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Computer-Assisted Survey Information Collection: A Review of CASIC Methods and Their Implications for Survey Operations

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Abstract: Computer-Assisted Survey Information (CASIC) is a new term that encompasses all forms of computer-aided survey data collection. The principal CASIC methods in current use are computer-assisted telephone interviewing (CATI), computer-assisted personal interviewing (CAPI), prepared data entry (PDE), touchtone data entry (TDE), and voice recognition entry (VRE). A review of the literature indicates that these methods can have very positive effects on key aspects of survey operations. These methods can reduce costs and improve timeliness on certain types of surveys and significantly improve the quality of the data collected. They also have generally positive implications for questionnaire administration, interviewer and respondent acceptance, and various non-data collection aspects of survey operations. While each method has its limitations, it is clear from the literature that these methods offer significant advantages over conventional paper-and-pencil alternatives.

Key words: Computer-assisted interviewing; computer-assisted telephone interviewing; computer-assisted personal interviewing; prepared data entry; touchtone; voice recognition.

1. Introduction

Since computers were first used in survey research by the U.S. Bureau of the Census over four decades ago, they have revolutionized almost every facet of survey operations. In today's world it is now commonplace for a survey organization to use computers to support sample design and selection, data entry, editing, tabulation, weighting and analysis. Computers are also used by many organizations to support telephone data collection, coding of responses to open-ended questions, monitoring of survey operations, and a variety of other applications. An increasing number of survey organizations are using computers to support face-to-face interviewing, and a few are using computers to conduct self-administered interviews.

Ironically, the application of computers to the data collection process has occurred fairly recently. Computers were first used to support telephone data collection in the early

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1970s, and CATI (computer-assisted telephone interviewing) was born. The pioneers were market research firms. They were followed by university-based survey organizations, which began exploring this new technology in the mid-1970s, and later by governmental agencies beginning in the early 1980s (Nicholls 1988). No one knows exactly how many CATI installations there are world-wide, but the Subcommittee on Computer-Assisted Survey Information Collection (1990) estimates their number at more than 1,000. They conclude that "in just two decades, CATI has become a standard collection vehicle grounded strongly in a firm body of research" (Subcommittee on Computer-Assisted Survey Information Collection 1990, p. 1).

With the advent of laptop computers in recent years, researchers began exploring the use of computers to support field surveys involving face-to-face interviews, which produced a new acronym, CAPI (computer-assisted personal interviewing). European development was led by the Netherlands Central Bureau of Statistics (van Bastelaer, Kerssemakers, and Sikkel 1987) and Statistics Sweden (Statistics Sweden 1989). The first full-scale CAPI application to a national household survey was the Netherlands Labor Force Survey in January 1987. Great Britain's Office of Population Censuses and Surveys adopted the Netherlands' system for use in their Labor Force Survey (Manners 1990), and the French are testing this system for use in their Labor Force Survey (Bernard 1989). In the United States the first national household survey to use CAPI for at least part of its data collection was the National Food Consumption Survey conducted by National Analysts in 1987. Since then a number of other survey organizations have conducted CAPI studies, including the Census Bureau, Research Triangle Institute, NORC, and Westat.

While CATI and CAPI are both interviewer-based methods, the latest advances in computer support of data collection have been in the area of computer-assisted self-interviewing (CASI). These methods allow the respondent to complete the information without any involvement of an interviewer. Prepared Data Entry (PDE) allows respondents to provide the survey data using their own computer. Touchtone data entry (TDE) allows the respondent to call a computer and respond to questions by using the keypad of a touchtone telephone, and Voice Recognition Entry (VRE) allows the respondent to call the computer and answer questions by simply speaking into the telephone.

In response to these rapidly expanding developments in the use of computers to support survey data collection, the U.S. Office of Management and Budget's Federal Committee on Statistical Methodology commissioned a subcommittee to explore this phenomenon. The subcommittee became known as the Subcommittee on Computer-Assisted Survey Information Collection (CASIC). The new acronym was designed to be broader than others in current use and to encompass all methods that use computers to collect data from respondents (Subcommittee on Computer-Assisted Survey Information Collection 1990).

In their landmark 1990 report, the Subcommittee identified five principal types of CASIC surveys: (1) CATI, (2) CAPI, (3) PDE, (4) TDE, and (5) VRE. The first two are interviewer-based methods (although as we shall see, CAPI has some self-administered options); the last three do not require an interviewer at all and are "pure" computer-assisted self-interview (CASI) methods.

This article reviews these five CASIC methods and what is known about their effects on selected aspects of conventional survey operations. The next section provides a brief

description of each CASIC method. This is followed by sections that discuss the implications of CASIC methods for survey costs and timeliness, questionnaire design and administration, interviewer acceptance, respondent acceptance, data quality, and various non-data collection facets of survey operations. These discussions are followed by a section that addresses problem areas and limitations of the CASIC methods. A final section summarizes the main conclusions to be drawn from this review.

2. CASIC Methods

2.1. CATI

CATI is a data collection mode that utilizes an interactive computing system to conduct a telephone interview (Nicholls 1988). The questionnaire is stored in the computer. The interviewer reads each question to the respondent as it is displayed on the screen and uses the keyboard to enter the response. The computer controls the flow of the interview and performs on-line edit checks on the responses as they are entered.

Unless otherwise qualified, the term "CATI" usually assumes a centralized telephone facility. However, interviewers can also conduct CATI interviews from their homes using laptops. While both centralized CATI and "home CATI" may utilize the same interview program, the latter lacks several important features that are standard components of a centralized CATI facility, including automated call scheduling and case management systems, on-site supervision, and unobtrusive audiovisual call monitoring by supervisory staff.

2.2. CAPI

CAPI is a data collection mode that employs an interactive computing system to conduct a face-to-face interview. The interviewer uses a portable computer (usually a laptop) to conduct the interview. The CAPI interview program functions in much the same way as the CATI program.

There are also some respondent self-interview options with CAPI. If the questionnaire contains highly sensitive items and the respondent possesses some basic computer skills, the interviewer can turn the laptop around and ask the respondent to complete all or part of the interview on his/her own. This approach is called "self-administered CAPI." Another method that is currently under development at several survey organizations is "audio CAPI" (also called "audio CASI"). In this method the interviewer gives the respondent a headset and an input device (keyboard, external keypad, etc.). The respondent hears the questions through the headset and enters his/her response through the input device. The computer records the response and plays the next appropriate question. Audio CAPI overcomes the literacy barrier to respondent self-interview, enhances privacy (the computer screen can be "turned off" so that no one other than the respondent is aware of the questions being asked), and allows for convenient multilingual administration.

2.3. Prepared data entry

Prepared data entry is a type of computer-assisted self interview (CASI) method. In the PDE approach, the survey organization provides the respondent with an electronic questionnaire. The respondent completes the questionnaire using his/her computer. The interview program controls the flow of the interview and provides on-screen instructions or a "help" utility. As data are entered, the program performs edit checks, just like a CATI or CAPI application. Since no interviewer is present, it is essential that the interview program provide adequate guidance to

respondents and that they have adequate computer skills.

Because of the need for a computer and computer skills, PDE is used almost exclusively in establishment surveys. In its most basic form, the survey organization mails the establishment a diskette containing the interview program, the respondent loads the file into a PC and enters the requested data from the establishment's records, and then mails the diskette back to the survey organization. However, a number of variations on this model are possible. For example, the establishment could download the questionnaire information to a PC, avoiding the need to key the data. Alternatively, they could download the data to tape and return the tape to the survey organization. They may also have the option of transmitting the data over telephone lines directly from their computer to the survey organization's computer.

An example of PDE is the U.S. Internal Revenue Service's program for electronic transmission of tax returns. Another is the Petroleum Electronic Data Reporting Option (PEDRO) used by the U.S. Energy Information Administration to collect the mandatory Monthly Refinery Report from petroleum companies. The Netherlands Central Bureau of Statistics also uses PDE methods for mandatory establishment surveys, and the U.S. Census Bureau is experimenting with various forms of electronic reporting for their establishment surveys.

2.4. *Touchtone data entry*

Touchtone data entry is a CASI data collection mode in which the respondent calls a computer and responds to questions asked by the computer. The caller responds by entering data using the keypad of a touchtone telephone. The computer repeats the respondent's answers and the respondent verifies the data by keying a "1" for "yes" or a "0" for "re-enter."

Touchtone data entry is widely used in many environments, including banking by telephone, college class registration, and menu-driven systems for routing incoming telephone calls. TDE is an option for survey data collection when the data desired are numeric or can be linked to a numeric code (e.g., "yes" = "1", "no" = "2") (Subcommittee on Computer-Assisted Survey Information Collection 1990). The largest survey application is the use of TDE by the U.S. Bureau of Labor Statistics (BLS) in their Current Employment Statistics (CES) Survey.

The CES has traditionally been collected by mail through state employment agencies. However, mail data collection yields only about a 50% response rate by the initial reporting deadline. To improve timeliness and data quality, BLS began testing CATI on the CES in 1986. While CATI was successful on both counts, the cost of expanding CATI to the full sample was prohibitive. In 1987, BLS began investigating touchtone data entry " . . . to reduce the cost of collecting data by CATI, while maintaining the timeliness and quality of CATI data collection" (Phipps and Tupek 1990, p. 3).

BLS sees the following advantages for TDE vis-a-vis CATI: (1) respondents can call and be interviewed at their convenience – any time day or night, (2) the interview requires half the time of a CATI interview, (3) TDE eliminates the need to support a large CATI workforce, and (4) TDE eliminates call scheduling and multiple calls. The disadvantages are: (1) limited respondent contact (and loss of rapport), (2) reliance on the respondent to initiate the call, and (3) some respondents do not have a touchtone telephone. TDE is best suited to surveys that are short, repetitive, and numeric (Clayton 1991).

2.5. Voice recognition entry

Voice recognition entry is a CASI data collection mode that is very similar to TDE. Like TDE, the respondent calls a computer which asks a series of questions. Rather than key-entering the information, however, with VRE the respondent simply speaks the digits. The computer reads the data back to the respondent, who confirms it by answering "yes" or "no."

VRE technology is used in a wide variety of applications, including automated dialing of cellular telephones, automated telephone operator systems, control of robots, and control of radio equipment by helicopter pilots (Harrell and Clayton 1991). The largest survey application is its use by BLS in the CES survey.

With the success of TDE, BLS took the next logical step and began testing VRE on the CES survey in 1989. VRE offers all of the advantages of TDE itemized above plus two additional advantages: (1) it does not require the respondent to have a touchtone telephone, and (2) respondents prefer it over TDE (Winter and Clayton 1990).

3. CASIC Effects on Survey Costs and Timeliness

3.1. CATI

The literature contains several reports of studies that compare the costs of CATI with a more or less comparable paper and pencil interview (PAPI) survey. These reports tend to focus on production costs rather than on a full comparison of all relevant phases of the survey process. This is no doubt due to the difficulty in capturing non-production costs and also to the lack of comparability among survey organizations with respect to such costs. Even if these costs could be captured, such data would have limited utility for other survey organizations.

The most obvious cost difference between CATI and telephone PAPI is the hardware, software, and maintenance costs required by CATI. CATI also requires more front-end labor than PAPI, to develop, test, and debug the CATI interview program. If the survey organization must first develop a paper questionnaire (which is often the case), then the difference in front-end development time between CATI and PAPI becomes even more pronounced (Nicholls and Groves 1986).

CATI requires more interviewer training time, especially for interviewers who are not facile with a computer (Nicholls and Groves 1986). The average length of a CATI interview also appears to be slightly longer than the same interview conducted via PAPI (Groves and Mathiowetz 1984; Harlow, Rosenthal, and Ziegler 1985; Nicholls and Groves 1986; Catlin and Ingram 1988). However, overall interviewer production rates may actually be higher for CATI, probably as a result of automated call scheduling and case management (Nicholls and Groves 1986).

CATI requires less telephone supervisor time, due to the automation of such conventional supervisory tasks as call scheduling and preparation of production reports (Coulter 1985; Catlin and Ingram 1988; Thompson 1989). However, the supervisors will tend to spend the time saved in other ways, such as increased monitoring (Curry 1989).

CATI reduces post-interview processing time and costs. Since CATI eliminates hard-copy questionnaires, it also eliminates the various processing steps required to process the questionnaires (e.g., document receipt, clerical editing, data entry, document storage and retrieval). CATI also reduces or eliminates post-data collection machine editing.

A very thorough CATI/PAPI comparison study was conducted by Catlin and

Ingram on the Canadian Labor Force Survey. They found that the two modes were essentially equivalent with respect to production costs (Catlin and Ingram 1988). Although the literature is not entirely consistent, there is no clear evidence to refute this conclusion.

Production costs, of course, are only one piece of the puzzle. What counts is the difference in the total overall cost for the two modes.

In order for CATI to be cost-effective relative to PAPI, the savings in back-end processing must more than offset the additional front-end costs associated with hardware, software, and design and development costs. Large surveys and ongoing surveys that use the same questionnaire for multiple rounds of data collection offer the best opportunity for cost savings with CATI.

The best way to determine the relative cost position of the two modes, short of actually doing a pilot using both modes, is to prepare cost estimates for both alternatives and compare the results. Such estimated cost comparisons typically use in-house cost data collected from similar surveys.

As a shortcut, many survey organizations develop guidelines for assessing the relative cost-effectiveness of CATI for a particular telephone survey. Generally, the larger the survey (in terms of number of interviews), the more likely it is that CATI will be cost-effective. As the number of interviews increases, so do the savings from the reduction in back-end processing costs. On the other hand, the additional front-end costs associated with CATI are largely fixed, and thus the cost per interview gets smaller as the number of interviews increases. Many organizations think that the break-even point is around 500 to 1,000 interviews. Below the break-even point CATI generally cannot be justified on the basis of cost.

The argument for timeliness is essentially the same as the argument for costs. CATI takes longer on the front end and less time on the back end. The net effect depends on the size and complexity of the survey. Again, large surveys and ongoing surveys offer the best opportunities to realize an overall time savings from CATI.

One advantage of CATI is that the survey results are available much sooner after the completion of the data collection effort than is possible with a conventional PAPI telephone survey. This is particularly important for surveys that place a premium on prompt release of survey results following a prescribed data collection time frame.

3.2. *CAPI*

Since CAPI is relatively new and the research is expensive, the tendency has been to assume that what has been learned about CATI effects also applies to CAPI.

In a small comparison study of CAPI versus face-to-face PAPI, Research Triangle Institute (RTI) found that training costs were 18% higher for CAPI and field data collection costs (excluding training) were about 17% higher (Sebestik et al. 1988). The increase in data collection costs was due primarily to added supervision time; the CAPI interviewers spent three times as much time as the PAPI interviewers conferring with their supervisors (due in part to an error in the interviewing program). A comparison of interviewing-related costs (visits to the households and questionnaire administration) showed that CAPI was only 1% higher than PAPI.

Using the RTI figures, Baker (1990) prepared budgets for a hypothetical nationwide face-to-face survey using CAPI and PAPI. He assumed a 20 minute interview and a staff of 75 interviewers. He included only direct costs associated with training, interviewing and processing. While the training and interviewing costs were higher

for CAPI, the processing costs were much lower. Overall, the CAPI budget was only 2% higher. However, this comparison did not include the cost of the CAPI hardware.

Although some early research found that CAPI interviews take longer, such differences are usually attributed to hardware and software problems (Couper, Groves, and Kosary 1989). In a carefully designed comparison study conducted in connection with the National Longitudinal Study of Youth, NORC found no significant difference in the length of the CAPI and PAPI interviews (Bradburn, Frankel, Baker, and Pergamit 1991).

Although there is much less evidence, it is tempting to conclude that the issue of CAPI effects on cost and timeliness is similar to the same issue with respect to CATI. CAPI requires a sizeable investment in hardware and more front-end design and development work. The savings in time and money come in the reduced processing costs on the back end. Since the back-end costs are variable and the front-end costs are largely fixed, the best opportunities for cost and time savings with CAPI are on large surveys and ongoing surveys. After reviewing the cost differences between CAPI and PAPI, Bateson and Hunter (1990, p. 8) reached the following conclusion: "Taking all these factors into account, our estimate is that, on large-scale continuous surveys and on other operations where the hardware can be efficiently utilized and the costs spread over time, net savings should be expected."

3.3. PDE

Although PDE includes a variety of computer-assisted self-reporting methods, they all have one feature in common: the respondent provides the survey data to the survey organization in computer-readable form, thus eliminating hardcopy questionnaires and all the associated processing steps. Computer editing and error resolution are also reduced to the extent that on-line edits are built into the interview program provided to respondents. These features offer the potential for significant cost savings to the survey organization.

Timeliness should also be improved with a PDE method versus a traditional mail survey that uses a hardcopy questionnaire. If the method is easier and more convenient for the responding establishments than the alternative of completing hardcopy questionnaires, then they can be expected to respond more rapidly, with less prompting. Moreover, if they can extract the desired data from existing computer files and provide it to the survey organization electronically, then they will also avoid the need to key the data and will be able to respond more easily and quickly. Finally, as noted above for CATI and CAPI, the elimination of hardcopy forms reduces the back-end processing time, which means that the survey results will be available much sooner after the data collection period than would otherwise be possible.

The experience of the U.S. Internal Revenue Service, with their electronic tax return filing program, supports these expectations for PDE. They have found that the program reduces labor costs associated with processing, sorting, and retrieving tax returns and makes faster processing possible (Subcommittee on Computer-Assisted Survey Information Collection 1990).

3.4. TDE

BLS has done extensive evaluations of their TDE system. They estimate that TDE monthly unit costs are approximately 30% less than mail collection, while CATI unit costs are 20% more than mail (Phipps and Tupek 1990). This means that TDE unit

costs are only about 58% of CATI unit costs. Moreover, BLS projects that TDE costs will rise at a slower rate than mail and CATI costs, so that the potential savings will increase over time (Clayton 1991).

With respect to timeliness, BLS has found that TDE (with a CATI backup) is as timely as a 100% CATI approach (Phipps and Tupek 1990).

3.5. *VRE*

BLS estimates that VRE costs are very similar to TDE costs and thus much lower than mail and CATI (Harrell and Clayton 1991). Like TDE, VRE costs are expected to rise at a slower rate than mail and CATI costs, so that the potential savings will increase over time (Harrell and Clayton 1991).

4. Questionnaire Design and Administration Effects

The movement from paper to CASIC methods can have a profound effect on the design and administration of a survey questionnaire. This section describes some of the principal effects various CASIC methods can have on questionnaire design and administration.

4.1. *CATI/CAPI*

CATI/CAPI questionnaires have the following attributes versus a traditional PAPI questionnaire:

1. More complicated routing patterns. Since the routing from question to question is controlled by the computer, the ability of the interviewer to follow complicated routing patterns correctly is no longer a limiting factor.
2. On-line range, consistency, and data completeness checks that would not be feasible or even possible for an interviewer to perform while the interview is in process.
3. Automated prompting. When a response provided by the respondent fails a preprogrammed edit check, the questionnaire program can provide the interviewer with an appropriate prompt to use. Thus, computer assistance allows the questionnaire designer to make much more extensive use of standardized prompts than would be possible in a PAPI interview.
4. An on-line "help" utility. This is a significant – and often overlooked – advantage of CATI/CAPI. For conventional surveys questionnaire authors often develop a manual of detailed specifications for the administration of each question. However, it is seldom feasible for the interviewer to consult the specifications manual in the midst of an actual interview. With CATI/CAPI, however, the specifications for the questionnaire item at hand can be only a keystroke away.
5. Customized wording of complex questions based on preloaded data about the respondent or on the respondent's answers to prior questions. This capability helps ensure that the interviewer reads the question item correctly and facilitates respondent comprehension. It also fosters rapport with the respondent since the interview is more personalized.
6. Ability to access data from external sources and use it in the interview. For example, in a longitudinal survey the computer can perform across-wave consistency checks and prompt the interviewer to clarify inconsistencies in the current interview. External data can also be accessed to perform table look-up routines to compare responses with acceptable possibilities.
7. Facilitation of methodological research. For example, questionnaire programs

can be designed to randomize the order of questions and response options to questions to check for possible order effects. Randomization of different versions of the same question can also be used to evaluate alternative wording effects.

8. Flexibility in presenting questionnaire items. CATI/CAPI systems may be classified as item-based, screen-based, or form-based in their approach to the presentation of the questionnaire items, and some systems permit the use of more than one approach, even within the same questionnaire (Nicholls 1988). In these systems it is possible to choose the most appropriate approach for a given questionnaire or section of a questionnaire. For example, an interview program for a demographic questionnaire may use a form-based approach when building a household roster and then switch to an item- or screen-based approach to ask the substantive questions.

4.2. *Self- administered CAPI*

Many face-to-face surveys that ask respondents sensitive questions utilize a self-administration format to obtain such data. That is, the interviewer gives the respondent a booklet containing the sensitive items and asks him/her to complete the booklet, seal it in an envelope, and return it to the interviewer for mailing to the survey organization. The problem is that self-administered questionnaires must be very simple and straightforward relative to interviewer-administered instruments. These constraints sorely limit the data that can be collected.

Self-administered CAPI provides a promising solution to this problem. The CAPI program can successfully administer a much more complicated interview without the respondent being aware of the complexities. Furthermore, the data will be of much higher quality because of the on-line edit checks and customized prompts. Also, as noted below, there is some evidence in the literature that this mode of questionnaire administration increases the accuracy of responses to sensitive questions.

Self-administered CAPI by itself, however, does not solve the perennial dilemma facing all self-administered surveys – what to do about nonreaders. One promising solution may be audio CAPI. As noted above, this new technology allows the respondent to hear the questions through earphones rather than reading them on the computer screen. Since it is not necessary for the questions even to appear on the screen, this new method also enhances the respondent's privacy.

4.3. *PDE*

Those PDE methods that send the respondent the interview program on a diskette are similar in several respects to self-administered CAPI, since respondents complete a computer-assisted interview on their own. The alternative to such PDE methods is usually a PAPI mail survey. The substitution of PDE for a PAPI mail survey means that the questionnaire can be more sophisticated and the data collected will be of higher quality. Also, most of the attributes itemized above for CATI/CAPI also pertain to some extent to PDE methods that provide the respondent with an interview program. The limiting factor is the ability and willingness of the respondent to follow the interview program and the instructions provided, in the absence of an interviewer.

4.4. *TDE and VRE*

TDE and VRE applications are confined to relatively short, simple surveys that collect

numeric data or numeric codes – at least at this stage in their development. Although not a part of the BLS system at present, the technology exists to include on-line edits, automated prompts, and other features of computer-assisted data collection in the TDE and VRE interview programs. The alternative to TDE and VRE is usually a PAPI mail survey. While TDE and VRE place constraints on the type of survey questionnaire that can be used, they have been shown to have other significant advantages vis-a-vis mail. These include higher response rates, more timely collection, lower cost, and higher quality data.

5. Interviewer Acceptance of Interviewer-Based Methods

5.1. *CATI*

The literature generally supports the conclusion that interviewers working with well-functioning CATI systems favor CATI over telephone PAPI. Nicholls (1978) found that 86% of telephone interviewers preferred CATI. While Groves and Mathiowetz (1984) found that interviewers who conducted interviews in both methods had no clear preference between them, their dissatisfaction with CATI was probably due in part to system related problems – slow response time between screens and difficulty in backing up to change an answer to a previous question. As Groves and Nicholls (1986, p. 120) observed, "interviewer acceptance of CATI appears to depend on the reliability and speed of the CATI system utilized." Today's advanced CATI systems are both reliable and fast, and based on this writer's conversations with telephone supervisors in several survey organizations, interviewer acceptance appears to be correspondingly high.

A personal experience serves to underscore this point. Recently this writer directed two telephone surveys, the first done by CATI and the second done via PAPI. The surveys were almost identical and used very similar questionnaires. It was decided, however, to do the second survey via PAPI instead of CATI because there was insufficient time to modify the CATI interview program. A subset of interviewers from the first survey was trained to do the second. During the training session and conduct of the second survey, the interviewers repeatedly commented on the added burden of having to do manually what the computer did for them automatically in the first survey. An informal poll indicated unanimous preference for the CATI mode and considerable indignation at having to administer the second questionnaire manually.

5.2. *CAPI*

The literature on CAPI indicates a substantial preference for CAPI over face-to-face PAPI. Sperry, Bittner, and Branden (1991, p. 4) cite anecdotal evidence of "very favorable" interviewer acceptance in Round 1 of the pilot study for the Current Beneficiary Survey. Olsen et al. (1990, p. 3) report very positive interviewer reactions based on feedback questionnaires completed by the interviewers who worked on the CAPI test in Round 11 of the National Longitudinal Study of Youth. Interviewers enjoyed using CAPI after getting over their initial apprehension. They felt that CAPI was more accurate than PAPI, they liked its quality control features, and it made them feel more professional. Baker (1990, p. 7) concludes as follows: "Despite the significant problem of needing to lug a computer door-to-door and some less significant problems with software, virtually every study done to date reports that interviewers quickly come to prefer CAPI to paper and pencil."

6. Respondent Acceptance of CASIC Methods

6.1. CATI

The evidence in the literature suggests that there is no cause for concern about the potential effects of CATI on respondents. CATI seems to produce response rates that are similar to telephone PAPI and may even produce a higher contact rate than PAPI, which is probably attributable to automated call scheduling (Groves and Nicholls 1986). CATI seems to have no appreciable effect on the refusal rate, and interviewers report that respondents do not seem to be affected by the knowledge that their responses are being keyed directly into a computer (Groves and Nicholls 1986; Catlin and Ingram 1988). Indeed, it is this writer's observation that respondents are seldom even aware of the role of the computer in a well-functioning CATI environment.

6.2. CAPI

The literature also indicates a favorable acceptance of CAPI by respondents. There is considerable evidence to indicate that CAPI produces response rates that are comparable to face-to-face PAPI (Statistics Sweden 1989; Bradburn et al. 1991; Sperry et al. 1991). In Round 1 of the pilot for the Current Beneficiary Survey, interviewers reported that only 3 of 138 CAPI respondents reacted negatively to the computer at the start of the interview and that only one remained negative at the conclusion of the interview. Thirty percent of the respondents were judged to be positive toward CAPI at the end of the interview and 69% were either neutral or had no reaction (Sperry et al. 1991). In the CATI test in Round 11 of the National Longitudinal Study of Youth, Olsen et al. (1990) report very positive respondent reactions to CAPI, based on Respondent Feedback Questionnaires, and Baker (1990, p. 4) observes that " . . . virtually every study done this far has concluded that, in general, respondents' reactions (to CAPI) range from indifference to enthusiasm."

6.3. PDE

While the literature on PDE is still very limited, it is clear that PDE methods will have wide appeal to respondents in establishment surveys if they reduce the time and cost of responding. To promote the new methods, however, the survey organization must take the initiative to design user-friendly PDE systems that will reduce the current reporting burden on the respondents. Ideally, the survey organization will develop multiple methods so that respondents can choose the one best suited for their computer environment. For large establishments in an ongoing survey, it might even be worthwhile for the survey organization to develop customized PDE reporting systems.

6.4. TDE and VRE

The Bureau of Labor Statistics reports excellent respondent acceptance of TDE and VRE. Both methods achieve the same high response rates as CATI (Winter and Clayton 1990). In a debriefing survey conducted by telephone interviewers with TDE respondents, 93% of the respondents indicated that their experience with TDE was very favorable (Phipps and Tupek 1990). In a similar debriefing survey of first-time users of VRE, 58% of the respondents preferred VRE to TDE, citing that VRE was easier to use (Clayton 1991).

7. CASIC Mode Effects on Data Quality

7.1. CATI

Given CATI's many quality-enhancing attributes (e.g., computer-controlled branching,

on-line edit checks, customized wording, preprogrammed probes), it is not surprising that the CATI experiments reported in the literature suggest that CATI can improve the level of data quality over a comparable telephone PAPI survey. In their CATI experiment with the Canadian Labor Force Survey, Catlin and Ingram (1988) found that the CATI item-based discrepancy rate – defined as the percentage of entries that are inconsistent or blank, including "don't know" responses and item-level refusals – was only 39% of the PAPI rate on the complicated Labor Force Questionnaire. Groves and Mathiowetz (1984) observed a significant reduction in branching errors with CATI. Tortora (1985) found that CATI reduced the number of critical errors by 77% in comparison to PAPI.

One area of concern about CATI has been its effect on the recording of responses to open-ended questions, given that they are keyed with CATI instead of handwritten. However, Catlin and Ingram (1988) looked at the recording of responses to open-ended industry and occupation questions and found no systematic mode differences between CATI and telephone PAPI.

An important advantage of CATI over telephone PAPI is the ability of the telephone supervisors to do visual as well as audio monitoring of interviews. Groves and Nicholls (1986) suggest that this feature should improve data quality vis-a-vis telephone PAPI.

7.2. *CAPI*

As with CATI, the literature suggests that CAPI can also improve data quality in face-to-face interviews. In the National Longitudinal study of Youth CAPI experiment, Bradburn, et al. (1991) found that CAPI eliminated skip errors and substantially reduced "don't know" responses and item-level refusals. In a comparison of CAPI data with data collected from earlier interview rounds via face-to-face PAPI, Olsen (1991) found that the CAPI data had an overall lower missing data rate. In a small CAPI/PAPI comparison study conducted by Research Triangle Institute, Sebestik et al. (1988) reported that over 90% of the errors made by the PAPI interviewers were failures to record a required response – errors that were not possible to make using the CAPI interview program.

With regard to the recording of responses to open-ended items, Baker (1990) summarizes the results of CAPI experiments by the French National Institute of Statistics and Economic Studies. They concluded that interviewers can record responses to both closed and open-ended questions as accurately with CAPI as with PAPI, and they found no significant difference in the amount of information recorded for open-ended questions in the CAPI interviews.

There is some evidence that the use of CAPI enhances the respondent's sense of privacy. Bradburn et al. (1991) found that CAPI respondents reported more alcohol-related problems. Duffy and Waterton (1984) had the same result when respondents completed a CAPI interview in a self-administered format. It will be interesting to see what effect the new audio CAPI method has on the reporting of sensitive data.

7.3. *PDE*

To the extent that PDE methods utilize the same quality-enhancing features as CATI and CAPI, such as controlled branching and on-line edit checks, similar improvements in data quality can be expected. Since the alternative to a PDE approach is usually a conventional mail survey, the differences in data quality can be significant.

Although the literature is limited, some

evidence exists of data quality improvements. The U.S. Internal Revenue Service reports that electronic tax returns have significantly fewer errors than paper returns. For the 1988 filing season, 20% of paper returns had errors versus only 5.5% for electronic returns (Subcommittee on Computer-Assisted Survey Information Collection 1990). The U.S. Energy Information Administration also reports that their PEDRO system produces higher quality data. They attribute the improvements to the edits performed as the data are keyed by the respondent. They also speculate that the computerized questionnaire has resulted in the utilization of better qualified respondents (Subcommittee on Computer-Assisted Survey Information Collection 1990).

7.4. TDE and VRE

The Bureau of Labor Statistics has conducted record check studies to evaluate the quality of the data collected via TDE and VRE. For TDE they found that the average error rate for data items was less than 1.8%, and all of the errors were caught routinely and resolved in the post-data collection editing process. Furthermore, the data indicate that first-time users had higher error rates and that respondents get better at TDE as they gain experience with it (Phipps and Tupek 1990). For VRE they found that the average error rate was 1.3%, which is even better than TDE (Harrell and Clayton 1991). In both systems, respondents are asked to confirm all data items. Hence, the error rates reflect the respondents' confirmation of incorrect answers, based on the entries on the respondents' paper instruments.

8. Other CASIC Effects

The transition to CASIC methods will affect other facets of survey operations besides data collection. The following discussion indicates some of the potential effects of CASIC on other areas.

8.1. Sampling

The sampling staff will need to work with the survey management staff to develop new ways of delivering their samples to the data collectors. For CATI surveys the old manual system of questionnaire labels or lists of telephone numbers will be replaced by an automated system in which the sample is preloaded into the case management system and assigned to the interviewers through the call scheduling system. For CAPI surveys the assignment information is distributed to the field staff on diskettes or otherwise transmitted to their computers. The sample selection process has been automated for decades, but until the advent of CASIC the case assignment system has been a labor-intensive clerical operation. The principal effect of CASIC on sampling operations is that it will automate the case assignment process and integrate it with the automated sample selection process and the automated data collection process.

The sampling area will also benefit from the wealth of timely information available in a CASIC survey on the progress of the data collection effort (discussed below). The sample design and selection process involves a number of assumptions about data collection outcomes, such as occupancy rates, eligibility rates, working residential number rates, etc. In a PAPI survey the sampling staff seldom get prompt and complete information on data collection outcomes in a timely manner. By the time they receive the information they need to make informed decisions concerning sample adjustments, it is often too late to get full benefit from corrective action. In a CASIC survey the sampling staff have a wealth of information

to use in making sampling decisions while there is still time to make a difference. To sum up, CASIC takes a lot of guesswork out of survey sampling.

8.2. *Cost monitoring*

CASIC surveys are able to monitor costs at a level of detail and timeliness that was unheard of in the pre-CASIC era. It is routine for centralized CATI facilities to produce a variety of computer-generated cost monitoring reports for fiscal management purposes. These reports include such data as average interviewer time per interview, labor cost per interview, toll charges per interview, computer charges per interview, and total cost per interview (Weeks 1988). The frequency with which these reports are produced is up to the survey management staff. They can be run daily if desired.

CAPI surveys can also produce similar reports. All that is required is to have the interviewers transmit their production, time, and expense data to the survey organization's host computer in the same manner as completed interviews are transmitted. As an added benefit, the survey organization can use these electronic reports for payroll purposes for the field interviewers, thus eliminating the hardcopy time and expense forms and expediting the payroll process.

8.3. *Progress monitoring*

One of the most significant advantages of CASIC over PAPI is the wealth of readily available monitoring data. Some of the generic types of monitoring reports typically available in a centralized CATI facility include: the queue listing, call record listing, current status report (which summarizes the current status of all cases in the sample), historical status report (which shows the results of past processing steps as well as the current status), interviewer performance report, duration report (which identifies cases that have remained in a particular status category beyond a prescribed duration), exception report (which identifies cases that have deviated from a prescribed processing path), and miscellaneous diagnostic reports (Weeks 1988).

Detailed monitoring reports are also readily available in a CAPI survey. All that is required is to have the field interviewers transmit information on the status of their caseload along with the transmission of their completed interview data. These reports can be telecommunicated to the survey organization's host computer each night if desired and the various monitoring reports can be available to the survey management staff and field supervisors by the time they start work the next day.

8.4. *Data processing*

As noted above, CASIC eliminates the processing required for hardcopy questionnaires in a PAPI survey. In terms of computer edits on the data files, the advantage of CASIC is that the data are much cleaner due to the on-line edits performed at the time of interview; therefore, there are fewer fail-edit cases and less error resolution effort is required. CASIC generally does not eliminate all fail-edits, because the machine edits are usually more extensive than the on-line edits built into the interview program. But it drastically reduces them as compared to a comparable PAPI survey.

8.5. *Analysis*

CASIC will have a beneficial effect on the analysis task because the quality of the data analyzed will be better. There will be fewer missing data items, fewer unusable responses, and fewer imputed values. And better data mean better analyses.

8.6. Publication

The main implication of CASIC for publication is timeliness. That is, the survey results can be published sooner after the data collection effort than for a comparable PAPI survey. While a CASIC survey may require more time prior to the start of data collection, this is often not as critical as having prompt results following a prescribed data collection time frame. And for ongoing surveys, the front-end time required for CASIC will greatly diminish after the first iteration of the survey.

8.7. Methodological research

Although not a standard component of the survey process, methodological research is one of the primary beneficiaries of CASIC. Since the data collection process is automated, research into a variety of survey methods is greatly facilitated. This type of research should become much more prevalent in the CASIC era, with attendant benefits to both the practitioners and the users of survey research.

9. CASIC Problem Areas/Limitations

9.1. CATI

As promising as CATI appears to be from the literature, it has its limitations and may indeed be less suitable than PAPI in certain telephone survey applications. For example, the additional front-end development work may make CATI more expensive for very small telephone surveys. For the same reason it may not be suitable for a survey that has limited front-end development time available. It may also be less attractive for surveys that involve numerous open-ended questions, because of the keyboard skills required of the interviewers.

The principal software problem appears to be the lack of flexibility with respect to "nonstandard movement." In a paper questionnaire it is usually a simple matter for the interviewer to move backward or forward in the questionnaire when indicated by the interaction with the respondent (e.g., the respondent wishes to correct an earlier response or volunteers responses to questions that lie ahead). Such nonstandard movement is much more problematic in a computer-assisted interview. As House and Nicholls (1988, p. 429) observe, while computerized control of the interview is one of CATI's greatest assets, it can also be its greatest weakness if "it strips the interviewer of the ability to improvise when unusual situations occur." While advanced CATI software systems facilitate nonstandard movement, the burden remains with the CATI questionnaire designer to anticipate and plan for what might happen in the course of an interview and to design in as much flexibility as possible (House and Nicholls 1988).

There may also be types of data collection where it is better to give up computer control of the process altogether. This may be the case when the respondent is likely to provide information out of order (for example, in providing household roster information) or when the interviewer may have to obtain the desired data from different respondents (as in a survey of businesses to collect record-based data). Another example is complicated decision processes that would be difficult to program and time-consuming to lead the interviewer through in a step-wise progression (for example, the selection of the most appropriate proxy respondent or the application of tracing procedures to attempt to locate a sample subject). In such situations the questionnaire designer may elect to switch from an item- or screen-based approach to a form-based approach (see Nicholls (1988) for details on these approaches). Advanced CATI systems

allow for all three types of displays within the same questionnaire.

One issue that has largely been overlooked in the research on CATI has been "home CATI," where the interviewer completes a computer-assisted interview from his/her home, using a laptop. The CATI research to date has focused exclusively on centralized CATI. However, one cannot assume that the findings for the latter apply equally to the former. A centralized CATI environment offers many benefits not available in the interviewer's home, such as automated call scheduling, constant supervision, monitoring capabilities, and a production-oriented environment. Nevertheless, home telephone PAPI is a common data collection mode and home CATI will become a logical successor to this mode as field interviewers are equipped with laptops. To assess the trade-offs involved in choosing between centralized CATI and home CATI, research is needed as to the relative merits of the two modes.

Finally, Groves and Nicholls (1986) point out that numerous questions still remain about CATI's consequences for data quality. They believe that too much energy has been devoted to software development, to the detriment of research into CATI's effects on nonresponse error and measurement error. While much has been done in this regard since they voiced this concern, much still remains to be done.

9.2. *CAPI*

As with CATI, CAPI also has its limitations vis-a-vis a face-to-face PAPI alternative. Like CATI, CAPI is less cost-effective for smaller surveys and requires more front-end development work. It is also less attractive for surveys involving numerous open-ended questions.

Computer hardware has been more of an issue for CAPI than for CATI. In fact, CAPI has become a practical reality only in the last few years, with the advent of inexpensive, lightweight, portable laptop computers (Bradburn et al. 1991). The complaints heard most frequently from interviewers concerned the weight of the computer and poor screen readability. The National Longitudinal Study of Youth switched from a Toshiba 1200 laptop, weighing 14 pounds, in Round 11 to a Compaq LTE laptop, weighing 6.2 pounds, in Round 12. With the Compaq, weight became less of a problem and screen readability was excellent (Olsen et al. 1990). Westat also used the Compaq LTE in the pilot study for the Current Beneficiary Survey, with excellent interviewer acceptance (Sperry et al. 1991). Given the pace of technology in this area, there is little doubt that keyboard machines with comparable capabilities will continue to become lighter and smaller.

Other concerns frequently heard from CAPI interviewers are slow speed of operation; batteries do not last long enough and quit without warning; batteries take too long to charge; interviewers need a second charger so that two batteries can be charged simultaneously; carrying cases need more pockets for batteries, adaptors, etc.; handles are preferred over shoulder straps on carrying cases; power cords should be longer; interviewers should be issued a three-prong adaptor; and interviewers should be provided with hardcopy versions of the questionnaire for use in case of equipment failure (Iverson 1991). Many of these problems are easily solved, however, and given the high level of interviewer acceptance in recent CAPI studies, it would appear that such concerns are not serious enough to dampen the interviewers' enthusiasm for CAPI.

An important CAPI issue has been the selection of appropriate hardware. Survey

organizations that conduct lengthy interviews in the respondent's home have used laptops (or notebooks), while those that conduct short interviews on the respondent's doorstep are looking toward hand-held computers (Couper et al. 1989). Each has its advantages and disadvantages. Many field surveys involve a screening interview done on the doorstep, followed by an in-depth interview conducted in the respondent's home with eligible persons identified in the screening process. Laptops work well for the in-depth interview but are impractical for the doorstep interview. Hand-held computers work better on the doorstep but may not be suitable for the in-depth interview.

The principal CAPI studies done to date have used keyboard-based machines. However, such machines require at least a modest level of keyboard skills on the part of the interviewer, and are more problematic in field situations than they are in a CATI environment (e.g., doorstep interviews). Recently, however, a new generation of notebook and hand-held machines have become available that use a screen-based pad as the data entry mode rather than a keyboard. Data are entered on the screen either by using an electronic pen (stylus) or by touching the screen. While still in its infancy, the pad machines may someday replace the keyboard machines as the standard for computer-assisted interviewing.

Finally, it should be recognized that the research on CAPI is still quite limited and that a number of issues remain to be explored. The reader is referred to Couper et al. (1989) for a discussion of these issues and suggested research approaches.

9.3. PDE

As noted above, PDE methods are used almost exclusively in establishment surveys because they require the respondent to have a computer and some level of computer skill. The major challenge facing survey organizations which conduct such surveys is to develop PDE methods that have widespread appeal to respondents. This requires that the survey organization take the initiative to learn the computer resources and capabilities of target establishments and to develop user-friendly methods that will reduce the time and cost required for them to provide the requested data.

9.4. TDE and VRE

As noted previously, TDE and VRE are appropriate for short, repetitive, "numeric" surveys. Of course, respondents must have access to a telephone (a touchtone telephone for TDE). The TDE technology is fairly well advanced. For VRE the potential for further technological advancement is considerable. Current research is focusing on the ability of computers to recognize spoken words. Computers currently recognize spoken digits and "yes" and "no." The next step will be to recognize spoken numbers instead of digits (e.g., "four hundred and fifty-seven" instead of "four, five, seven"), then additional words, and finally, conversational language.

10. Summary

The research reported to date on the five principal CASIC methods, while meager in places, is generally favorable as to the effects of these methods on conventional survey operations. A summary of key points from this review of the literature follows.

- The five principal CASIC methods are CATI, CAPI, PDE, TDE and VRE. The first two are interviewer-based methods and the last three are computer-assisted self-interview (CASI) methods.

- CATI/CAPI surveys involve more front-end costs for hardware, software, and design and development work, while comparable surveys involving paper and pencil interviewing require more back-end processing costs. The back-end costs are variable, while the front-end costs added by CATI/CAPI are primarily fixed. The upshot of this relationship is that large surveys and ongoing surveys offer the best opportunities to realize cost and timeliness savings from CATI/CAPI.
- PDE methods have the potential for reducing cost since they eliminate hard-copy questionnaires and all the associated processing costs. PDE can improve timeliness by providing respondents with a faster and easier way to provide the requested data.
- TDE and VRE are less expensive than CATI and mail survey alternatives.
- CATI/CAPI interview programs can offer a number of quality-enhancing features over a conventional paper questionnaire. These include more complicated routing patterns, on-line edit checks, automated prompting, customized wording, ability to access data from external sources, facilitation of methodological research, and greater flexibility in presenting questionnaire items.
- Self-administered CAPI and PDE methods can also include computer-driven edit checks and other quality-enhancement features that permit the questionnaire to be more sophisticated than would be practical if a self-administered paper questionnaire were used.
- Interviewers generally prefer CATI and CAPI to paper and pencil interviewing. CATI and CAPI produce response rates that are comparable to conventional surveys. CATI seems to have no effect on respondents. Respondent reactions to CAPI appear to range from indifference to enthusiasm.
- PDE methods can have a wide appeal to respondents in establishment surveys by reducing the time and cost of responding.
- Respondents appear to be enthusiastic about TDE and VRE as an alternative to mail or CATI surveys.
- The evidence suggests that CATI and CAPI can improve the level of data quality over a comparable paper and pencil survey. Both have been shown to eliminate skip pattern errors and reduce item-based errors. An important quality-enhancement feature of CATI is the ability of supervisors in a centralized CATI facility to do visual as well as audio monitoring.
- PDE methods can improve data quality by building edit checks and other quality-enhancement features into the computer interview program.
- Record check studies conducted by the Bureau of Labor Statistics have shown that the data collected by TDE and VRE have very low error rates (less than 2%).
- The transition of CASIC methods will have a beneficial effect on other facets of survey operations besides data collection, including: sampling, cost monitoring, progress monitoring, data processing, analysis, publication, and methodological research.
- While the literature is favorable towards CATI and CAPI in many respects, they have limitations and may not be superior to conventional paper and pencil interviewing for some types of surveys. Also, there remains a number of unanswered research issues for both modes.
- Because of the need for a computer and

computer skills, prepared data entry methods are used almost exclusively for establishment surveys. The challenge here is for survey organizations to learn the computer resources and capabilities of the target establishments and to provide user-friendly PDE methods that will reduce the time and cost burden on respondents.

- TDE and VRE are primarily suited for short, numeric surveys. TDE technology is rather well developed but there is tremendous potential for technological advancement with VRE, leading toward the goal of developing a computer that can recognize conversational speech.

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