complex CAI instruments. In fact, this subject was recently the primary focus of a 2-day workshop that involved survey researchers and computer scientists (CNSTAT, 2002) to see if successful software development and testing approaches used in computer science could be adapted to the development of CAI instruments.

The use of edits to improve data quality remains another major, unresolved issue in complex CAI instruments. Although there is ample support for the concept of getting the data correct at the source to avoid errors and expensive callbacks, the primary concern is that edits could complicate the response process, lengthen it, and lead to respondent disgruntlement or even an outright refusal to continue with the interview. Basic range edits for questions with a clearly defined set of answers (for example, 1 for yes, 2 for no) are straightforward, easy to implement, unlikely to add to burden, and result in data quality improvements. But more complex edits require the use of "pop-up" windows that analyze and describe the situation and ask the interviewer to resolve any inconsistencies. For example, a respondent may report an expenditure that is either too large or too small based on a history of previous reports for similar persons. These types of interactions clearly pose an additional burden for both the interviewer and the respondent.

Although some features may add to burden, the multimedia capabilities of Windows-based applications may actually enhance the interview situation and possibly lead to the perception of reduced burden from a respondent's perspective. However, since these types of applications for complex government surveys are still relatively uncommon, this remains an unsupported assertion.

Although help functions exist in all CAI applications, they are generally limited to providing definitions or procedural and conceptual information that must be read and processed by the interviewer (or other user). As such, the perception exists that such limited help functions are not widely used, nor perceived to be that helpful. Conrad (1993) made an attempt to incorporate an expert system within a CAI application to help deal with the difficult problem of price substitution: i.e., deciding what product to use for determining the price of a product or service when a pre-designated product was not available. But this attempt was unsuccessful because of sponsor resistance to the extensive knowledge engineering that would have been required for implementation.

With the increasing use of graphical features in Windows-based instruments, interviewer usability has become an increasing concern (Mockovak and Fox, 2002; Fox, 2003).

Even very modest design changes can have a dramatic impact on usability and, hence, data quality. For example, the question shown below appeared in the Current Population Survey (CPS), which is used to produce monthly estimates of employment and unemployment for the U.S.

> Did you ever get a high school diploma by completing high school OR through a GED or other equivalent?
>
> (1) Yes, completed high school
> (2) Yes, GED or other equivalent
> (3) No

Previous questions in this instrument had routinely used 1=yes and 2=no as response options, so that interviewers got in the habit of entering a 1 for yes and a 2 for no.

Of those respondents asked this question, about 12 percent purportedly responded with Option 2. But by using external data sources, Frazis and Stewart (1998) concluded that almost all of these responses were due to spurious data entry by the interviewers: that is, the respondent said no, but the interviewer entered a 2. The question format shown resulted in an estimate of 4.8 million additional GEDs in the U.S., when the true population estimate was closer to 400,000. Therefore, a slight change in question design, but a serious violation of a basic usability convention (maintain consistency) led to a significant impact on the resulting data.

Features of a CAI Interface

Figure 1 shows a screen shot from a recently developed

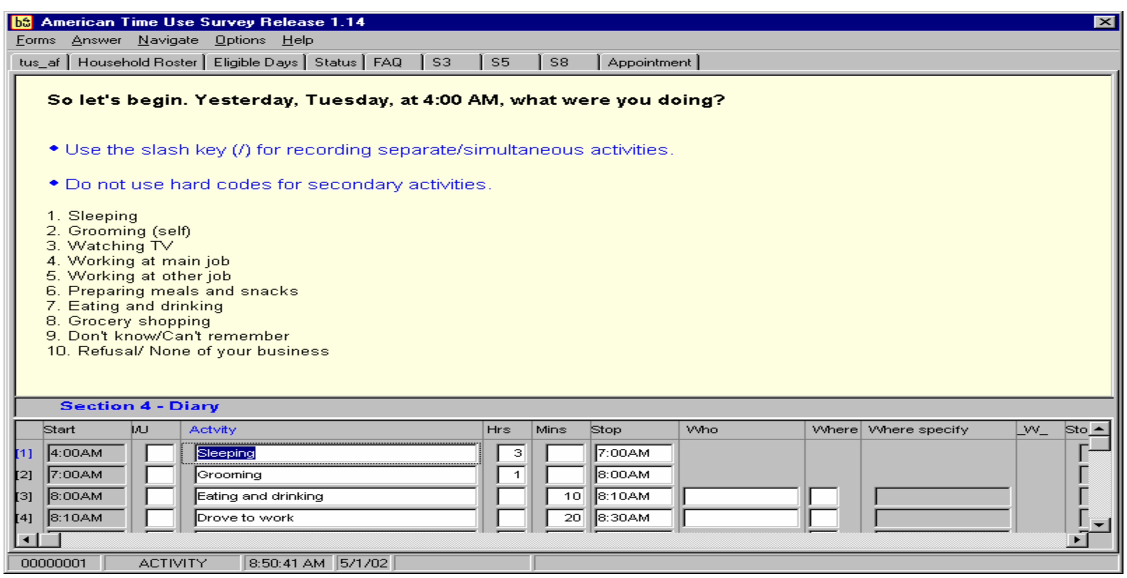

Figure 1
Illustration of a Data Capture Screen

complex computer-assisted interviewing application developed for a survey on how people use their time (American Time Use Survey).

In Figure 1, the data-entry table has been partially completed, and the interviewer has backed up to the first entry field in the table, which describes what the respondent was doing at 4 a.m. on the day of the interview. As noted previously, allowing an interviewer to back up and change answers at any point in the interview is a basic interviewing requirement for any modern computer-assisted interviewing system, but a complication for the programmer, who much take special steps to protect counters and flags built into the application.

As can be seen in the illustration, some standard Window graphical features are used to improve usability. For example, tabs are displayed at the top of the screen to identify sections in the questionnaire. Unless entries in later sections are dependent on the answers given in previous sections or the designer specifically prohibits a navigation movement, an interviewer can access later sections of the questionnaire by clicking on the appropriate tab. However, some survey managers require that the sections of a questionnaire be completed in exactly the same order to avoid any possible bias effects from changes in question order, so although navigation flexibility can be built into an instrument, it is not always permitted.

In this particular application (a survey about how people use their time in a 24-hour period), the interviewer is supposed to read the question shown in bolded text. As the cursor moves to different entry fields in the table, the appropriate question (and instructions) will appear in the top part of the screen, and depending on the path, new questions (and valid answers) will appear. For example, Who was with the person? and Where did the activity occur? Special instructions to the interviewer are preceded by a diamond (♦). A respondent's description of an activity can be typed directly into the "Activity" column of the table (Section 4 – Diary), or if a common standard response is given, the interviewer can simply enter the number of the response in the entry field for that activity, and the appropriate text will be filled automatically. For example, if the interviewer enters 1, the word "sleeping" will be automatically inserted into the activity column. As activities are described, the table will expand as new rows are added automatically to the table.

In this application, critical design decisions involved making the "Start" time of an activity "read only," because it would simply be the Stop time of the previous activity. To ease the burden of reporting, the instrument was designed so that a respondent could describe the length of an activity by reporting a duration in minutes, hours, or both, or through use of a "stop" time – for example, a respondent might say, "I slept until 7:30 a.m." No matter how duration is reported, the other duration fields are filled automatically. Since experience has clearly shown that respondents frequently forget to include activities or erroneously include an activity, the software allows an interviewer to return to an earlier point in the table to insert or delete activities, after which a corresponding adjustment of subsequent Start and Stop times based on the length of the inserted activity would be made automatically.

Almost without exception, interviewer-administered, computer-assisted interviews are designed so that movement through the entire questionnaire is predetermined by the program logic. And, as mentioned previously, instruments are also generally designed so that interviewers can back up to preceding questions in any section of the questionnaire and change the answer, if necessary. However, if a new entry results in new questions, or a new path through the interview, the new questions will be automatically displayed and the interviewer will be required to ask those questions before being allowed to progress to another screen. In the design of the time-use survey instrument, the survey manager decided to give the interviewers complete flexibility of movement in the basic data-entry table shown in Figure 1, so that movement to any cell is possible using the mouse, arrow keys, or tab key.

A general observation of interviewers is that most prefer to use the keyboard, because it allows for more rapid data entry during an interview. On the other hand, there is an increased tendency to use the mouse for navigation. However, these observations must be considered tentative, since instruments using these features have only recently been introduced, and these preferences might change with experience.

The instrument designer can allow the predetermined order of sections to be overridden, but when this occurs, some additional checks must be programmed to ensure that all questions have been completed within a section, that all sections have been completed within the instrument, and that, if an interview is interrupted, it resumes at the exact point (question) at which the interruption occurred. For example, an interviewer might be on question 5 in Section 3 when a respondent insists on reporting data for Section 10. The interviewer can jump to Section 10 and collect that information. After the data are collected, a navigation function is usually provided so that all the interviewer has to do is press a single key to return automatically to the next relevant question in Section 3. Logic in the instrument always keeps a record of the main path through an instrument, as well as the status of each question: for example, question answered and on main path; question answered, but off main path; question not answered, and not encountered. Special indicators are programmed to keep track of the status of a case: for example; case completed; case started, but not completed; refused the interview; no one home; etc.

Another common requirement in a CAI instrument is that every required question must have an answer. If a respondent does not know the answer, or refuses to provide the information, then the interviewer is generally provided with generic missing data values that can be entered. This is usually accomplished using some simple approach (e.g., by pressing a single key). Some instruments also allow a final comprehensive review of these items at the completion of the interview in case the respondent has had a change of heart and now agrees to answer the questions, or has been able to locate the relevant records to provide the missing information.

Conclusions

Automated survey instruments present a set of conventions for interactivity and data collection that may not be typical of other applications, and definitely not typical of most Internet applications.

To the maximum extent possible, possible answers are predefined and assigned numerical precodes, so all an interviewer has to do is enter a number, rather than a detailed response (although some questions do require open-ended textual responses). Since a mouse is difficult to use in the various situations that interviewers often find themselves in, use of the keyboard for data entry and navigation is always an option, and is often the preferred method among interviewers. Cursor movement between items and among sections is tightly controlled through the program logic, although some survey designers will allow flexibility of movement within a section or even among sections. However, in these cases, special checks are incorporated to ensure that each required question in the survey has an answer of some type, even if it is an answer of don't know or a refused. Range and other types of basic edits (e.g., ensuring that text is not entered into a numerical field) are routinely built in, although the proper use of more complex edits remains an unresolved issue.

Although this varies by the application, most survey designers try to provide interviewers with the same flexibility of movement that they would have using a paper questionnaire. This means that the interviewer must have the ability to back up at any point in the interview, review previous answers, change answers to questions, and answer new questions, if necessary, that result from changes. In some instruments, it also means the flexibility to jump ahead and complete items out of sequence although, ultimately, all relevant items must be answered

Some survey researchers (Baker, 1998) have argued that in the not-too-distant future interviewers will be largely removed from the survey data collection process by a variety of developing technologies that vary from the use of "knowbots," or computer programs that prowl the Internet collecting desired information about the population, to enhanced computer-assisted interviews that will allow for easy self-administration of complex questionnaires using the Internet or other approaches.

Confidentiality concerns aside, this prediction overlooks one glaring fact. Survey response rates have been falling dramatically for many years, and this trend shows no signs of reversing. Interviewer-mediated surveys have also suffered from this trend, but it is clear to survey practitioners that interviewers play a vital role in persuading respondents to participate in long, complex government surveys and to provide quality information when doing so.

A related trend is that as CAI software and related technologies have improved, survey complexity has continued to increase, as survey designers incorporate requirements that were simply impossible using paper questionnaires or more rudimentary automated questionnaires. As conveyed by one instrument designer, the existing automated Current Population Survey simply could not be done today using a paper questionnaire, and this is a relatively simple questionnaire.

On the other hand, survey managers know that higher quality data can sometimes be obtained for certain types of sensitive information (for example, sexual practices or drug use) by removing the interviewer from the data-collection process. In these cases, approaches such as audio-CASI (computer-assisted self-interviewing), where the respondent uses a headset to listen to an interview, while entering responses into a laptop computer, have been clearly shown to yield better information (Turner, Lessler, and Gfroerer, 1992).

As automated questionnaires increase in complexity and take advantage of the multimedia and graphical features offered by Windows-based operating systems, usability has become an increasing concern. Usability affects ease of learning, efficiency of use (including error frequency and severity), memorability (how easy it is to use software after a period of disuse), and subjective satisfaction. Even in DOS-based instruments, poor design led to poor quality data, interviewer frustration, and increased training costs. However, a constant tension exists among the needs of programmers, who want to keep things as simple as possible and produce an error-free product, the needs of interviewers who use the software in a wide variety of situations, and the requirements of survey designers who want instruments to do increasingly complex tasks. Further complicating the situation is the survey manager who must see that the automated questionnaire is produced on schedule and within budget.

As computer-assisted interviewing enters the 21st century, besides maintaining high levels of respondent cooperation, the single most important problem facing developers remains testing and debugging. Despite a tremendous amount of effort, there have been few advances to reduce the huge human investment in this process. It remains a labor-intensive, time-consuming process with only a few automated tools being developed to speed up development (Levinsohn and Rodriquez, 2001). As a result, survey data-collection instruments have gone into the field with errors, both known and unknown.

A related challenge involves the timely and cost-effective development of complex applications. Special-purpose packages designed specifically for developing CAI exist, but have generally failed in their basic purpose: to allow non-programmers to do the bulk of the work. Instead, large developers routinely rely on skilled programmers for this task, which is expensive and can lead to other problems, such as high rates of turnover among the programmers. The need clearly exists for better tools to simplify the development process, and to move the bulk of this process to non-programmers.

A big unknown concerns the impact the Internet will have on survey data collection in the near future. It is already widely used for survey research, but the applications have been simple and widely criticized for being non-scientific (non-representative) and for poor response rates that could lead to highly biased results. Despite these drawbacks, this mode will continue to be developed, so that it's likely future surveys will offer respondents multiple modes of responding (for example, via phone, interviewer, Internet). Moreover, despite some predictions of its demise, interviewer-mediated data collection will continue to remain a key approach for many years to come, especially in complex government surveys that require face-to-face interviewing.

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