Computer-Assisted Self-Interviewing Tailored for Special Populations and Topics

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Self-administered questionnaires have many advantages, especially when sensitive questions are asked. However, self-administered paper questionnaires have a serious drawback: Only relatively simple questionnaires can be used. Computer-assisted self-interviewing (CASI) can overcome these problems. CASI can be part of a personal interview in which the interviewer hands the computer over to the respondent for specific questions. It also can be a computerized version of the disk-by-mail survey. The authors have used both forms with very special populations (primary school children, visually impaired young adults, and parents and children from multiproblem families, in which professional guidance for the family was sought). This article introduces CASI and reviews its advantages and disadvantages, giving special attention to data quality.

Keywords: *sensitive questions; special groups; disk-by-mail; self-administered questionnaire; self-interviewing; CASI; A-CASI*

Traditionally, when surveying special or sensitive topics, researchers use self-administered questionnaires, either as a mail survey or as a paper questionnaire that is handed over by an interviewer and filled in by the respondent in private, without direct participation of the interviewer. After completion, the respondent can seal the questionnaire in an envelope and mail it back or return it to the interviewer. Self-administered questionnaires have the advantage of evoking a greater sense of privacy than surveys that involve personal interviewing, and they lead to more openness and self-disclosure (Sudman and Bradburn 1974; Tourangeau and Smith 1996). Empirical research has

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shown that compared to interviews, self-administered paper questionnaires produce more valid reports of sensitive behavior and less socially desirable answers in general (e.g., Hochstim 1967; Siemiatycki 1979; Turner, Lessler, and Devore 1992; Aquilino 1994; for a comprehensive review, see de Leeuw 1992; for an introduction into research on sensitive topics, see Lee 1993).

In self-administered procedures, the respondent is the "locus of control" and determines the pacing of the question-and-answer sequence. When filling in a questionnaire, the respondent is in control and may decide to pause, reread a question, or think about an answer. The usually more leisurely pace of the self-administered procedure gives the respondent more time to understand the meaning of the question and retrieve and compose an answer, which improves the quality of answers (Schwarz et al. 1991). This is especially important when surveying special populations, such as children, adolescents, or the elderly who need extra attention and time (de Leeuw and Collins 1997). If mail surveys—a special form of self-administered questionnaire—are used, additional advantages are low costs and minimum resource requirements (Dillman 1978). Of course, questionnaires that are handed over during an individual face-to-face interview will be as costly as the interview, but substantial savings can be made when questionnaires are given to a larger group of people simultaneously, such as school classes, hospitals, or HIV testing centers (Catania et al. 1990).

A serious drawback of self-administered paper questionnaires is that only relatively simple questionnaires can be used (Dillman 1978, 2000). Complicated skip-and-branch patterns or adjustments of the order in which the questions are posed threaten both the data quality and the motivation of the respondent to complete the questionnaire. Examples of complex questionnaires are, for instance, health survey questionnaires, which use many contingent questions that instruct the respondent to skip questions or branch to a specific section of the questionnaire depending on a previous answer. Even highly educated respondents may have trouble following the instructions for navigating through such a questionnaire. Complex self-administered paper questionnaires, with many skippings and branchings, negatively influence the survey quality in two ways. The length and complex structure enhance the perceived response burden and will lead to more explicit refusals to cooperate. When a respondent is willing to answer the questionnaire, the complexity increases the cognitive burden of the respondent, putting more strain on the question-and-answer process, which will negatively influence data quality (Schwarz et al. 1991; Tourangeau and Smith 1996).

Computer-assisted survey techniques overcome these problems and make it possible to use very complex questionnaires without the aid of an interviewer, which is a vast advantage when studying sensitive topics. In computer applications for self-administered questionnaires, the interview program takes over and handles the questionnaire's logic and question flow. Respondents read each question from the screen, type in an answer, and are no longer burdened with complex routing instructions for navigating through the questionnaire. Studies comparing computer-assisted self-administered questionnaires with self-administered paper questionnaires concluded that, in general, data quality was higher in the former because fewer errors are made when completing the questionnaire (de Leeuw and Nicholls 1996; Nicholls, Baker, and Martin 1997).

A standard self-administered questionnaire, be it on paper or via a computer, requires that respondents have adequate reading skills. A recent innovation that solves this problem is audio–computer-assisted self-interviewing. This application uses the more advanced technology of multimedia computers: Respondents view the question on the screen while listening with headphones to a recorded version of the question stored in the computer at the same time (Turner et al. 1998).

Because of the confidential nature and flexibility, computer-assisted self-administered survey methods are especially suited for special population surveys and for surveys on sensitive topics. In this article, we give a general introduction to computer-assisted self-administered surveys, describe their advantages and disadvantages, review empirical findings, and offer advice on how to use this technology including examples from our experience with special populations. We end with a short section on software and give suggested readings.

COMPUTER-ASSISTED SELF-ADMINISTERED QUESTIONNAIRES: TYPOLOGY AND DEFINITIONS

In survey research, computer-assisted forms of data collection are rapidly replacing paper-and-pencil methods in the United States and Europe. Computer-assisted methods in general are often summarized under the global terms *computer-assisted data collection* or *computer-assisted survey information collection*; in this context, the traditional paper methods are often denoted by *paper-and-pencil interviewing*. The computer-assisted forms of telephone interviewing (CATI) and face-to-face or personal interviewing (CAPI) are well known and hardly need an introduction (for an overview, see de Leeuw and Nicholls 1996; Nicholls, Baker, and Martin 1997). Computer-assisted self-administered questionnaires are less widespread, but as computer use keeps growing, computer-assisted questionnaires have a promising future. The acronyms CASI (computer-assisted self-interviewing) and

CSAQ (computerized self-administered questionnaire) are used to indicate self-administered forms of data collection using computers in general (Couper and Nicholls 1998).

Computerized self-administered data collection takes many forms. The oldest is the electronic questionnaire or electronic test, which is used in the medical and psychological sciences (Weisband and Kiesler 1996). In survey research, a computer-assisted self-administered questionnaire is frequently used during a face-to-face (CAPI) interview on sensitive topics, when the interviewer hands over the computer to the respondent for a short period but remains available for instructions and assistance. This is the most common use of CASI and is equivalent to the traditional procedure in which an interviewer might give a paper questionnaire to a respondent to fill in privately. A promising variant of this method is audio-CASI (A-CASI), in which the respondent listens to the questions read by a computer-controlled digitized voice over a headset and at the same time views the question on the computer screen. This overcomes literacy problems with special populations and guarantees the respondent's privacy (Johnston and Walton 1995; Turner et al. 1998).

In health studies on sensitive topics, such as alcohol and drug use, sexual behavior, and HIV, computer-assisted self-interviews are often administered at a central site outside the home of the respondent (e.g., in a clinic, a health center, a mobile van). Even in very disadvantaged populations, this technology can be used with some adaptations, as has been shown by Thornberry et al. (2002). In their study, Thornberry et al. combined audio and touch-screen technologies in computer-assisted self-interviews of young, little-educated, pregnant women. The computer administered the recorded questions via headphones and displayed them on the screen at the same time. The response choices were highlighted on the screen when heard on the headphones, and the respondents answered by touching the response of their choice on the computer screen.

Computer-assisted equivalents have also been developed for the traditional mail survey. Disk-by-mail is now used on a regular basis, and methodological knowledge on how to implement a successful disk-by-mail survey is available (e.g., Witt and Bernstein 1992; Saltzman 1993; Ramos, Sedivi, and Sweet 1998; Van Hattum and de Leeuw 1999). In a disk-by-mail survey, a disk containing the questionnaire and a self-starting interview program is mailed to the respondent via the postal service. The respondent runs the program on his or her own computer and returns the diskette containing the completed questionnaire. Electronic mail surveys (EMSs) or Internet/Web surveys differ from disk-by-mail surveys because respondents receive the request and return the data electronically, either by e-mail or via a Web page.

This field is still very much in development. At present, EMSs are possible only with special populations who have Internet access, but the limited experience is so far positive (Clayton and Werking 1998; Schaefer and Dillman 1998; Couper 2000; Dillman 2000). Especially in establishment surveys, EMS techniques are gaining popularity (de Leeuw et al. 2000).

A way to overcome the limited computer access of special groups is to bring a computer to the respondent. This may involve bringing computers to a household, an establishment, or a special site such as a school or hospital (we will discuss some examples in the Case Studies section). A special application of this is computer-assisted panel research, in which a panel of households is selected, and the research institute provides computers and communication equipment. Surveys are then sent electronically to the household members on a regular basis and, after completion, are sent back automatically. This approach has been successful for consumer panels in the Netherlands and is being implemented in other countries such as the United States (Saris 1998).

ADVANTAGES AND DISADVANTAGES: A REVIEW OF THE LITERATURE ON DATA QUALITY AND COST

One of the main reasons that computer-assisted data collection has become popular so quickly was the general expectation that it would improve data quality and efficiency and reduce costs. This could be attributed to technological possibilities, psychological processes, and logistic changes in survey procedures affecting timeliness and costs.

Prevention of Errors and Data Quality

Data quality in computer-assisted surveys may be improved by technological factors. In an optimally implemented computer-assisted self-interview, many errors may be prevented. Compared to an optimally implemented paper-and-pencil interview, the optimally implemented computer-assisted interview has three apparent advantages:

1. *There are no routing errors.* Based on previously given answers, the program decides what the next question must be and guides the respondent through the questionnaire. There are no missing data that are due to routing and skipping errors.
2. *Data can be checked without delay.* A well-implemented data collection program performs some internal validity checks. Simple checks are range checks that compare the given response to the range of possible responses. Thus, the

program refuses the response "4" when only three response categories are possible. More complicated are consistency checks that analyze the internal consistency of several responses. Here, the researcher must anticipate all valid responses to questions, list possible inconsistencies, and devise a strategy for the program to cope with them. In a paper-and-pencil study, internal validity checks are conducted at the data-cleaning stage after the data collection stage, and inconsistencies are then usually recoded to a missing data code because it is no longer possible to ask respondents what they really meant. In a computer-assisted interview, there is an opportunity to rephrase the question and correct range and consistency errors. This should lead to fewer data entry errors and missing data.

3. *The computer offers new possibilities to formulate questions.* One example is the possibility to randomize the order of questions within a scale, giving each respondent a unique question order. This eliminates systematic question order effects. Response categories can also be randomized, which avoids question format effects. The computer can also assist in the interactive field coding of open questions using elaborate coding schemes, which would be unmanageable without a computer.

When we look at the empirical evidence, we see that the technological possibilities of CASI indeed have a positive influence on data quality. Item nonresponse is minimized by computer-controlled routing and by checking whether an answer or a "do not know" is entered before proceeding to the next question. A consistent finding in the literature is that item nonresponse caused by respondent errors is virtually eliminated but that there is little reduction in rates of explicit "do not know" and "no opinion" answers (Nicholls, Baker, and Martin 1997). Computerized self-administered questionnaires (CASQ) and computer-assisted self-interviewing (CASI) make it possible to use very complex questionnaires without the aid of an interviewer. But also in standard, less complex self-administered questionnaires, CASI reduces item nonresponse considerably (Ramos et al. 1998; Schaefer and Dillman 1998; Van Hattum and de Leeuw 1999; Kwak and Radler 2002). Finally, a small number of studies have explicitly compared respondent entry errors in computerized versus paper-and-pencil questionnaires. Fewer respondent errors are reported in CASI than in paper-and-pencil self-administered questionnaires. For an overview, see Nicholls, Baker, and Martin (1997) and de Leeuw (2002).

Psychological Processes and Data Quality

The visible presence of a computer may affect data quality, apart from the technical aspects of using a computer. As with most technological innovations, there is a "novelty" effect. However, after some time, respondents get used to the new machine, and its influence on the interview situation diminishes. Compared to traditional paper-and-pencil methods, the presence of a computer could lead to the following effects (positive and negative) on how the whole data collection procedure is perceived:

1. *Reinforcing.* It is new and has a high attention value. People notice it and react to it. For instance, a disk-by-mail survey will be noticed more quickly and positively among all "junk" mail than will a standard paper questionnaire. This effect will decrease over time when people get used to the new technique.
2. *Less privacy.* When one is unfamiliar with computers, there could be a "big brother" effect, leading to more refusals and socially desirable answers to sensitive questions. When researchers first started to use computer-assisted data collection, this was a much-feared effect.
3. *More privacy.* Using a computer could also lead to the expectancy of greater privacy by the respondents; responses are typed directly into the computer and cannot be read by anyone who happens to find the questionnaire. Much depends here on the total interview situation and how the survey is implemented.

Empirical research on respondents' reactions shows that respondents generally appreciate the various forms of computer-assisted self-administered questionnaires; they evaluate it positively and find it interesting, easy to use, and amusing (Zandan and Frost 1989; Witt and Bernstein 1992; Ramos, Sedivi, and Sweet 1998). Beckenbach (1995) reported that more than 80% of the respondents had no problem at all using the computer and the interviewing program and that only very few respondents complained about physical problems such as eyestrain. Furthermore, respondents tend to underestimate the time spent answering a computer-assisted questionnaire (Higgins, Dimnik, and Greenwood 1987).

The generally positive appreciation of CASI also shows in the relatively high response rate with disk-by-mail surveys. Disk-by-mail response rates vary between 25% and 70%, and it is not unusual to have response ratios of 40% to 50% without using any reminders (Saltzman 1993). If disk-by-mail is typically used with a special population interested in the research topic, a comparable, well-conducted paper mail survey using no reminders may be expected to yield about 35% response (Dillman 1978; Heberlein and Baumgartner 1978). The high response rates may be partly caused by the novelty value of disk-by-mail in the early studies. It should be noted that Ramos, Sedivi, and Sweet (1998) found no evidence for higher response rates in disk-by-mail in academic and government surveys in the United States.

When e-mail and Web surveys are compared to traditional paper mail surveys, one sees the opposite pattern: Paper mail surveys have, in general, a

higher response rate than an equivalent Web or e-mail survey (Schaefer and Dillman 1998; Couper, Blair, and Triplett 1999; Kwak and Radler 2002). Perhaps the novelty value is wearing off as electronic junk mail is rapidly increasing. Also, one mouse click is enough to throw away anything unwanted or uninteresting, making it easier to ignore a Web survey than a disk-by-mail survey.

As respondents are generally positive about CASI, we expect that respondents will experience a higher degree of privacy and anonymity, which should lead to more self-disclosure and less social desirability bias. Several studies showed more self-disclosure on sensitive topics (e.g., abortion, male-male sexual contact) when using CASI (see Tourangeau and Smith 1996; Turner et al. 1998). There is some evidence that the use of A-CASI shows the same effect (O'Reilly et al. 1994; Turner et al. 1998). Weisband and Kiesler (1996) carried out a meta-analysis on thirty-nine comparative studies and report a significant effect in favor of computer forms. This effect was stronger for comparisons between CASI and face-to-face interviews, but even when CASI was compared with self-administered paper-and-pencil questionnaires, self-disclosure was slightly higher in the computer condition. The effect reported was larger when more sensitive information was asked for.

Weisband and Kiesler (1996) also reported that the advantage of CASI has been diminishing over the years but has not disappeared totally. They attribute this to a growing familiarity with computers among the general public. Richman et al. (1999) partly corroborated these findings. They found clear effects of less social desirability distortion on computerized forms compared with face-to-face interviews. When computerized forms were compared to paper self-administered questionnaires, no consistent effects were found; much depended on the questionnaire and on other variables, such as whether the respondent was alone when completing the questionnaire. The interview situation and the perceived privacy seem to be more important than the use of the computer as such.

The effect of computerization on the quality of the data in self-administered questionnaires has also been a concern in psychological testing. In general, no differences between computer-assisted and paper-and-pencil tests were found in test reliability and validity (Harrel and Lombardo 1984; Parks, Mead, and Johnson 1985). This is confirmed by a meta-analysis of twenty-nine studies comparing conventional and computerized cognitive tests (Mead and Drasgow 1993). There are some indications that time pressure interacts negatively with the perceptual and motor skills necessary for reading questions from a screen and typing in answers correctly. Respondents, especially when they are a special or "difficult" group, should never be put under time pressure.

Logistic Factors and Data Quality

Going from paper-and-pencil to computer-assisted interviewing asks for an initial investment, not only in equipment but also in time. One must invest in hardware and software and in acquiring hardware- and software-related knowledge and skills. In addition, constructing, programming, and checking a computer-assisted questionnaire take considerable time. On the other hand, no questionnaires have to be printed, and there is no separate data entry phase. No extra errors are added during data entry, and the first tabled results can be available soon after the data collection phase. Thus, a well-planned computer-assisted survey has a real advantage when the results must be quickly available right after data collection (as in election forecasts).

After the initial investments are made, a computer-assisted survey may be less costly and quicker than traditional data collection, but it all depends on the study: its complexity, its size, and its questionnaire. To evaluate the cost-efficiency and timeliness of a computer-assisted survey, a distinction should be made between front- and back-end processing. In general, front-end processing (i.e., developing, implementing, testing the questionnaire) takes more time and is therefore more expensive. On the other hand, no data entry is needed, and data editing and data cleaning take less time; back-end processing is faster and less expensive. Usually, there is no difference in the total time needed for the research. But once data collection has started, results are available much faster than in traditional paper-and-pencil interviewing (Schaefer and Dillman 1998; Couper 2000; Kwak and Radler 2002). Samuels (1994) mentioned a reduction of delivery time of 50% for the results of an omnibus survey. When timeliness and a fast release of results are important for a client, this is an important advantage of computer-assisted data collection over paper-and-pencil methods (de Leeuw and Nicholls 1996).

An advantage of computer-assisted self-administered questionnaires and disk-by-mail and Internet surveys is that no interviewers are needed, so they are less expensive than survey procedures that do need interviewers, such as CATI and CAPI. This is one of the main reasons why Baker (1998) predicted a decline of interviewing and a rise of computer-assisted self-administered methods. When one compares computer-assisted self-administered procedures with the traditional paper mail survey, cost savings are not so obvious. As with all forms of computer-assisted data collection, the extra investment in programming the questionnaire and debugging pays off only for large surveys in which printing and editing of a paper questionnaire would make the paper form more costly (Ramos, Sedivi, and Sweet 1998). In disk-by-mail, the mailing costs include a special protective envelope. Also, a disk is heavier

than a short paper questionnaire, which makes disk-by-mail generally somewhat more costly than paper mail questionnaires (Saltzman 1993). However, when large numbers of longer questionnaires have to be mailed, disk-by-mail can be a real cost saver. Van Hattum and de Leeuw (1999) systematically compared the costs for a disk-by-mail and a paper mail survey of six thousand pupils in primary schools. They concluded that the average cost for a completed questionnaire is $1.01 for their disk-by-mail survey and $3.22 for their paper-and-pencil mail survey.

E-mail and Web surveys are reported to reduce research costs in the United States, where transmission costs (telephone/modem connect time) are practically zero (Clayton and Werking 1998; Kwak and Radler 2002). However, unlike the United States, in most European countries, local telephone calls are not free and have a per-minute rate. This slightly increases the costs for the researcher but may considerably increase the costs (connect time both receiving and sending) for the potential respondent. To ensure high response rates, one should find ways to reduce respondent costs comparable to prepaid return postage in mail surveys or reimburse costs of respondents. This will increase the costs of Web surveys in Europe compared to the United States.

Summing Up

Empirical comparisons between paper-and-pencil and computer-assisted self-administered questionnaires point to less item nonresponse and slightly more self-disclosure in the computer-assisted form. Furthermore, eliminating interviewers saves costs. When large surveys are done, a computer-assisted self-administered survey is less costly than a standard paper mail survey.

ADAPTING COMPUTER-ASSISTED INTERVIEWING TO SPECIAL GROUPS

Computer-assisted data collection methods improve data quality and are widely used in general surveys. Because of their flexibility and facility to ask complex research questions (Sikkel 1998), they are attractive for surveying special groups. However, for a successful survey of special groups, adaptations have to be systematically incorporated in the standard current best methods of computer-assisted data collection (de Leeuw and Collins 1997).

The main points for adaptation are the following: optimize the design by preanalysis of the goal of study, the group to be surveyed, and the logistics; follow this up by using the full potential of computer-assisted data collection to optimize the questionnaire and procedures; check the total design by pretests of questionnaire, implementation, and procedures; and, finally, build in repairs for the rare cases that errors will occur. One should always aim to anticipate problems and have a repair mechanism available. We want to stress that all this can be implemented using existing, flexible software. In the case studies discussed in the Case Studies section, we will give examples of how we used these principles in surveys of special groups.

Optimizing the Design

The essential first step is a systematic analysis of the group to be surveyed and of the research problem. What do we want from this special survey? What makes the research question special? Why is the group under study special? To answer these questions for a computer-assisted self-administered survey, one has to consider the following points:

1. How well are the cognitive skills of the respondent developed (e.g., consider the different developmental stages in children or the potential for reduced mental capacity in elderly)?
2. Which channel capacities can be used during data collection (e.g., can one use visual stimuli or only audio, as in the case of visually impaired respondents)?
3. What are acceptable social customs for the group under study?
4. Are there potential hazards to eye-hand coordination? Could one use a keyboard or mouse, or should one use a touch screen or special equipment, for instance, for hospital patients, or handicapped?
5. How used to computers are the potential respondents (i.e., how computer literate are they)?
6. Is there easy access to computers, either the respondents' own or a company or school computer?
7. If not, how easy is it to provide respondents with a computer on a temporary basis, for example, having a computer delivered to a key contact at a hospital (consider the risk of theft)?
8. Are there key persons or contacts available to introduce the survey, for instance, a teacher in school surveys, a social worker in a health center?

Using Computer-Assisted Interviewing Potential Fully

The strength of computer-assisted data collection is that intelligence can be built into the program. A complex questionnaire (e.g., a questionnaire with checks of answers, complicated branchings, and randomization of response categories) can be used safely in a self-administered situation since the computer program takes care of the complex navigation through the ques-

tionnaire. Nevertheless, it remains important that the questionnaire appears logical and simple to the respondent. The magic words are *appear* and *to the respondent*. What the respondent sees on the screen should be simple, while what happens in the program may be complex. To achieve this goal, sophisticated questionnaire design, as described by Fowler (1995) and Dillman (2000), among others, should be combined with the flexibility of computer-assisted interview programs (see also Sikkel 1998).

In constructing a computer-assisted survey for special groups, one must keep in mind the following:

1. The questionnaire should be experienced as simple, short, and structured to compensate for potentially lesser cognitive skills and smaller channel capacity.
2. The point of reference is always the respondent; what is simple and logical for the respondent is not necessarily logical or easy for the program designer.
3. The questions should be grouped in a logical order, in blocks of questions that use the same question format as far as possible.
4. As texts are harder to read on a monitor than on paper, ergonomical text presentation and careful screen design are very important.
5. As perceptual and motor skills necessary for responding to a computer-assisted questionnaire are more complicated and take somewhat more time than those necessary for paper-and-pencil tests, one should avoid any suggestion of time pressure, especially with inexperienced users. If eye-hand coordination is expected to be suboptimal, one should allow for extra time.
6. In all cases, simple keystroke combinations must be used for answering.

Finally, the full power of computer-assisted data collection should be used. Therefore, a system should do everything it can do to minimize respondent burden. For instance, starting the questionnaire, making backups, keeping administrative records, and stopping and resuming at the right point should be automatic. We discuss this further in the Case Studies section.

Pretest and Check

Often, there is not enough time and/or money for extensive pretests and a full pilot study. However, this is not an excuse for omitting pretesting altogether. Carefully planned, small-scale pretests can be implemented at relatively low costs. As a start, dry runs without any real respondents can be done in-house to check the programming. This can be followed by qualitative interviews with a small number of real respondents to detect errors in the questionnaire. In this type of interview, respondents are explicitly asked to point out what they do not understand or what is strange in the formulation of questions or not handy or ergonomical in the computer setup. Observation of

a respondent in combination with in-depth interviewing after the performance is a good method for testing the implementation.

A full-scale pretest program involves three steps. First, one has to pretest the questionnaire itself. The issue here is whether the respondent understands the meaning of the question, the meaning of terms used, and the response categories. This type of pretest can be done early in the research process with a paper version of the questionnaire. In this type of pretest, a small focus group or a limited number (five–seven) of in-depth interviews are used with carefully selected persons who resemble the intended respondents on important background characteristics (see Forsyth and Lessler 1991; Fowler 1995; Snijkers 2002). The second step consists of pretests of routings in the questionnaire and the computer implementation (e.g., starting up, making backups). For these technical pretests, no respondents are necessary; these tests can be done by the researchers and/or programmers in-house (e.g., Kinsey and Jewell 1998). The third step is a usability test of the final product (e.g., Dumas and Redish 1994). Important in this usability test is to have some naive respondents try out the computer-assisted questionnaire in a "real-life" situation to test the user-friendliness of the system, the screen layout, and, if applicable, the use of special keytouch screens, and so forth. Full pretesting requires an extra investment of time, effort, and money in the beginning (front-end processing), but part of this is regained at the end of the research (back-end processing, such as data editing and data analysis).

Build In Repairs

Even in the best-tested questionnaires, something can go wrong. To quote Murphy's law: "If something can go wrong, it will, and at the worst possible moment." Therefore, help options are extremely important. There is a range of possibilities from a simple help message on the screen to a specialized helper on site.

When the questionnaire is programmed, the researcher should give clear instructions on extra information or help texts that will be used. For instance, internal checks on "out-of-range" answers and consistency checks are used almost automatically in a computer-assisted questionnaire. If an error is detected, this should be followed by a clear message on the screen, and the respondent should be given an opportunity to give a different response.

When an error occurs, or the respondent realizes that the answer just given is incorrect, inexperienced respondents often do not know what to do and may stop. Built-in help functions are usually then not enough, as they may confuse the flustered respondent even more. Therefore, always have a short list on paper with instructions and essential information, such as what to do if

one typed in the wrong answer and how to go back to a previous question. Print this information on lightly colored paper, slightly heavier than normal, and use a large character type without serif (e.g., Helvetica 20).

Sometimes a person is needed to help out. Have a help desk available or use informed key persons in the vicinity as help. Make sure that "first-aid" disks are available with a complete backup of the questionnaire and the system requirements, either with the key persons or at the help desk ready to be mailed out immediately.

CASE STUDIES

Case 1: A Disk-by-Mail Survey of Pupils in Primary Schools[1]

In spring 1995, a disk-by-mail survey was implemented in 106 primary schools that formed a random sample of primary schools, scattered all over the Netherlands (Van Hattum and de Leeuw 1999). The respondents were 6,428 pupils, aged eight to twelve years; the topic of the questionnaire was bullying. The survey had ninety-nine questions on attitudes regarding bullying, handling of bullying by teachers and parents, and actual bullying, either as a victim or as an active culprit.

Traditionally, this type of research is done with group administration of paper self-administered questionnaires in the classroom. Analysis of the research problem and group to be studied made us opt for computer-assisted self-interviewing. Pupils are generally reluctant to talk about bullying, even with their parents or teachers, so we looked for a procedure to enhance feelings of privacy, to reduce the influence of close proximity of classmates, and to create a more informal, relaxed mood (see Scott 1997). The pupils were young, and to keep them motivated to complete the questionnaire, it was important that it appeared simple and attractive. An additional point was that printing and mailing such a large number of questionnaires is costly. We were lucky in that thanks to a large government-sponsored project to improve computer literacy among the young, in 1995 all primary schools in the Netherlands were equipped with personal computers of the same type and teachers had basic knowledge of computer technology. Therefore, the basic requirements for a successful disk-by-mail survey were met (Witt and Bernstein 1992): All pupils had easy access to computers, and knowledgeable teachers were available as key contacts.

Logistics of Disk-by-Mail

A disk-by-mail version of the questionnaire was developed using the CI3 program (Sawtooth 1994). We used the full potential then available in computer-assisted interviewing, so range checks were defined for all questions, and questions were randomized within blocks of related questions. A special code was defined for "do not know," which did not appear on the screen but was explained to the pupils in a separate instruction. Special attention was given to producing a simple but attractive screen layout. Only simple keystrokes were needed to answer the questions. To accommodate the needs of this special population, we created a possibility for a temporary stop when a child was tired or when the teacher needed a pupil. The pupil could resume answering the questionnaire at a more convenient time.

The questionnaire implementation was thoroughly pretested, and a paper version of the questionnaire was available as backup. Six schools used this paper version; the main reason was that those schools were extremely large and that it would take the teachers too long to have their pupils take the individual computer questionnaire.

A small package was sent to the teachers of the participating schools. It consisted of two or more disks (depending on the number of computers), three short printed instructions, and an accompanying letter. To make the procedure as simple as possible for the teachers, the disk contained automated batch files for installing the interview programs. Other batch files were used to automate the tasks of starting the questionnaires, pausing and resuming, saving the data, and making backups. Two of the printed instructions were for the teacher: The first gave instructions on how to start up the children's questionnaire; the second gave instructions to start up a special teacher's questionnaire. The third instruction, a yellow card with eight points in large letters, was developed for the pupils. This instruction was simple and to the point and was always kept next to the computer so pupils could refer to it whenever they felt the need. Main points in the instruction were the use of the keys of Enter and Backspace, and an explanation of the "beep" used to indicate that a child gave an out-of-range answer or used Enter without giving an answer. The instruction also stated that they were allowed to type in "9" if they really could not give an answer to a specific question.

The teacher installed the questionnaire and allocated pupils to answer the questionnaire individually on the computer; so the teachers acted as helpers and key persons. The pupils got positive feedback by the system at regular intervals to keep them motivated (e.g., "You are doing fine," "Great, thank you").

A telephone help desk was available for the entire data collection period, and people were on standby to go to a school with problems if necessary. Several university laptops were available as backup if hardware problems occurred or if large schools needed an additional computer. Only one school asked for on-site personal assistance because they were not sure that they could do the "computer things."

Acceptance, Data Quality, and Costs

We investigated the acceptance of the method, the data quality, and the costs involved. At the end of the data collection period, the participating teachers received a personalized report based on the results of their own class, and they were asked to complete a short evaluation questionnaire. The teachers were very positive—even those who were older and those who had limited computer experience. The children, even the youngest, also liked the procedure. The teachers reported only few problems. These were mainly general reading or language problems, not technical ones concerning the computer or keyboard.

We could also compare the results of the computer questionnaire in 245 classes (5,872 pupils) with those of the paper-and-pencil questionnaires that were used in a limited group of very large schools (18 classes, 556 pupils). The classes were comparable with respect to their teacher characteristics (e.g., teaching experience, education, and class level). The paper version had a far higher percentage of question-missing values ($p = .00$). In the computer version, the mean of the percentage missing values was 5.7, while in the paper-and-pencil version, the mean of the percentage missing values was 14.1. A very interesting result is that the corresponding standard deviations also differed strongly between the groups. In the computer version, the standard deviation was 3.4; in the paper-and-pencil version, the standard deviation was 25.0. These results suggest that not only the average amount of missing data is less in computer-assisted data collection but also that the individual variability, indicated by the standard deviation, is less. This may be attributed to the fact that with a paper questionnaire, children who are not concentrating very much or who are careless can easily skip a question or even a whole page by mistake. The computer forces children to be more precise by preventing skipping mistakes; at the same time, it keeps the children motivated by giving them positive feedback.

The pupils' main questionnaire also contained a short test for the tendency to give socially desirable answers. A high score on this nine-item test indicates that a child has the tendency to give honest, socially undesirable answers.

There was a significant difference between the two versions ($p = .00$). Children in the computer version gave slightly more undesirable answers ($M = 30.6$) than did children in the paper-and-pencil version ($M = 29.9$). The standard deviations did not differ between versions.

We looked at the answers on both the bullying and the victimization tests concerning openness and self-disclosure. Children in the computer version reported that they were actively involved in more bullying than did children in the paper version ($p = .00$). The mean score for the computer version was 30.5, while the mean score in the paper version was 27.7. Furthermore, more victimization was reported in the computer version ($p = .00$). The mean score on the victimization test was 26.4 for the computer questionnaire and 23.1 for the paper questionnaire. Again, standard deviations did not differ between the two.

Besides data quality, costs are an important factor. Cost comparisons are always difficult because they depend strongly on the organization one works in. To present a reasonable comparison, we calculated the costs we made and compared these with the costs we would have incurred if we had done the same survey with paper and pencil. The costs of sampling, of developing the questionnaire, and of keeping account of the returned questionnaires are not taken into account; these would have been approximately the same in both cases. In the computerized disk-by-mail case, we included costs for acquiring the CI3 program, for computer disks, programming, staffing the help desk, and mailing. For the paper equivalent, we included printing and mailing costs using the cheapest mailing procedures. We also included the costs for data entry and coding. For the disk-by-mail procedure, the total costs were \$1.01 for each completed questionnaire; in a paper mail survey, this would have been about \$3.22.

Summing Up

This case shows the following:

1. A disk-by-mail survey can be successfully implemented in Dutch primary schools.
2. Children from the age of eight years on can successfully complete a computer-assisted self-administered questionnaire and enjoy it.
3. Even teachers with few computer skills can assist in carefully designed computerized surveys and enjoy it.
4. Data quality in the computer-assisted group was better than in the paper-and-pencil group.
5. Disk-by-mail surveys result in fewer costs for each completed questionnaire compared to a paper mail survey.

Case 2: A Mixed-Mode CAPI and CASI Survey of Visually Impaired and Blind Adolescents and Young Adults

The second challenge was a study of blind and visually impaired adolescents and young adults (aged fourteen–twenty-four years). In total, 354 respondents scattered over the Netherlands had to be interviewed about their personal networks, perceived social support, feelings of loneliness and self-esteem, well-being, and handicap acceptance. This resulted in a complex questionnaire of more than 260 questions (Kef 1999). A number of questions on the ego-centered network were especially complex for interviewers to administer. For these questions, every important network member in specific domains (e.g., family, friends, neighbors) had to be enumerated. This was followed by questions on practical and emotional support for each listed network member. To ease the task of the interviewer and to minimize interviewer error, a computer-assisted procedure seemed appropriate. In CAPI, the interview program takes over and handles the complex questionnaire logic, which prevents interviewer errors; an additional advantage is that the interviewer can concentrate on the special needs of the respondent and establishing rapport (de Leeuw, Hox, and Snijkers 1995).

The questions on self-esteem, well-being, and loneliness were judged to be sensitive and private. Analysis of the research problem and group led to the decision that a mixed-mode CAPI-CASI survey was the best choice, with special adaptations to accommodate the special needs of the blind and visually impaired respondents. For the sensitive questions, computer-assisted self-interviewing was used, while the other questions were asked by the interviewer using CAPI, to ease the burden on the respondent.

Logistics

A computer version of the questionnaire was developed using CI3 (Sawtooth 1994). We used the full potential of computer-assisted interviewing for this complicated network questionnaire. Thus, lists of persons were programmed in a roster routine with the network questions, and range checks were defined for most of the questions. Additional instructions to the interviewers were also programmed in to ease the interviewer burden (e.g., when to hand over the computer to the respondent for the CASI part of the survey). Some extra adaptations had to be programmed for the CASI application. For instance, the limited channel capacity of the visually impaired forced us to compensate for visual stimuli by using audio and paralinguistic cues, and we used braille for keyboards and response cards.

We opted for a manual A-CASI. At the time of our survey, A-CASI equipment was still in the developmental stage (O'Reilly et al. 1994; Johnston and Walton 1995), and standard software could not handle audio. We devised a procedure that used the interviewer. The interviewer handed the computer to the visually impaired respondent, making clear by audibly shifting the chair that she could not see the screen or keyboard. The interviewer had the text of the questions in writing and read them aloud to the respondent, who typed in the answers. To synchronize the text of the question on the screen with the one the interviewer was reading, a series of "beeps" was programmed to sound after the respondent typed in a response. The questions were all rating-scale type, and the respondent had to type in just one numerical key. For this A-CASI application, we developed a special hardboard template to cover the keyboard. In the template, the part for the numbers from 1 to 0 was cut out, since these were the only keys that would be used. At the appropriate places above the keys, the hardboard template had both braille and magnified numbers, enabling the respondents to use the keyboard themselves while answering.

To help the respondent's memory, we also developed paper flash cards with the response categories used. There were three versions: one with braille text, one with a very large magnification, and one with little magnification.

The questionnaire and the procedure were pretested extensively, using qualitative pretests and a small-scale pilot study on blind and visually impaired adolescents. Interviewers attended a three-day interviewer course. Topics were standard interviewer training, handling the laptop, the contents of the questionnaire, an introduction to CAPI and CASI, and the structure of the computerized questionnaire. Very important issues in the interviewer training were the special adaptations in the interview and specific interviewer skills needed for our target population. The training included a visit to a special school for the visually impaired.

The questionnaire was implemented on the laptops of the interviewers, together with an automated system for making backups and a virus scanner, automating as much as possible to reduce respondent and interviewer burden. Before the fieldwork started, each laptop was thoroughly tested, including the interview program and the backup facilities. A disk version of the questionnaire was available as standby in case of emergencies. The standby version was implemented to run adequately on a diversity of computers. If the interviewer laptop should break down, the respondents' own personal computers could be used. Since a personal computer is a very important tool for visually handicapped persons, we could rely on the availability of the respondents' computers. A paper field guide was prepared for the interviewers. It contained the text of the questions for the A-CASI part, a summary of basic interviewer rules, and a short manual summarizing the main computer commands and help with problems.

The fieldwork took five months. In this period, sixteen interviewers traveled all over the Netherlands, each interviewing approximately twenty respondents. An interview, including the self-administered part, took ninety minutes on average. During the fieldwork period, both laptops and software proved to be very robust. A field manager could be consulted by phone, even at odd hours in the evening and during the weekend, and acted as technical help desk and general nontechnical support (e.g., to keep up morale and instruct interviewers in difficult situations).

Data Quality

We had two means to verify the acceptance of the methods used and the internal validity of the data: acceptance of the new method and general data quality. To investigate respondents' acceptance and to systematically list any problems that may have occurred during the data collection, we had structured interviewer debriefing sessions. As the knowledge of interviewers and the information they possess on past interviews is often rather diffuse and unstructured, we used concept mapping. This is a qualitative, highly structured method especially developed to extract diffuse information and quickly proceed from fuzzy knowledge to an acceptable conceptual framework (Trochim 1989). In addition, we analyzed the results of short evaluations by both respondents and interviewers, completed immediately after the finished interview.

The experiences of the blind and visually impaired adolescents were very positive. In the Netherlands, almost all visually impaired young persons are very familiar with computers. Many respondents asked a large number of questions about the kind of laptop used and the reasons why we used a computer in this study. Our mixed-mode approach created interest and motivated the respondents. The CASI part gave the respondents more privacy and offered more variation in the interview situation, while CAPI proved an efficient way to deal with the complex network questions. The interviewers substantiated that it was important to clearly verbally state that they were not looking at the screen during the CASI part, thereby verbally compensating for the missing visual channel. The hardboard braille template for the keyboard worked well, and the respondents had no difficulties typing in their answers. By accident, some respondents pushed some keys through the hardboard device. Since the questionnaire was programmed to check the responses and to accept only numerical input at this point, this created no problems.

CAPI and its adaptation to the special population did not cause any problems; the special flashcards with response categories in braille and large letter type worked extremely well. The interviewers mentioned that it was extremely important to verbalize every action. When interviewing visually impaired individuals, only a limited channel capacity of communication is available (audio and touch). Interviewers had to rely heavily on verbal and paralinguistic communication (e.g., humming instead of nodding as a positive reinforcement).

To investigate the internal validity of the data, we checked missing values, psychometric reliability, and interviewer variance. As to the first, no missing values occurred at all. To examine the psychometric reliability, we analyzed the responses to the multi-item scales. For each multi-item scale, Cronbach's coefficient alpha was computed as a reliability index for the whole group of respondents and for subgroups (i.e., blind vs. visually impaired). We expected that it would be somewhat harder for the blind to use the CASI part, which should have resulted in somewhat less consistent answers for the blind compared to the visually impaired. This was not confirmed by the data. In the group as a whole and in the subgroups, the multi-item scales all had sufficient reliability. We found no significant differences in reliability of scales (Cronbach's alpha) between subgroups.

Finally, we investigated whether there were any interviewer effects for the difficult question on network size. Again, we analyzed the data for the group as a whole and for the blind and visually impaired subgroups separately. Although we expected that the blind needed more assistance, which would have resulted in a larger interviewer effect, this was not confirmed by the data. In fact, no interviewer effects on network size were found for the whole group or for the subgroups.

Summing Up

1. A mixed CAPI-CASI approach can be successfully used with visually impaired adolescents and young adults.
2. Given the high level of computer sophistication of Dutch young visually impaired and the fact that almost all own a personal computer with braille adaptations, even a CASI-only survey could be successfully implemented.
3. Acceptance of computer-assisted data collection methods is high. Both interviewers and respondents were positive in their reactions.
4. The special adaptations using braille and audio–computer-assisted self-interviewing procedures worked well.
5. The combination of computer-assisted data collection and well-trained interviewers results in good data quality.

Case 3: A Pilot Study of Deviant Adolescents and Their Parents

In summer 2000, a pilot study was started to survey adolescents with deviant behavior (e.g., aggressive behavior, delinquency) and their parents (Kef 2000).[2] The adolescents investigated were between twelve and nineteen years old, they all spoke Dutch, and they all were under professional counseling. For part of the group, the counseling was voluntary; the adolescents and their daily caregivers have sought counseling themselves. For others, the counseling was mandatory (e.g., ordered by a judge or juvenile court). Both the adolescent and the daily caregivers were surveyed at the same time by one interviewer with two or three laptops. The laptops were equipped with special dedicated computer-assisted questionnaires, one questionnaire for the adolescent and another for their daily caregivers. A mixed-mode interview and self-completion (CAPI-CASI) approach was used.

Both the adolescents' and the parents' questionnaires contained very sensitive topics. For instance, the questionnaire for daily caregivers contained questions on family relations, marriage satisfaction, norms and values, well-being, coping, child rearing, and counseling experiences. The adolescent questionnaire contained questions on physical and psychological health, friendships, family situation, how they were reared, coping behavior, norms and values, and deviant behavior (violence, crime). Both the adolescents' and the parents' questionnaires contained questions on background demographics, including gender, date of birth, ethnicity, education, and sources of income. Each questionnaire was rather long (around three hundred questions) and contained complex routings. To program the questionnaire, CI3 was used and the customary range and consistency checks were programmed in. After careful analysis of the special needs of the study, a pilot was devised and conducted, followed by a debriefing in which the respondents were asked to comment on the procedure and the questions.

To accommodate this very special population in combination with the sensitive nature of the topic, a mixed-mode CAPI-CASI survey was the best choice. The majority of the questions were asked in CASI questionnaires. The interviewer's task was to introduce the survey, start up the questionnaire, ask some introductory questions, and then hand over the computer to the respondent. Thus, interviewers acted more like knowledgeable key persons to make the self-administered procedure accessible and provide technical assistance when needed than as traditional interviewers. The interviewers carefully explained the self-administered procedure and made sure that all the individual members of the household could answer the questions in privacy, each using a different laptop. For instance, the mother was installed

with a laptop in the family room, the father in the bedroom, and the adolescent in his or her own room. The usual procedure was that after a short general introduction for the whole household, first the daily caregivers were introduced to the questionnaire in total privacy and then the adolescent.

An important role of the interviewer was to guide and support the respondents both technically and emotionally. To facilitate this, the self-administered part was programmed with a short break in which respondents could consult the interviewer, let off emotional steam, and relax. The pilot results suggested that this worked well to relieve the stress of responding, and many respondents suggested including a second break. To keep the respondents motivated and again to reduce tension, short supportive texts appeared on the screen between questionnaire modules. These texts thanked the respondents and introduced the next set of questions. The pilot respondents appreciated this because it gave some structure to the questionnaire. In general, the adolescents really appreciated the CASI procedure; they thought it was "cool." The caregivers were more neutral in their reaction: They appreciated the privacy, but the computer did not add anything special for them. One adult respondent commented that she missed the feeling of order and the overview of a paper questionnaire.

Summing Up

The computer-assisted data collection methods worked well. Based on the results of the pilot study and the debriefing, the following adaptations are proposed for this special survey:

1. Include several short breaks to relieve stress and give the interviewer an opportunity to offer (emotional) support.
2. Add even more introductory texts between the modules to guide the respondents through the questionnaire.
3. Have a summary card with a description of the modules and its contents to give the respondents a feeling of control and familiarity with the structure of the questionnaire. This is analogous to the summary lists often given to interviewers during training.

CONCLUSION: SOFTWARE AND INTERNET RESOURCES AND SUGGESTED READINGS

Computer-assisted self-administered questionnaires definitely have advantages for data quality, especially when sensitive topics are investigated and/or complicated questionnaires are used. The high potential and flexibil-

ity of computer-assisted data collection is well suited for surveying special populations. Most important is a systematic approach to data collection. The research problem should be carefully analyzed, and the design should be adjusted to the special group as we described in general above and illustrated with the case studies.

New developments in multimedia systems, using sound and video, increase the power of the tools available for surveying special groups. We are confident that everyone, even little-educated individuals or at-risk groups, can be surveyed using computer-assisted (self) interviewing, provided that time and effort is taken to tailor the research design to the specific needs of the respondent and the special group of interest.

We want to stress that using computer-assisted interviewing does not require enormous resources. The cases presented above were carried out by a small research team, and the largest investment was the software and the laptops, which were written off on two different research projects.

It is not necessary to develop special software; quality standard software is available to accommodate your special survey. The question of which software is the best is impossible to answer because software is continually improved and different investigators may have very different needs. In our case, we used the commercially available software CI3 by Sawtooth Inc. (http://www.sawtooth.com). This survey software is directed at large-scale application of large and complex questionnaires. Despite its power and flexibility, we found CI3 relatively easy to use. Since developing survey software is obviously computer related, it is no surprise that major survey software makers maintain well-designed and informative Web sites for their product. Directing a search engine to search for *survey software* turns up dozens of hits. A Web site documenting a number of survey packages available on different computers can be found at http://www.researchinfo.com/dosc/software. The survey software Blaise, developed by Statistics Netherlands (http://www.cbs.nl), stands out because it is actually a survey system with many different and highly programmable modules. These can be used to create management systems, metafiles that describe the data, and a number of analyses. Blaise is clearly intended for experienced research teams in large organizations. But Blaise is not easy to implement for inexperienced users.

A recent review in *Field Methods* (Crawford 2002) compared three programs for conducting Web surveys: SurveySolutions for the Web (http://www.perseus.com), Ztelligence (http://www.markettools.com), and MrInterview (http://www.spssmr.com). Crawford (2002) concluded that the more powerful systems come at a price, not only in money but also in difficulty of use. For researchers who are not part of a large and wealthy organization, Infopoll Designer (http://www.infopoll.com) is interesting because the entry-level package is free. It can be used to develop relatively simple Web surveys. By putting the questionnaire on a laptop and using a browser offline, this product can also be used for CAPI and CASI interviews. Researchers who need to use the highly portable palmtops should consider Entryware (http://www.techneos.com). A recent review of this product in *Field Methods* (Gravlee 2002) found it very useful for field research.

Most software makers maintain a page with papers and other information on their Web site. These are, of course, partial to their own product but in some cases are genuinely informative.

Two academic sources of information containing research papers and articles are Don Dillman's homepage at Washington State University (http://survey.sesrc.wsu.edu/dillman/) and the homepage of the Internet research group at the University of Ljubljana in Slovenia (http://www.ris.org/group.html).

We end with some suggestions for further reading. The reference list contains many specialized references to articles on different aspects of computer-assisted data collection. In addition, the 1998 monograph edited by Couper et al., *Computer-Assisted Survey Information Collection*, contains many helpful reviews and a thorough bibliography on the topic. For a general introduction into the advantages and disadvantages of computer-assisted data collection, including computer-assisted telephone and face-to-face interviews, we recommend de Leeuw, Hox, and Snijkers (1995). A thorough summary of empirical findings on data quality is the chapter by Nicholls, Baker, and Martin (1997). An excellent critical introduction to Internet surveys is Couper (2000).

Regarding writing and testing questions in general, we recommend Fowler (1995). Finally, Don Dillman has written many articles and two well-known books on self-administered questionnaires. For interesting articles on visual design of questionnaires and Web surveys, we refer to his homepage (http://survey.sesrc.wsu.edu/dillman/).

NOTES

1. For more details, see Van Hattum and de Leeuw (1999).

2. For more details, contact Dr. Sabina Kef, Department of Education, University of Amsterdam (sabina@educ.uva.nl).

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