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A Comparison Between Mail and Web Surveys: Response Pattern, Respondent Profile, and Data Quality

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This study reports results from a mode comparison between mail and web-based surveys, for the latter of which emails were used as a form of cover letter. Two samples of 1,000 target respondents were randomly selected from a university student population, and identical mail and web surveys were respectively administered to each of these samples. Findings of this study revealed some of the opportunities and limitations that web surveys have. The web survey had significantly smaller turnaround time, but it had a lower response rate, both overall and for each of three mailings attempted. Interestingly, the advantage of the mail survey over the web survey in response rate seemed to become greater as repeated mailings were attempted. The web survey was found to have lower item nonresponse and longer open-ended responses. Younger, male, avid Internet users, and those with greater technological sophistication tended to be over-represented in the web survey.

Key words: Survey mode effects; electronic survey; Internet survey; response rate.

1. Introduction

With the number of Internet users having increased very rapidly since its introduction, the applicability and significance of this new technology has become of great importance to many public opinion researchers (Couper 2000). Internet-based surveys via email or the web have brought many important advantages, including reduction in research costs and efficient survey administration in terms of time and resource management (Kiesler and Sproull 1986; Oppermann 1995; Parker 1992; Schaefer and Dillman 1998; Schmidt 1997; Schuldt and Totten 1994; Smith 1997; Weible and Wallace 1998). Notably, recent interest in Internet-based surveys has been well reflected in the proliferation of firms and services specializing in online research (Kirkwood 1999; Mosley-Matchett 1998; McCullough 1998).

Given the practical benefits associated with Internet-based surveys in general and web surveys in particular, as well as the expected wider application of this technology in future survey research, it is important and indeed necessary to understand benefits and limitations this newer method brings to public opinion research. As previous studies have suggested (Kiesler and Sproull 1986; Schaefer and Dillman 1998), the utility of web surveys may be best assessed by analyzing its comparability to other traditional survey methods.

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This study reports results from a mode comparison between mail and web-based surveys. Two samples were randomly selected from a university student population for which a comprehensive population list of email addresses existed, and identical mail and web surveys were respectively administered to each of these randomly selected samples. These procedures allowed this research to eliminate the effects of coverage error in examining survey mode effects. We employ the terms ''mode effects'' and ''mode comparison'' in a broader sense such that a mode is defined not only by the method of survey delivery, but also by design characteristics and differences inherent to a particular survey technology (e.g., interactive features in the web survey automatically skip unnecessary questions). This broader definition is necessary for this study, because technological innovations and resultant differences in questionnaire configuration are defining characteristics of web surveys.

Three broad areas of inquiry were attempted on the mode comparison between mail and web surveys: response pattern (response rate and response speed); respondent profile (demographic and technology-related characteristics); and data quality (item nonresponse and length of open-ended responses). Given that the interest in web surveys is a relatively recent phenomenon and that there is much functional similarity between web and email surveys, we incorporated the literature on email surveys in conducting this study.

2. Literature Review

2.1. Response pattern

In the literature, two aspects of response pattern have been intensively compared between mail surveys and electronic surveys, including web-based surveys: response rate and response speed. Past studies have generally reported that electronic surveys produce a lower response rate than traditional mail surveys, with the advantage of mail surveys over email or web surveys ranging from 8% to 37.2% (Couper, Blair, and Triplett 1999; Kiesler and Sproull 1986; Schuldt and Totten 1994; Tse et al. 1995; Weible and Wallace 1998; cf. Parker 1992; Schaefer and Dillman 1998). Notably, recent studies that compared web surveys with traditional mail surveys among populations with little coverage error have reported higher response rates for web-based surveys (Guterbock, Meekins, Weaver, and Fries 2000; for a general review of web-based surveys, including possible reasons for lower response rates in such surveys, see Couper 2000).

However, past evidence has suggested that email or web surveys fare better than mail surveys in terms of response speed, or the time required for a survey to be returned (Kiesler and Sproull 1986; Schaefer and Dillman 1998; Schuldt and Totten 1994; Tse et al. 1995; Weible and Wallace 1998). In electronic surveys, transmission time required to deliver and return a survey is virtually eliminated, which should decrease the turnaround time (Schaefer and Dillman 1998). Also, *after* completing the questionnaire, respondents for mail surveys may have greater burden in returning the survey than those for electronic surveys. Mail respondents need to perform trivial but necessary tasks to return the survey, such as enveloping and mailing, which may hinder a prompt return after completion; in contrast, web respondents only need to click a ''Send'' button. In addition, mode differences may dictate responding behavior by affecting a sense of time. Because of such characteristics of communication via the Internet as spontaneity and interactivity,

prospective respondents may be accustomed to providing instant feedback to Internet-relayed messages (e.g., emails) and may consequently perceive a quick response to an electronic survey as a norm.

Consequently, this study expects a faster response speed from the web survey than the mail survey. In other words, the average number of turnaround days is expected be smaller for the web survey as compared to the mail survey.

Although multiple contacts have been acknowledged as an important way to improve response rates (Dillman 2000; Kittleson 1997; Schaefer and Dillman 1998), few studies have examined to what extent follow-up mailings alter the comparison between electronic surveys and mail surveys in respect to response rate and response speed. In some studies, the number of mailings was not equivalent across modes (Schaefer and Dillman 1998) and in other studies that attempted an equal number of multiple contacts, detailed wave-by-wave analysis was not done (Weible and Wallace 1998). In other studies, while a follow-up emailing was found to significantly improve response rate, comparable statistics for mail surveys were not available (Kittleson 1997; Oppermann 1995). In short, it is yet to be known how repeated attempts to reach respondents comparatively influence mail and web surveys.

2.2. Respondent profile

Studies on new technology adoption help understand whether demographic characteristics of web respondents are comparable to those of traditional mail respondents. These studies show that the adopters of computer technology and the Internet tend to be more affluent, better educated, and younger than nonadopters (Atkin, Jeffres, and Neuendorf 1998; Dickerson and Gentry 1983; Dutton, Rogers, and Jun 1987; Lin 1998). At the introductory stage, males were clearly more likely to be adopters of the new technology (Reissman 1990), but recent studies have evidenced that gender equality in this area is beginning to emerge (Atkin et al. 1998; Lin 1998) and that gender differences are more a matter of the *intensity* of new technology usage than of the *adoption* of it (Bucy 2000).

While these findings have a direct implication for the issue of coverage error and the validity of electronic surveys involving the general public, they also have relevance to surveys that do not have the problem of coverage error. As compared to Internet usages such as emailing and surfing, electronic surveys are certainly one of the newer Internet applications (Beniger 1998; Stanton 1998). At this early stage of electronic surveying, just as observed in the technology adoption research, we may expect that even among Internet users some groups will tend to be more open to this application. Furthermore, we may expect that those demographic groups who were more likely to be early adopters of Internet technology should be more willing to participate in a survey that is based on that technology. Supporting these expectations, Couper et al. (1999) reported that males and those with more education were more likely to respond by e-mails than by mail in their study of government statistical agencies, where all the employees had access to the Internet. In sum, this study expects that those who are disposed toward adopting new technology to a greater degree, such as males, the younger, and the more educated, are more likely to be over-represented in the web survey than in the mail survey.

Some researchers have reported findings that suggested that potential respondents'

technology-related uneasiness – e.g., computer anxiety–or perceived difficulty in completing an online questionnaire may be responsible for lower response rates in electronic surveys (Bertot and McClure 1996; Brosnan and Davidson 1994; Kittleson 1997; Sexton, King, Aldridge, and Goodstadt-Killoran 1999; Zhang 2000). A direct test of this thesis may be to examine the levels of technological sophistication of the respondents of the web and mail surveys. If technology-related factors are a cause of relatively lower response rates in electronic surveys, we may expect various technological indexes to be higher among web respondents. This will demonstrate that those with a lower degree of technological expertise may have been reluctant to answer questions online, as other studies have suggested (Bertot and McClure 1996; Kittleson 1997; Schuldt and Totten 1994; Zhang 2000). Thus, this study expects that web respondents are more likely to be technologically ''advanced'' than mail respondents.

2.3. Data quality

One of the most frequently employed criteria of comparative survey quality is item nonresponse, or conversely, item completion. Item nonresponse occurs when respondents fail to answer questions that they are supposed to respond to. When the average number of questions respondents leave unanswered is small, then this is regarded as an indicator of good survey quality. (Couper et al. 1999; Schaefer and Dillman 1998; Stanton 1998). Because of their convenient format (Schaefer and Dillman 1998) and interactivity (Kiesler and Sproull 1986), both of which are assumed to increase respondents' attention to survey questions, electronic surveys have been expected and found to have a lower rate of item nonresponse (Kiesler and Sproull 1986; Schaefer and Dillman 1998; Stanton 1998). For example, in contrast to other self-administered surveys, web-based surveys can implement various interactive features that allow complex skip patterns to appear seamless to respondents and make it possible to validate responses by utilizing an instant feedback function while respondents are still online (Schaefer and Dillman 1998; Schmidt 1997).

Open-ended questions as well as closed-ended questions have been found to generate a lower rate of item nonresponse in email surveys (Schaefer and Dillman 1998). Although some past studies reported inconsistent findings (Tse et al. 1995; for a review, see Schaefer and Dillman 1998), systematic and extensive analyses in recent studies lead us to expect that the web survey will have a lower rate of item nonresponse than the mail survey.

Schaefer and Dillman (1998) assumed that longer responses to open-ended questions would indicate detailed responses, which contribute to the quality of a survey method. Some survey researchers have assumed that relative ease of typing a longer response, as compared to handwriting, should make electronic surveys generate longer open-ended responses (Schaefer and Dillman 1998). Findings have supported such expectations (Kiesler and Sproull 1986; Schaefer and Dillman 1998). Notably, according to review articles in educational research, the vast majority of studies have found that subjects were more likely to write longer essays when they used a word processor, as compared to paper and pencil (Bangert-Drowns 1993; Cochran-Smith, Paris, and Kahn 1991; Hawisher 1989; Wolfe, Bolton, Feltovich, and Bangert 1996). Ease of identifying and rectifying mistakes, improved concentration, and more physical comfort from using a keyboard than a pencil or a pen were among the reasons for longer word-processed

responses (Baer 1998). Accordingly, this study expects that the web survey is more likely than the mail survey to produce longer responses to open-ended questions.

3. Study Design

For this study, two separate samples of 1,000 students at a large university in the U.S.A. were selected on the basis of a random selection of the last four digits of their social security numbers. All students were eligible for selection in the survey, regardless of undergraduate or graduate, full- or part-time status. Every student was eligible for the mail mode since every student had a registered postal address in the university database; thus, the mail sample of 1,000 students could be directly selected from the total student population. However, since it was known that not all students registered their email addresses, respondents for the web survey were oversampled. Of the 2,669 student records initially sampled, 96% had email addresses. Of these students, a random sample of 1,000 was selected.

Though drawn from the same student population, the two samples selected for the surveys were not strictly comparable, because the frame for the web survey sample was restricted to those with registered email addresses. This necessitated some adjustment before conducting analyses, because findings might otherwise simply reflect the difference in the definition of target respondents between these two samples. As a solution to this problem, all target respondents without registered email addresses were removed from the mail sample; as a result, 45 sample points were excluded from the analyses, including 13 respondents. This adjustment ensured that this study would have equivalent samples drawn from the same population and that differences between the surveys uncovered by subsequent analyses could be attributed to mode effect.

A questionnaire was developed to meet the research needs of the Division of Information Technology at the university, the sponsor of this research. The questionnaire, which concerned students' use of computing and Internet technology, was laid out in four general sections, each dealing with a particular topic area so that related items were in proximity to each other. A booklet-size questionnaire was used for the mail survey, as has been used in previous years' research. For the web survey, using *Active Server Pages* software, the questionnaire was posted online. The questionnaire's website consisted of 20 pages, each with a ''continue'' button at the bottom. These continue buttons were inserted after questions where it was necessary for the server to determine which page the respondents were next presented (e.g., after screener questions, to check whether respondents answered correctly, etc.). The purpose of splitting the questionnaire into separate pages was twofold: first, it made downloading each page much quicker than downloading the entire questionnaire on one page; and second it allowed the use of screener questions and skip patterns so that respondents skipped questions irrelevant to them. For example, if a respondent indicated they did not own a computer, they were not asked questions regarding types of a computer owned and were instead presented with the next appropriate question. Most of the pages in the web survey consisted of one to three questions. However, the mail and online questionnaires were identical in their contents–question wording, sequence, and skip patterns.

A cover letter was sent to both groups. For the mail survey, this was sent along with

the questionnaire in each mailing. For the online research the cover letter took the form of an email, explaining the purpose of the survey and how to connect to the survey web site. The web site's Universal Resource Locator (URL) was listed in the email. While all respondents were referred to the same web site, each individual URL address had a unique random number, or ''key,'' attached to it. This ensured that only those respondents with the correct key could access the site. It also operated as a check against respondents filling out the survey more than once since they were assigned one case in the database, which corresponded to their key. Respondents were also allowed to suspend the survey and return at another time to complete it. Only 14 individuals began the survey and failed to complete it. There was no systematic dropoff through the questionnaire. It took individuals on average twelve minutes to complete the survey (s.d. = 5.5 minutes). The minimum and maximum completion times were 4 and 41 minutes.

In order to ensure that differences between survey methods in item nonresponse were not an artifact of differential data entry procedures between surveys, we adopted the identical coding system for both open- and close-ended questions. A coding system for the mail survey was first developed, and we then applied the coding system to the web survey; this procedure resulted in the same operational definition of item nonresponse for both surveys.

One initial mailing/emailing was sent to all respondents in both groups on February 18, 1999. Two follow-up mails/emails were sent to non-respondents on March 15 and April 5. Both modes reminded respondents of the survey and encouraged them to complete it. Each email cover letter included the respondent's URL, which was identical during the study, and every mail follow-up included a replacement questionnaire. All cover letters mentioned an incentive designed to boost response. This incentive was a drawing in which all respondents would be entered for a chance at one of four 50 USD gift certificates to the campus computing retail center. A total of 13 emails and ten mail questionnaires were returned undeliverable. These undeliverables were excluded in the computation of response rates.

4. Results

4.1. Response pattern

In order to examine whether there was a significant difference in response pattern between the mail and the web-based survey, the response rate and response speed were analyzed overall and for each mailing. When the response rate for each round of questionnaires was computed, those who had responded to a prior survey were excluded from the baseline. Thus, these response rates indicate the percentage point unique to each wave. Response speed refers to the number of days required for a completed survey to be returned. In other words, we counted the number of days taken for each survey to be returned, starting from the day of the mailing to which respondents responded. Overall response speed refers to the average number of days taken by all the completed surveys after the respective mailing dates.

As expected, findings show that the mail survey generated a higher response rate, and web respondents returned their questionnaire more quickly (see Table 1). Overall, 42.5% of mailed surveys were returned, as compared to 27.4% for the web survey ($\chi^2 = 49.07$; $p < .001$). However, the web survey was found to have a clear edge over the mail survey

Table 1. Comparison between mail and web surveys: Response rates and response speed

	Mail	Web	Test-statistics
Response rate			
Overall	42.5% (402)	27.4% (270)	49.07***
Initial mailing	24.2% (229)	18.1% (179)	10.78***
1st follow-up	14.1% (101)	7.5% (61)	17.18***
2nd follow-up	11.7% (72)	4.0% (30)	28.80***
Response speed			
Overall	9.0 days	2.2 days	−20.89***
Initial mailing	9.3 days	2.2 days	−17.49***
1st follow-up	9.0 days	2.4 days	−10.09***
2nd follow-up	7.7 days	1.7 days	−6.50***

Notes.
1. When response rates were computed, cases with invalid postal or email addresses were excluded. Also, excluded from the mail survey analysis were 45 cases without email; among those 45 cases, 13 respondents sent back their questionnaires. Consequently, the final target sample sizes employed in the analyses were 945 and 987 for the mail survey and the web survey, respectively.
2. Actual number of questionnaires returned at each mailing is in the parentheses.
3. Test-statistics for response rate were obtained from χ^2 tests and those for response speed were obtained from *t* tests.
*** $p < .001$.

in terms of overall average number of turnaround days ($t = -20.89$; $p < .001$), with the web survey being more than four times faster than the mail survey (9.0 days vs 2.2 days).

Table 1 also shows results concerning the relationship between repeated mailings and comparability between the two survey modes. Findings indicate that across all three mailings, the mail survey maintained a significantly greater response rate than the web survey. However, when the relative ratio is compared, the gap in the response rate between the two methods tended to become gradually wider as additional mailings were attempted. While for the initial mailing, the mail survey produced 1.3 times greater response rate (24.2%/18.1%; $\chi^2 = 10.78$, $p < .001$), the response rate of the mail survey was 1.9 times greater for the first follow-up (14.1%/7.5%; $\chi^2 = 17.18$, $p < .001$) and almost three times greater for the second follow-up (11.7%/4.0%; $\chi^2 = 28.80$, $p < .001$). When incremental contribution of each mailing to the overall response rate was analyzed, an identical pattern emerged. For the first follow-up, the mail survey generated a response rate of 10.7% (101/945), which is 1.73 times greater than 6.2% (61/987), the response rate of the web survey. For the second follow-up, the response rate of the mail survey was more than 2.53 times greater (7.6% vs 3.0%).

In terms of response speed across repeated mailings/emailings, the web survey was found to be consistently four times faster than the mail survey (*t*-values range from −6.50 to −17.49; for all *p*'s $< .001$), thereby showing that the gap in response speed between the modes barely changed over the course of follow-ups.

4.2. Respondent profile

We also attempted to assess the comparability between the two survey modes in regard to various respondents' characteristics. Table 2 reports related results. Out of three

Table 2. Comparison between mail and web-based surveys: Demographics and technology-related characteristics

	Mail	Web	Test-statistics	N
Demographic characteristics				
Gender (% female)	59.6%	49.6%	2.55*	663
Year in school	3.52	3.38	−1.21	664
Age (years)	24.46	23.42	−2.01*	662
Technology-related characteristics				
Computer ownership	78.6%	78.5%	.00	672
Internet use (hours)	10.35	12.88	2.63**	664
Internet service familiarity				
Basic services	7.04	7.00	.31	670
Advanced services	1.31	1.55	2.32*	671

Notes.
1. Test-statistics for gender and computer ownership were obtained from χ^2 tests and those for the other measures were obtained from t tests.
2. Response categories for year in school are 1 Freshman; 2 Sophomore; 3 Junior; 4 Senior; and 5 Graduate students.
3. Basic Internet service familiarity and advanced Internet service familiarity scores are based on awareness and use measures for four and two Internet services, respectively. Respondents were given ''1'' or ''0'' depending on whether they were aware of or had used each service. Thus, the composite indexes range between zero and eight for basic service measures and between zero and four for advanced service measures.
* $p < .05$; ** $p < .01$.

demographic characteristics analyzed, gender and age were found to be significantly different between the surveys, with the web survey involving fewer female respondents (49.6% vs 59.6%; $\chi^2 = 6.47, p < .05$) and younger respondents (23.42 years vs 24.46 years; $t = -2.01, p < .05$). Given similar findings in Internet adoption studies, these demographic differences indicate that respondents who were more likely to be adaptive to new technologies were overrepresented in the web survey.

Table 2 also compares technology-related responses between the two survey methods: computer ownership, Internet use, and Internet service familiarity. Respondents were separately asked to report whether they owned a desktop computer, a laptop computer, and/or a work station. Responses were dummy-coded so that those who owned each type of computer were differentiated from those who did not. Internet use indicates the average number of hours per week respondents spent connected to the Internet during the current academic year.

Familiarity with Internet services refers to whether respondents were aware of various Internet services provided on campus and had used those services during the current semester. Responses to six Internet services were examined: electronic library, email, FTP, web browser, newsreader, and electronic student records, with respondents separately indicating their awareness and use of each service. A factor analysis with principal component extraction and oblimin rotation was conducted for a total of twelve awareness and use measures. A two-factor structure emerged, with 51.2% of the total variance accounted for. The first factor represents familiarity (i.e., awareness and use) with basic Internet services (i.e., electronic library, email, web browser, and electronic student records), which are easily accessible to and utilized by average students. The second factor

Table 3. Multivariate analyses of technology-related respondents' characteristics

	Computer ownership	Internet use	Internet service familiarity	
			Basic	Advanced
Control variables				
Age	.31***	.02	−.09	−.02
Gender (Hi: female)	−.03	−.15***	.03	−.30***
Year in school	−.01	−.16***	.02	.24***
Survey mode (Hi: Web)	.04	.08*	−.01	.08*
R^2	9.3%***	5.1%***	0.7%	16.3%***
N	658	653	656	657

Note. Entries refer to standardized final regression coefficients.
* $p < .05$; ** $p < .01$; *** $p < .001$.

is composed of advanced services (i.e., FTP and newsreader) that are more likely to be apprehended by experienced users. Hence, the first factor was labeled as ''basic Internet service familiarity,'' whilst the second factor was labeled as ''advanced Internet service familiarity.''

The mail and web surveys were found to be different on some technology-related respondent characteristics. As shown in Table 2, whereas there were no significant differences in basic characteristics such as computer ownership and basic Internet service familiarity between the two survey modes, time spent using a computer for online activities (i.e., Internet use; 12.88 vs 10.35 hours; $t = 2.63$, $p < .01$) and fluency in advanced Internet technology ($t = 2.32$, $p < .05$) were found to be greater among the web respondents. These findings suggest that technology-related reasons may have been partly responsible for the gap in response rates between the modes by discouraging some of those with less expertise in Internet use from participating in the web survey.

Although findings in Table 2 showed significant technology-related differences between the mail and web respondents, it is plausible that the relationships observed may be spurious due to the differences in demographic composition of the modes. For example, given the greater technological disposition of male respondents (Miller 1996), a greater level of Internet expertise of the web respondents may not indicate differences between the modes, but may be simply an outcome of the web survey having a greater proportion of male respondents. To clarify this issue, a series of multiple regressions were run, which aimed to test whether differences in technology-related characteristics between web and mail respondents existed even after controlling for the influence of key demographic variables (Table 3). Findings from this multivariate analysis showed that there were indeed differences in demographic composition between the two modes, with each demographic variable significantly influencing two technological characteristics examined. More important, however, the results replicated the earlier zero-order findings such that the dummy-coded survey mode measure was significantly related to Internet use ($\beta = .08$, $p < .05$) and familiarity with advanced Internet services ($\beta = .08$, $p < .05$) after taking into account a significant contribution of gender and year in school.

4.3. Data quality

Two criteria of data quality, item nonresponse and length of open-ended responses, were employed in this study. Item nonresponse concerns the extent to which the respondent failed to give a valid response to individual survey questions presented to them. The overall number of items each respondent failed to respond to was computed. Length of open-ended responses refers to the number of words the respondent gave for five open-ended questions that were included in the survey. Findings are shown in Table 4.

Overall, as compared to web respondents, mail respondents tended to leave a significantly greater number of questions unanswered ($t = -3.49$, $p < .01$). For closed-ended questions, the mail survey was twice as likely to generate non-response to survey items ($t = -3.91$, $p < .001$). Such a difference was not observed for open-ended responses; results indicate that there was little difference between the survey modes concerning to what extent respondents left open-ended questions incomplete.

Among those who provided an answer to open-ended questions, however, the web respondents tended to write a longer response. As can be seen from the findings reported in the bottom panel of Table 4, in four out of five comparisons the average number of words in completed open-ended responses on the web survey was about two to four times greater (t-statistics range from 4.40 to 5.47, all p's $< .001$). One exception was the last question of the survey (i.e., Question 31), which asked respondents to freely provide any additional comments; on average, the mail survey generated a longer response ($t = -2.23$, $p < .05$).

Findings in Table 4 were re-tested by a series of multivariate analyses, in order to guard against the possibility that the observed differences were the outcome of spurious relationships. In particular, given the topical nature of the survey (i.e., Internet use and computing on campus), there is a possibility that more complete and detailed responses of web respondents may have been a consequence of greater interest in technology among web respondents – which is inferred from their demographic or technology-related characteristics – rather than of survey mode.

Table 4. Comparison between mail and web-based surveys: Data quality

	Mail	Web	t-statistic	N
Item nonresponse (average number of items unanswered)				
Overall	2.47	1.98	−3.49**	672
Closed-ended	.60	.23	−3.91***	672
Open-ended	1.87	1.75	−1.27	672
Length of open-ended responses (average number of words)				
Question 4	5.90	19.03	4.40***	66
Question 15	9.31	17.43	5.47***	388
Question 18	5.38	11.17	5.00***	267
Question 21	6.38	11.21	3.73***	240
Question 31	26.30	18.96	−2.23*	226

Notes

1. The average number of words for open-ended questions is for completed responses.
2. Questions 4 and 18 are follow-up questions to skip questions, to which 83 and 299 respondents were expected to respond. For the other open-ended questions, all respondents (672) were asked to answer.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Table 5. Multivariate analyses of data quality

	Item nonresponse			Length of open-ended responses				
	Closed-ended	Open-ended	Overall	Q4	Q15	Q18	Q21	Q31
Control variables								
Age	.17**	−.05	.06	−.07	.17**	.14#	.08	.25**
Gender (Hi: female)	.03	.05	.06	.08	.07	.10#	−.04	.13#
Year in school	−.06	−.03	−.06	.03	.01	−.08	.08	−.01
Computer ownership	−.14***	.04	−.06	.02	−.02	−.10	−.05	−.02
Internet use	−.06	−.04	−.07#	.08	.01	−.02	−.01	.18*
Internet familiarity								
Basic	.03	−.04	−.01	−.17	.08	−.04	−.06	.06
Advanced	.01	−.02	−.01	.26#	−.04	.10	.05	−.03
Survey mode (Hi: Web)	−.24***	−.07#	−.19***	.54***	.29***	.29***	.24***	−.11
R^2	10.3%***	1.7%	6.1%***	30.9%**	11.4%***	10.8%***	8.5%**	11.5%***
N	651	651	664	62	379	262	234	221

Note: Entries refer to standardized final regression coefficients.
#$p < .1$; *$p < .05$; **$p < .01$; ***$p < .001$.

Indeed, as shown in Table 5, some demographic and technology-related characteristics such as age and Internet use were significantly related to the data quality measures. After the control, however, the web survey was still found to have fewer items incomplete than the mail survey for closed-ended questions ($\beta = -.24$, $p < .001$) and overall ($\beta = -.19$, $p < .001$). The consideration of control variables made the completion rate of open-ended responses on the web survey marginally greater than that of the mail survey ($\beta = -.07$, $t = -1.66$, $p < .10$). Just as reported in Table 4, each of the first four open-ended questions in the web survey was found to produce a significantly longer response (β's range between .24 and .54, all p's $< .001$), but the mail survey failed to maintain a significant edge over the web survey for the final question when all the other variables simultaneously considered ($\beta = -.11$, $t = -1.59$, $p > .10$).

5. Discussion

The findings of this study revealed some of the opportunities and limitations that web surveys have, compared to traditional mail surveys. Each survey method was found to have its own advantage in response pattern, with the mail survey generating a higher response rate and the web survey being accompanied by a faster response speed. In respect to data quality, the web survey emerged with more desirable attributes, such as lower item nonresponse and longer open-ended responses; these differences remained even after demographic and technology-related characteristics were controlled for. Overall, the younger, male, avid Internet users, and those with greater technological sophistication were over-represented in the web survey.

Results of this study also demonstrated that the advantage in response rate of the mail survey over the web survey seemed to become greater as repeated mailings were attempted. That is, while repeated contacts with respondents increased the overall response rate for both survey modes, the effectiveness of follow-up mailings in encouraging respondents' cooperation trended lower over time for the web survey. These findings strongly suggest that strategic efforts are needed in administering the multiple contact method for web surveys in order to maintain an acceptable response rate. One option may be to utilize a mixed mode method by employing such methods as sending a postcard reminder between emailings, which has been suggested by past studies (Schuldt and Totten 1994; Schaefer and Dillman 1998).

In addition, future studies need to inquire into the timing of follow-ups for web surveys. While suitable for the purpose of the present study–a comparative analysis of follow-up mailings with the interval between mailings controlled for–the interval of several weeks between mailings may not be optimal for web surveys. Given the significantly faster response speed for the web survey and recommended design principles for e-mail surveys (Dillman 2000, pp. 367–368), it is plausible that a shorter interval would have been more effective for the web survey in encouraging respondents to complete the survey. According to a recent study of a web survey (Crawford, Couper, and Lamias 2001), an experimental group that received a reminder two days after the initial invitation indeed demonstrated a higher – albeit modestly – response rate than the other group that received a reminder five days after the invitation.

Although this study found differences in demographic characteristics between web and

mail respondents, such demographic discrepancies between the survey modes may be a transient phenomenon. Assuming that the users of the Internet are not equally comfortable with or capable of using new Internet technology, just as they were not originally so when adopting the Internet, this study reasoned that the nature of web surveys as a newer Internet application would lead to differences in respondents' demographics between the modes. However, if recent Internet adoption trends of lowering demographic barrier are any indication (Pew Research Center 1999), the demographic discrepancies between the Internet and traditional surveys are expected to significantly decrease in the near future. In fact, findings of this study suggested that very direction by demonstrating that technology-related differences between respondents of the survey modes existed only in regard to advanced areas (e.g., awareness of advanced Internet technology) rather than elementary characteristics (e.g., computer ownership).

As for the length of open-ended responses, findings overall documented the existence of a mode effect. However, the advantage of the web survey over the mail survey was not robust, which suggests that not only the survey mode, but also other factors may have affected the degree to which the web survey generated lengthier responses for open-ended questions. Upon close examination of the question that did not favor the web survey in terms of the average number of words provided by respondents (Question 31; see Tables 4 and 5), we found that for this question mail respondents were offered more than three linear feet of writing space. This writing space is considerably larger than that for other questions, which ranged only between four and ten inches. In addition, Question 31, as the last question of the survey, allowed the respondent to freely provide any comments regarding the topics of the survey; in contrast, the other questions were applicable only to a sub-group of respondents, who were pre-selected by a prior filter question, and thus limiting in terms of the scope of the responses expected.

Given such differences, we reasoned that respondents in the mail survey may have taken differences in question layout and wording as cues in determining what an ''appropriate'' response was. Thus, when presented with Question 31 mail respondents may have risen to the occasion and consequently been more verbose than they were when responding to other questions. Our reasoning, which cannot be more than speculative in light of current findings, suggests that the simple conclusion that the electronic survey produces longer open-ended responses may need to be qualified. Future studies need to employ experimental manipulations so that we can have better understanding of the degree to which survey mode, survey design, and question wording each affects the detail of survey responses.

It should not be all that surprising that the mail survey tended to generate more item nonresponse than the web survey. One of the stated strengths of using the web for survey research is the control and direction it affords the researcher. For example, the burden to the respondent in following the various skip and branch directions is somewhat substantial for the mail respondent. For the web respondent, all the skip and branch patterns are programmed in, and the individual need only submit his or her response in order to be taken to the next appropriate question. In addition, a web survey can be programmed to check for accuracy or completeness of answers. For instance, in this research respondents were asked how they would allocate a hypothetical 100 USD across a variety of new or improved computing services. The server software checked if their allocations

summed to 100 USD. If not, subjects were presented with the same page with a message in red explaining that their answer was inaccurate and asking them to review it. These interactive features show that the web survey applies some of the primary strengths of CATI in a self-administered context.

From a practical perspective, the greatest strength that web surveys possess–the cost savings without any sacrifices of time – will hasten their adoption by practitioners. Unlike mail surveys there are no postage or data entry costs associated with web surveys, and the number of follow-up contacts is not limited by the research budget. And unlike telephone surveys, one need not pay exorbitant telephone bills to conduct a web survey. On this research project, with the chief deliverable product being a finalized, cleaned dataset, the cost of delivering the web data set was less than one-fourth of the cost for the mail data set.

While the rapid increase in Internet population will reduce the degree of coverage error, developing a scientific sampling methodology for Internet surveys may be a bigger challenge, which can limit the application of Internet surveys to populations with well-defined contact information via the Internet. Even among those populations, technology-related factors, various contextual constraints, and privacy concerns may have an effect on whether or how target respondents respond to an online questionnaire (see Couper 2000; Dillman 2000; Kaye and Johnson 1999). For these issues, future researchers can employ various manipulations in their studies and analyze the effects on Internet surveys, including emphasizing the ease and time-efficiency of the survey in email cover letters; allowing questionnaire return by mail by setting up a separate web site where respondents can download a printer-friendly version of the survey; and implementing privacy-related information such as researchers' credentials and privacy certification by third parties (Cho and LaRose 1999).

Finally, it should be noted that the generalizability of current findings cannot be assumed until comparable analyses are conducted among non-student populations on non-technological topics. While findings concerning response patterns are similar to those found in other studies investigating technology-related issues among students (Guterbock et al. 2000), it is not clear to what extent these findings are applicable to general populations and to other topics. It is possible that students who tend to be early adopters of new technologies may shed light on where web survey technology is headed; however, continued research efforts in different contexts are clearly needed.

6. Appendix

Question Wording

DEMOGRAPHIC VARIABLES

Age. What is your age?

Year in school. What is your year in school? 1 Freshman; 2 Sophomore; 3 Junior; 4 Senior; 5 Graduate student; 6 Special student. Special students were recoded as graduate students.

TECHNOLOGY-RELATED CHARACTERISTICS

Computer ownership. Which of the following information technology products do you own? (Respondents were asked to check all that apply) Desktop computer (PC or Mac);

Laptop computer (PC or Mac); Work station. ''1'' was coded, if a respondent owned one of these computer products; otherwise, ''0'' was coded.

Internet use. On average, how many hours per week have you spent connected to the Internet since the beginning of fall semester?

Internet service familiarity (awareness and use). Which of the following services are you aware of? Which have you used since the beginning of fall semester? (Respondents were asked to check all that apply) Electronic library (MADCAT); Eudora or Nupop email; FTP or Telnet; Netscape web browser; Newsreader, and Student records (EASI).

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