

HOW DO HEALTH RESEARCHERS BENEFIT FROM WEB-BASED SURVEY SYSTEMS?

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ABSTRACT

This paper discusses the needs of researchers working in areas of medical research in which the collection and analysis of people's opinions is central to the research activity. Until quite recently, collection of survey data has been either paper-based, or achieved using computer software that largely duplicates paper-based processes with limited additional functionality. The authors, who have developed and used many Web-based surveys in their health-related research, discuss the needs of health researchers who use surveys and similar tools to collect research data, and propose a set of functionalities that efficiently satisfies those needs. A Web-based software architecture that delivers on researchers' identified needs is presented, and an example implementation that has demonstrated its capabilities in recent research projects is introduced.

KEYWORDS

Survey Software, Web-based Surveys, Research Support, eResearch.

1. INTRODUCTION

Surveys are tools used to collect research data on people's opinions, perceptions and self-reported behaviours. Each survey comprises a set of closed and pre-determined questions asked of a group of respondents intended to be representative of the population of interest (Shaughnessy et al., 2011). This contrasts with interviews and polls: interviews involve personal interaction between the interviewer and interviewee and may include open questions or the collection of qualitative data; polls ask a single question rather than a set of questions.

While qualitative interviews are a more personal and revealing way of collecting population information compared to surveys, considerable time is required to code and analyse qualitative data and the number of participants is very limited.

Data collection using surveys is an important facet of research, particularly in the areas of health, psychology and sociology.

Health professionals, for example, may wish to directly assess patient perspectives about whether healthcare meets their needs (McDowell, 2009) because involvement of patients as partners in their own care is now considered best practice (Institute of Medicine, 2001). Survey data can be used to identify patient views about or preferences for healthcare services; to assess patient outcomes; and identify areas of unmet service needs. Patient or clinic characteristics that are associated with a higher risk of poor outcomes can also be identified and targeted for appropriate interventions. Surveys are, of course, also important in other research areas, for example political science (Pasek and Krosnick, 2010) and business (Weathers et al., 2005).

There are several features that enhance the quality of survey data. These include ensuring that data are collected from a representative sample and that questions are posed in a manner that maximises the reliability and validity of responses. Strategies that increase the acceptability of surveys through improving participant

comprehension and ease of use of the survey tool will contribute to the aim of collecting high quality survey data.

Surveys are increasingly used as a data collection tool for topics as diverse as ‘preferred times for a meeting’ to ‘workforce opinions on corporate strategy and function’. This paper discusses the ideal features and capabilities of a ‘good’ survey system as informed by health researchers, and shows that a Web-based environment naturally supports implementation of these ideals and improves the experience of both researchers and participants.

It is intended that the observations and ideas engrossed in this paper should provide valuable information to health researchers selecting a survey tool to support their research, and assist software developers working on design and implementation of web-based survey systems.

2. SURVEYS AS A RESEARCH TOOL

Ideally, survey-based measures should be capable of providing an accurate assessment of the behaviour or state of interest for a representative sample of consumers (McDowell, 2009), as well as be reliable, acceptable and easy to administer (Clinton-McHarg et al., 2010a). Several factors influence measurement accuracy and reliability, and these should be taken into account at the survey design phase. They include the ease with which the questions can be understood, and the acceptability and relevance of the questions (Dillman et al., 2008). The Internet is now widely available to respondents (Paul et al., 2011), and the use of computers for interaction is acceptable (Paul et al., 2013a, ABS, 2011).

A multidisciplinary collaboration between behavioural scientists and information technology experts was formed to further investigate requirements and structure of the ideal Internet-based survey system. Their experience, and consultation with other researchers who regularly use surveys in their research, led to compilation of the following properties of a high quality survey:

2.1 Relevance

In contrast to paper surveys, electronic surveys have the capability to enable respondents to automatically “skip” questions that are not relevant to their circumstances (as determined from responses to previous questions). For example, respondents may be asked whether they are male or female. Those who indicate that they are male may then be automatically redirected to a next question asking whether they have had a recent PSA test, whereas females may be redirected to a question asking whether they have taken a mammogram in the past two years. Those who answer the ‘PSA’ question may then be automatically redirected to a ‘indicate the value range of your result’ question, and so on. This automatic assistance with question navigation streamlines the survey completion process and omits the need for respondents to follow complex instructions.

2.2 Respondent Acceptability

To increase participant completion rates and reduce missing data, it is important that survey respondents find the survey interesting, visually attractive, easy to understand and navigate with a logical user interface, and are able to complete the survey in a reasonable amount of time (Fan and Yan, 2010).

The tool used to conduct the survey is also important. The advent of easy-to-use tablet computers and smart phones has removed the need for use of cumbersome personal or laptop computers for computer-based surveys. Tablet computers are highly portable, provide privacy for survey completion through their more intimate form factor and immediate transfer of data, and have a high level of user acceptability (Paul et al., 2013a). However, web-based survey page layouts do not always automatically adjust from the space available on larger PC monitors to the smaller displays of tablet and hand-held devices, so care must be taken to render content that is appropriate to each individual user’s screen.

2.3 Immediate Feedback

Creating immediate feedback for a survey respondent and/or the conductor of the survey, based on the respondent's answers, improves relevance and recall of information for the participant (McPherson et al., 2001) and can synthesise relevant answers for researchers and health care professionals. It can also be used to improve patient literacy and self-management by highlighting those areas in which patients may need additional information or personalised assistance.

For example, answers to questions about medication adherence could be inserted into a feedback template containing evidence-based recommendations about ways to improve adherence. This can be tailored to individual participants, based on their answers. The template could incorporate design features to enhance recall and understanding of information such as categorisation of information (Girgis and Sanson-Fisher, 1998, NHMRC, 2004), repetition of important information (Ley et al., 1973), and the use of simple language (Fallowfield and Jenkins, 2004). This improves the accessibility of information for the participant and assists those with low literacy.

Immediate feedback from surveys can also be used by health care professionals in order to inform care delivery (Treweek et al., 2002). For example, an electronic screening tool for depression in a general medical setting may be used to identify patients who require further diagnostic assessment. In this way, electronic surveys could be used as an efficient and time-saving screening tool with improved detection rates.

Respondents can also benefit from immediate feedback. Evidence suggests patients and caregivers have unmet informational needs and desire more information during a consultation (Schoen et al., 2009). Health service providers may be limited by time constraints and unable to provide the amount of information desired in a single clinical encounter. Electronic surveys can produce personalised information sheets based on participants' demographic or disease characteristics, allowing information needs to be appropriately addressed. This may be used to improve patient self-management, information recall, and literacy.

2.4 Comprehension

Electronic surveys also have the potential to incorporate features that can enhance survey comprehension. For example, font size or mode of presentation (i.e. inclusion of visual or audio) can be customised to suit respondent preferences or needs, and embedded video clips can be used to demonstrate complex information. Such features may be particularly beneficial in improving comprehension among respondents with poor literacy skills (Murphy et al., 2000).

2.5 Respondent Privacy

Electronic surveys may be conducted in several ways, most commonly either by executing the survey software on a non-connected stand-alone PC or portable computer, or by using a Web browser to connect to a central server that uses the Internet to provide the survey content. Both approaches have different advantages, disadvantages and privacy issues. Assurance of data security and respondent privacy are critical issues for human research ethics committees (Bier et al., 1996).

The use of non-connected stand-alone or portable computers does not require an Internet connection for survey completion. Data collected during conduct of non-connected surveys are stored on the computer's local disk, with the data later aggregated for analysis. This is convenient in geographically isolated locations, or screened locations such as some factories or hospitals, where Internet connections cannot be established or are unreliable. However, this approach has the disadvantage that data (and thus respondent privacy and confidentiality) is vulnerable to compromise through unauthorised access, for example after theft or loss of the computer, or by a curious (or malicious) subsequent survey participant.

In contrast, use of a central Web server to generate survey content and collect and store participant responses means only one system needs to be secured. Encryption can be used to ensure confidentiality and privacy of transmitted data.

2.6 Data Quality

When technical difficulties are managed, electronic surveys have the potential to overcome problems with data quality by reducing respondent errors, missing data and errors in data entry (Gallagher et al., 2008).

Programming features can be applied to reduce the chance of respondent errors, for example, if a person enters a value outside the expected range for the question (e.g. age is entered as 221), then immediate feedback can be provided about this, giving the respondent the opportunity to correct their answer. Surveys may also be programmed so that a respondent cannot move to a subsequent question without completing the preceding questions, and partial answer sets can be used to determine dropout rates for particular questions. Furthermore, item response formats can be pre-specified, such as single response only, or multiple responses allowed, reducing the potential for respondent error (Boneveski et al., 1999).

Unlike paper surveys, electronic surveys automatically store participant responses in digital form, thereby avoiding potential transcription errors. Electronic data can be automatically downloaded in a variety of file formats (commonly csv) in order to conduct analysis.

More complicated response formats lead to greater opportunity for respondent error. For example rank-style items require participants to undertake the complex task of considering a list of variables, then rank, weight or distribute points between each, and finally ensure these total the pre-specified allocated value. (Clinton-McHarg et al., 2010b). Some rank-style items can most effectively be administered by a more labour intensive ‘card-sort’ approach (Shackley and Dixon, 2013). Electronic surveys can reduce that labour and facilitate completion by helping respondents to narrow down the list via the deletion of unimportant items, visually order options, calculate the cumulative and total value, and provide immediate instructions for the respondent to correct their answer.

2.7 Researcher Convenience

Use of a central Web server to generate the survey content and to collect and store responses has several advantages to do with researcher convenience: these may be categorised as participation management; data management; and response analysis.

With regard to participation management, paper and pencil survey responses require manual tracking to calculate completion rates or to determine whether reminder letters need to be sent to non-responders. As surveys typically include a large sample size, this requires considerable resources for data entry and monitoring. In contrast, electronic surveys may be embedded within the data management system that tracks survey responses and provides automatic prompts to the researcher, e.g. for follow-up surveys or reminders to people who have not yet responded. Reminders can also be fully automated so they go directly to the participant, e.g. via SMS.

Having a central Web server manage a survey also has several advantages related to data acquisition and management: respondents can take the survey using any client computing device with a Web browser, such as tablet computers, smart phones, or PCs and laptops; any changes to question wording are made in one place and immediately seen by all subsequent respondents; responses are centrally stored, which removes the need for aggregation and facilitates statistical analysis.

For optimal analysis of response data, survey results should be available to the researcher immediately, and in a format that is accessible to statistical programs such as STATA (Stata Corporation, 2013) or SAS (SAS Institute, 2013). This allows the researcher to review individual or group data as required.

In addition, recording and reporting of timing data (for example how long a respondent spent on each survey page; how many times a respondent stopped and restarted the survey; if a respondent watched a provided video clip or skipped past it) can enhance researchers’ understanding of responses, help inform the interpretation of data, and inform the design of future surveys.

3. SPECIFYING A ‘GOOD’ SURVEY SYSTEM

The requirements of an ideal survey system were described above. In this section we use the same headings to discuss specific survey system features that deliver those requirements, and show that the Web provides an ideal delivery platform.

There are a number of successful existing survey systems, for example PC-based systems such as Digivey (CREOSO Corporation, 2013), and Web-based systems such as Survey Monkey (Survey Monkey, 2013). These systems provide a set of core features required of ideal systems, for example: ability for researchers to

define surveys without a need for computer programmer assistance; a set of pre-defined question types; and support for branching, i.e. skipping past questions based on previous responses.

These features require extension and enhancement to achieve the 'ideal', as follows

3.1 Enhancing Relevance

Support for definition of more complex branching rules is central to enhancing the relevance of surveys. It should be possible to include or exclude questions based on either raw answers or calculations (e.g. body mass index (BMI) or age) based on answers to ANY previous questions, not just the answer to the question immediately preceding the branch.

The set of core question types should include: Informational; Text; Checkbox; Radio Button; Drop Down; Calendar; Rank Order; Distribution of Points; and Likert Scale to account for all possible question formats.

There should also be support for dynamic questions (e.g. Dynamic Checkbox; Dynamic Rank Order; Dynamic Distribution of Points) that provide options based on a subset of respondent answers to previous questions.

3.2 Enhancing Acceptability

To enhance acceptability of surveys, modelling of dynamic survey screens with content based on participants' previous responses is required. Support for three forms of content modelling is recommended. It should be possible to dynamically:

- Define the number of questions received by an individual based on their previous answers;
- Construct the question stem containing content from previous answers; and
- Set the possible response options (e.g. for checkbox or radio button questions) available for selection after implementation of a selection algorithm based on previous responses.

Use of Web browsers for researcher and participant interaction with the survey system makes use of an interface that is increasingly familiar to the user population and implemented on a wide range of Internet-connected devices.

3.3 Enhancing Feedback

It should be possible to generate on-the-spot printed or screen-based tailored feedback to respondents based on survey answers. In the case of Web-based surveys, printed feedback would be in a document form such as PDF, with the operator being able to send it to a printer to produce hard copy, or save to a file (that enables, for example, distribution by email).

3.4 Enhancing Comprehension

Comprehension is assisted by a number of features. Firstly, the ability to present related questions on a single screen assists the participant understand context. While this is available in some existing survey systems, it is a feature in need of enhancement, for example every question included on a screen should be tailored based on previous answers, and those that are not relevant should not be included. In this way, multi-question screens are dynamic, and previous questions determine the content of the page and possible response options.

The use of stimuli such as audio, still pictures or movies can assist respondents and/or provide content as the basis for questions. A wide range of stimulus file formats should be supported. Standardisation of Web browser support for such files is currently in progress and should be available in the next generation of browsers (W3C, 2013).

3.5 Enhancing Privacy

It should be possible to specify who can take a survey and how often. Appropriate options include that a survey can be taken by any participant, with no form of login or other identifying action required; participants who provide identification – in the case of multiple-response surveys, this supports participation by multiple linked respondents e.g. family members, or patients and their support person; or participants who authenticate by providing a username and password. Participants can provide their own ID, e.g. SURNAMEDDMM where DDMM is taken from their date of birth to achieve identification, or the researcher can associate a list of valid IDs with a survey. In the case of authenticated surveys, login details must be pre-prepared and individual details distributed to participants.

The survey system must also support privacy from the researcher viewpoint by, for example, ensuring that only survey owners are permitted to access responses or respondent lists. There should be support for multiple research groups, and a hierarchy of researcher users, for example: *administrator* with super user privileges including ability to create groups; *group leader* who can 'create' group members (researchers) and change survey ownership; and *researcher*, who can define individual surveys and access the corresponding data.

Web-based survey implementation allows the use of strong physical security of the server, and https-based encryption helps ensure security of data while in transit from the respondent's browser to the server.

3.6 Enhancing Data Quality

Centralisation of data storage through implementation of a Web-based survey system, and therefore automatic aggregation of the data, has an immediate positive effect on data quality because it removes the need for transcription or transfer of data.

Other features that enhance data quality include researcher-specified control over permissible responses (Dillman et al., 2008), with accompanying prompts that request the respondent re-enter non-compliant data.

It should also be possible to specify, on a field or individual character basis, whether input data is alpha and/or numeric. For answers that require a numerical response, a number pad or calendar can appear on the screen to assist respondents provide valid and correctly expressed responses.

Finally, the above-mentioned 'allocation of points' feature (Section 3.1), which allows participants to prioritise options as well as ranking them, provides researchers with richer and more meaningful data on which to gauge opinion and base decisions.

3.7 Enhancing Researcher Convenience

Having a central Web server responsible for generating and distributing survey screens and collecting responses provides a single point for participation monitoring and participant management. The central server software can provide features such as automatic generation of non-participation reports and other forms of follow up.

The server should render survey pages whose content and appearance are separately specified; appearance should be defined using a presentation semantics language such as CSS (Bos, 2013), with an optional WYSIWYG editor, allowing researchers to easily manage the *style* of the survey. In addition, the use of CSS provides the ability to differently render survey screens depending on the kind of device (tablet, smart phone, laptop) being used by the respondent, and even render the same survey in different languages.

Centralised management should reduce the need for researcher administration. It should be possible to specify participation in identified and authenticated surveys as being 'once only' or 'multiple permitted', providing support for linked input to a particular survey iteration (e.g. a participant's and their family member's opinion on the same point of interest), or to track changes in participant opinion over time. This assists researchers by removing the need to manually match responses.

The survey system should automatically record the date a survey was commenced, and the time (relative to commencement of the survey) at which the respondent receives and leaves every survey page, pauses and restarts the survey, and ultimately leaves the survey. This timing data helps researchers to picture respondents' behaviour while taking the survey, possibly highlighting those questions on which participants do not take much time to reflect, or those that require a longer time to understand.

Survey responses are best exported in a form such as CSV or XML, suitable for processing by popular statistical packages. Researcher understanding and statistical analysis are assisted by automatic inclusion of

markers indicating questions that were visited but not answered, c.f. those not visited because of branching rules.

In addition to these convenience features, the system should provide survey definition assistance to researchers such as preview and branch checking capabilities. Branch checking should occur in preview mode, so that when a branch rule is encountered, the system displays the rule, its positive and negative destinations, and its outcome determined from the previous question(s).

Finally, the survey system should be extendable so that it is not too difficult to add new survey question types to the system.

4. BUILDING THE SURVEY SYSTEM

A generic survey generation system called QuON had been previously developed and addressed some of the above needs; that initial version of QuON (Paul et al., 2013b), grew out of a need to collect the survey-generated research data and to make its presence discoverable in ANDS (Australian National Data Service, 2013). The basic QuON package was subsequently enhanced in a collaboration of the Distributed Computing Research Group (DCRG), and the Health Behaviour Research Group (HBRG), involving behavioural scientists, statisticians, medical general practitioners and specialists, dieticians, biologists, psychologists, computer scientists and software engineers at the University of Newcastle to provide all of the desirable features presented in this paper.

4.1 Design

The survey server is structured using three communicating components: the survey definition component; the survey generation component; and the storage system, which provides a receptacle for survey definitions and responses using an SQL database (Oracle, 2012).

The fundamental unit from which surveys are constructed is the *survey object*; each of these objects specifies either: a question; an information screen that may include text enhanced by sound, picture or movie content; a branching rule; a non-displaying calculation; or a wrapper that conditionally aggregates a number of survey objects into a single unit termed a *meta object*.

Survey objects can be created in any order. They are then imported into the survey and can be rearranged as required. The only restriction is that calculation, branching, or dynamic objects must be placed after any survey objects they reference. Each survey object has a unique identifier in the survey context. Survey objects are ordered in the knowledge that navigation is sequential unless the sequence is over-ruled by implementation of a branching rule.

Once a survey has been defined, it is executed using the survey-generating component, which can operate in either *preview* or *user* mode. The generation component executes a cycle; it extracts each next survey object from the database; interprets the object and takes the appropriate action (i.e. renders a survey screen, calculates and applies a branch condition, or calculates and returns a value); records timing information; and if appropriate, stores the participant's response and timing data.

4.2 Implementation

An enhanced version of QuON that engrosses the features suggested in this paper has been implemented; see (Henskens et al., 2014) for details including screen shots and evaluation. It uses a typical Model-View-Control (MVC) approach (Krasner and Pope, 1988) as provided by CakePHP (Cake Software Foundation, 2012). It utilises Web standards so that the same survey can be presented on different devices such as computers, tablets, and smart phones. To the extent possible, QuON also conforms to the W3C Web Content Accessibility Guidelines 2.0 (Caldwell et al.), though complete compliance is dependent on the question content entered by researchers.

QuON is covered by the open source MIT licence, so programmers can easily add new question types by creating new CakePHP *Helpers*, which define the attributes survey designers (researchers) are allowed to

specify, how the question should be displayed, how responses should be validated, and how responses are stored.

Support is provided for easy inclusion of customised Cascading Style Sheets (CSS) to change the appearance of survey screens, and to specify different styles for mobile and non-mobile devices. Customised Javascript (Arnold and Gosling, 2000) is also possible, allowing researchers to implement custom client-side logic on the participants' devices while they are taking a survey.

5. CONCLUSION

This paper discusses the features of a good survey and possible survey applications; and presents a Web-based survey generation system architecture that delivers these features in a convenient and safe environment. The system provides all the building blocks necessary to create a fluid survey that 'learns' from and adapts to previous answers. Researchers, who are not required to have programming knowledge, can assemble these blocks or objects, allowing them to construct customised surveys to meet their specific needs.

Surveys can be developed from scratch, modified, or reassembled from sections of one or more previous surveys. This flexibility, ease of use, participant specificity and provision of individual feedback make the presented system architecture unique and very attractive to any researcher seeking customer preferences and opinions.

Such a survey system has been implemented by the authors, and is called QuON. The initial version of QuON may be downloaded from <http://code.google.com/p/quon/> and can be freely used as a basis for development of advanced survey systems. The authors use such an enhanced QuON system that implements all the question types and features presented in this paper. They continue to work with survey-intensive researchers in a quest to identify and provide the most complete set of survey question types. For example, we recently learned of a need for a question type that allows a partitioned diagram to be displayed so that the survey client can select one or more of the regions using a touchscreen or mouse. The selected region(s) would be indicated by a change in fill colour or shading; the new question type will support questions such as 'On the body image, select the areas in which you feel pain'.

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