Is SMS APPropriate? Comparative properties of SMS and apps for repeated measures data collection

Walsh, E.I, & Brinker, J.

The ubiquity of mobile telephones worldwide offers a unique opportunity for bidirectional communication between researchers and participants. There are two ways mobile phones could be used to collect self-report data: via Short Message Service (SMS), or app (mobile telephone software applications). This study examined the comparative data quality offered by SMS and app, when mobile phone type, self-report instrument, and sampling schedule are controlled. One hundred and ten undergraduate students used their own iPhones to complete the same repeated measures instrument on twenty occasions, responding either by SMS or app. There were no differences between SMS and app respondents in terms of response rates, or response delay. However, data from those responding via SMS was significantly less complete than from app respondents. App respondents rated their respondent experience as more convenient than SMS respondents. Though findings are only generalizable to an undergraduate sample, this suggests that researchers should consider using apps rather than SMS for repeated measures self-report data collection.

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Over three quarters of the global population own a mobile telephone (The World Bank, 2012). As either a supplement or replacement to traditional research modes such as telephone or postal surveys, mobile telephones offer an unprecedented opportunity for researchers to communicate with participants in self-report research. Though uptake of mobile technology in self-report research is gaining momentum, there remains little structured investigation into the optimal way to use mobile phones in self-report research (Haller, Sanci, Sawyer, Coffey, & Patton, 2006a). Two of the ways mobile telephones can support self-report data collection are Short Message Service (SMS), and mobile telephone applications (apps).

SMS is a text-only messaging system available on even the most basic mobile telephone handset, and a very common communication method in people's daily lives (ACMA, 2013; Anhoj & Moldrup, 2009; Mackay & Weidlich, 2009). Its widespread nature may provide an important opportunity for researchers to communicate with their participants (Haller, Sanci, Sawyer, Coffey, & Patton, 2006b; Lehman, 2011). Some research using SMS involves sending messages through a mobile handset, but a more common approach is to manage scheduling, sending and receiving of SMS through online databases. Some do this through pre-existing SMS aggregation services (as in Walsh and Brinker, 2012), and others write a computer program of their own to manage the SMS (as in Reimers and Stewart, 2009).

Apps are downloadable software programs that are common to all smartphones (Miller, 2012). They are typically tied to a particular mobile operating system, such as Android or iOS, though there has been a move toward cross-system app compatibility (Ribeiro & da Silva, 2012). There are millions of apps used for different purposes, from communication to games, and many are designed specifically for self-report data collection. With over a thousand self-report survey apps and at least six thousand different health-related apps, use of apps for health and medical research and intervention is gaining traction (Rosser

& Eccleston, 2011). Self-report apps can be designed to mimic the web browsing experience (and thus involve a user experience similar to online surveys), or can have their own aesthetic more in line with mobile telephone interfaces (Kojo, Heiskala, & Virtanen, 2014). Researchers using apps may choose to use pre-existing software, such as iSurvey, or design their own apps to meet their specific research goals (e.g. Fukuoka & Kamitani, 2011; and Morris et al., 2010).

Recognising the global saturation of mobile phones, and the potential use of both apps and SMS as platforms for self-report data collection, it is important to establish how SMS and app compare as a data collection method. Complete and timely responses are important for building a high quality dataset, and so response completeness and response delay are a useful metric for comparing how SMS and app perform as data collection tools. Two sources of data incompleteness are complete non-responses, and item skipping resulting in an only partially complete instrument (Sax, Gilmartin, & Bryant, 2003). Non-responses threaten the total sample size available for analyses (Fox, Crask, & Kim, 1988) and can lead to an unrepresentative portion of a given population being sampled, threatening the validity of research (Flick, 1988). Skipping items can result in small levels of incompleteness. This is problematic because score totals cannot be calculated (Mogensen, 1963), and item missingness causes difficulties for many methods of statistical analysis (van Buuren, 2010).

Meta analyses suggest that the average response rate in academic research is roughly fifty percent (Baruch & Holtom, 2008). This can depend on the specific mode used for data collection, with comparative studies indicating mail surveys obtain a higher response rate than voice calls (Dillman et al., 2009), and online surveys a higher response rate than mail surveys (Cook, Heath, & Thompson, 2000). A comparison of participants responding via app and via paper diary has found a higher response rate in app respondents (Tsai et al., 2007).

Repeated measures research using apps has reported roughly eighty percent response rates (Fukuoka & Kamitani, 2011), suggesting that a relatively high response rate may be expected from apps. Many apps follow the lead of online surveys by prompting participants to complete skipped items, and only allowing them to submit their response when every item in the survey has been satisfactorily completed. For online data collection, some studies have found this has led to significantly less item skipping in online surveys in comparison to paper surveys where no such prompts are possible (Vijver & Harsveldt, 1994), though others have found the opposite (Richardson & Johnson, 2009).

Response rates to research using SMS to communicate with participants vary from twenty percent (Chib, Wilkin, Ling, Hoefman, & Van Biejma, 2012) to one hundred percent (Donaldson, Fallows, & Morris, 2014). SMS has no provision for automatically detecting and prompting participants to complete skipped items in a larger questionnaire, so provides no barrier to incomplete submission. In a comparison of completeness of SMS, paper and online diaries, Lim, Sacks-Davis, Aitken, Hocking, and Hellard (2010) found that participants responding via SMS were more likely to return diaries, but provided more incomplete data, than those responding using paper or online diaries. Together, this literature suggests that data collected via SMS may offer higher response rates, but lower response completeness, than data collected via app.

As the time between an event or experience increases, so does the likelihood of recall bias distorting self-report (Raphael, 1987). Minimising the delay between when a response is required, and provision of that response would likely improve the accuracy of the data. Mode can impact on both how quickly people begin their response, and how long it takes to complete it. For example, web surveys are quicker to complete than paper surveys with the same content (Richardson & Johnson, 2009). Participants tend to respond more promptly when using SMS, in comparison to paper (Asiimwe et al., 2011; Broderick et al., 2012). Response delays in SMS research range from two minutes (Conner & Reid, 2012) up to an hour (Lepper, Eijkemans, Beijma, Loggers, & Tuijn, 2013). Response delays in app research have been around eight minutes (Hofmann & Patel, 2014). Although range and median are informative for forming response delay expectations, they have limited usefulness for direct comparison of the response delays that may be expected when collecting self-report data via SMS and app. To date, no research has directly compared the response delays associated with SMS and app self-report responses.

The way participants perceive a particular research mode can impact upon how they engage with it (Dillman, et al., 2009). Positive perceptions of convenience can lessen the perceived burden of responding (Sharp & Frankel, 1983), and lead to deeper engagement with research, and thus more honest and thoughtful responses (Naughton, Jamison, & Sutton, 2013). Negative perceptions regarding data privacy can be a barrier to using mobile phones for research purposes (Déglise, Suggs, & Odermatt, 2012; Ranney et al., 2014). Reflecting on their participation experience, across a number of studies participants have reported that they felt responding via SMS (Akamatsu, Mayer, & Farrelly, 2006a; Broaddus & Dickson-Gomez, 2013; Lim et al., 2010; Matthews, Doherty, Sharry, & Fitzpatrick, 2008) and app (Fernandez, Johnson, & Rodebaugh, 2013; Marshall, Medvedev, & Antonov, 2008) were convenient and private. To date, there has been no research directly contrasting perceived privacy and convenience of SMS and apps being used for self-report research.

The aim of the current paper is to directly contrast SMS and app in terms of response rate, response completeness, response delay, and participant evaluation of privacy and convenience. Findings will be used to discuss the potentially different utility of apps and SMS for researchers.

Method

Participants

To standardize the response platform, this study was only open to individuals who owned an iPhone One hundred and ten undergraduate students in Australia participated in return for course credit. Aged 17-55 (*M*=22), 58% of participants were female.

Materials

All participants completed a computer administered questionnaire consisting of demographic and mobile ownership questions. This was followed by a short instrument on the topic of mental time travel (the temporal orientation of current thoughts) completed via the participant’s mobile phone. The instrument consisted of six questions requiring a numeric or short open-ended response, with all questions but the sixth being mandatory. Participants responding via app did so via *iSurvey*, those responding via SMS replied using their own phone plans. Upon exit, participants completed a second computer administered questionnaire regarding their participation experience. This consisted of rating the privacy and convenience of their response experience on a three-point scale of poor, neutral, or good.

Procedure

Participation began with a physical meeting with the researcher to complete the first computer administered questionnaire, and to have the protocol explained to them. Because the end user experience can be markedly different even with very similar mobile phones due to different screen sizes, and user interface layouts (Keijzers, Ouden, & Lu, 2008), all participants in the current study responded via iPhone. Those responding via app were guided through the app installation process. The app had the six questions pre-loaded. Those responding via SMS had the six items sent to them via SMS within 30 minutes of the meeting. A test SMS prompt was sent during this meeting to confirm the researcher had the appropriate contact details, and a test run of the six item questionnaire was completed to ensure the task was clear and the mobile systems were functioning correctly.

Due to a limited licensing timeframe associated with the survey app, data collection began with all participants responding via app, then proceeded to use only SMS once that phase of data collection was complete. To minimise the potential for this non-random assignment to bias participant behaviour, participants were not aware upon sign-up whether they would be responding via app or SMS. In the two days following the physical meeting with the researcher, all participants received a total of twenty prompts (ten per day) to complete the short questionnaire. The prompts were sent via SMS to both SMS respondents (who responded by replying to the prompt SMS with their answers) and the app respondents (who responded via *iSurvey*). Upon completion, participants attended a follow-up appointment to complete the second computer administered questionnaire. When required, those who spent money on the SMS aspect of participation were reimburse

Results

SMS and app responses were compared in terms of response completeness and response delay. A *partially* complete response consisted of an attempt of at least one question, a *basically* complete response was an attempt of the five required questions, and a *fully* complete response an attempt of all six questions (where the sixth was specified as optional). To explore whether responses were being provided according to prompts, or participant's own schedule, responses were coded as *extraneous* if their preceding prompt had already received a response.

Descriptively, app respondents provided more full (60% versus 38%) and basic (74% versus 35%) responses than SMS respondents, though partial responses were equivalent across the two groups (74%). A logistic multilevel model was fit, with mode as a predictor of receipt of a full response, which was nested by participant at level 1. A significant level 2 random intercept (*b*(SD)=2.68, 95% CI [2.59, 3.55]) indicated this nesting was meaningful for this comparison. The level 1 model coefficient indicated that there was a significant difference in full response rate between those using an app, and those using SMS, *b*=-2.69, 95% CI [-4.25, -1.98]. The exponent of this corresponds to an odds ratio of 0.067, which can be interpreted as stating that participants using SMS were much less likely to provide a full response than those using an app.

A logistic multilevel model was fit, with mode as a predictor of receipt of a partial response, which was nested by participant at level 1. Both the level 2 random intercept (*b*(SD)=2.824, 95% CI [2.72, 3.83]), and level 1 model coefficient (*b*=-3.42, 95% CI [-5.21, -2.74]) were significant. The model provided an odds ratio of 0.03, that is participants using SMS were significantly but slightly less likely to provide a basic response than those using an app.

A logistic multilevel model was fit, with mode as a predictor of receipt of a partial response, which was nested by participant at level 1. The level 2 random intercept (*b*(SD)=1.90, 95% CI [1.76, 2.69]) was significant, but the level 1 model coefficient indicated that there was not a significant difference between scheduling occasions, *b*=-0.25, 95% CI [-0.99, 0.47].

This pattern of results suggests that while people's likelihood of responding (i.e. providing any response) was not significantly affected by mode, people using an app were significantly more likely to provide complete responses. To investigate this further, percentage of response complete was calculated in terms of how many of the basic questions were attempted when a response was given, with 100% indicating basic completion, (i.e. all five questions had been attempted). Descriptively, apps had a mean completion percentage of 98% (median of 100%), while SMS had a mean completion percentage of 86% (median of 80%). The distribution of percentage completion was negatively skewed and bounded, so a poisson distribution was used for model fitting. The level 2 random intercept was significant (*b*(SD)=2.68, 95% CI[2.59, 3.55]) . The level 1 model coefficient indicated that there was a significant difference between modes, with those using SMS providing lower percentages complete than those using an app *b*=-2.69, 95% CI [-4.25, -1.98]. This supports the assertion that mode is significantly associated with response completeness.

While coding the data, it was clear that SMS respondents were not completing one question in particular as required. When asked to rate their mood on a likert scale, many SMS respondents instead provided a qualitative mood descriptor such as "frustrated" or "bored". Though some manner of response had been provided, this was coded as a missing response as it did not conform to the required response format.

Response delay was evaluated by way of number of minutes between a prompt, and response in minutes, with the shortest delay possible set at one minute. As can be expected given this was a response time variable, this response delay was strongly bounded and skewed. Given that this data shape is theoretically expected, rather than transform the data to meet model assumptions, models were fitted using a poisson distribution. The median response delay for responses completed via app was three minutes, while those completed via SMS was four minutes. A logistic multilevel model was fit, with mode as a predictor of receipt of response delay (in minutes), nested by participant at level 1. Again, the level 2 random intercept (*b*(SD)=0.91, 95% CI [0.87, 1.10]) was significant, but the level 1 model coefficient was not (*b*=0.15, 95% CI [-0.18, 0.51]), indicating that mode did not significantly affect response delay.

Summarized in Table 1, two chi-square tests were completed to explore differences in participant perceptions of convenience and privacy, based on whether they participated by way of SMS or app. While the two groups did not significantly differ in their perceptions of privacy, those using apps were significantly more likely to rate their data collection mode as having “good” convenience than those using SMS.

Table 1. *Ratings of convenience and privacy by mode*

	Counts		Model Properties		
	App	SMS	χ^2	χ^2 power	Fisher's *p*
Convenience					
Poor	1	4			
Neutral	8	18	5.956 *p*=.05	.58	.05
Good	43	36			
Privacy					
Poor	0	2			
Neutral	7	11	2.909 *p*=.203	.31	.24
Good	46	43			

Discussion

This study examined whether app or SMS provided superior data completeness, response delay, and participant evaluation of privacy and convenience. Collecting data by app or SMS did not impact upon whether or not a response was attempted, whether the response was extraneous or a duplicate, or how promptly participants responded. The response rate for SMS and app respondents was equivalent, promisingly exceeding the average response rate in academic research estimated by Baruch and Holtom (2008). However, mode did significantly impact on response completion. Following the same pattern as in Lim et al. (2010), SMS data was significantly less complete than app data. This may be due to two factors caused by the uncontrolled response format of SMS. Firstly, whilst app respondents had fixed forms in which to provide their answers, the free-text nature of SMS responses allowed participants to respond in a non-standard format (i.e. providing qualitative mood descriptors such as ‘fine’ rather than requested Likert ratings). Though participants technically answered the question, this data must be considered missing as it cannot be confidently reconciled with the required numeric format. Secondly, apps offer item skipping prevention akin to online surveys, whilst SMS does not. This allows more accidental response omissions to occur in SMS. Given the almost identical overall response rates, this indicates that data collection via app provides superior data completeness, particularly when the usability of the data is contingent on participants following specific response format instructions.

Minimising response delays minimises potential data distortion due to retrospective recall bias (Raphael, 1987). The median response delay of under four minutes for both modes was consistent with the literature using SMS (Conner & Reid, 2012; Lepper et al., 2013), and was better than what may be expected from the literature using apps. This may be because the current study had a more compressed sampling schedule (ten times in a day) than those reviewed in Hofmann and Patel (2014) (three to seven times in a day), thus engendering a greater sense of rush to respond, lest a late response become a missed response. Another possibility is that the current study sampled only from university undergraduates, a population particularly likely to have their mobile telephones nearby at all times, while the studies in Hofmann and Patel (2014) were a mixture of undergraduates and members of the general population. These short response delays are particularly promising for ecological momentary assessment, where researchers seek to tap transient, current thoughts and feelings, as problems of recall bias are minimised when responses are prompt. These results suggest that either app or SMS may be a viable method of data collection where prompt responses are particularly important.

As in previous research using SMS and apps as a means for communicating with participants, perceptions of the privacy and convenience of both modes were generally positive (Akamatsu, Mayer, & Farrelly, 2006b; Broaddus & Dickson-Gomez, 2013; Lim et al., 2010; Matthews et al., 2008). Here, participants who responded via apps were significantly more likely to rate their data collection mode as having “good” convenience than those using SMS. This difference cannot be due to the response platform (as all participants were using iPhones), or the response schedule (which was randomised), suggesting that something may be more convenient about responding via app than SMS. One possibility is that respondents participating via SMS received the questions in an initial SMS, and only prompts when it came time to respond. This resulted in the questions and the input space for answers being separated, thus necessitating scrolling. Conversely, those responding via app were presented with the questions directly next to answer input. This could be clarified in future research, by sending the full SMS questionnaire on each response occasion, rather than just a prompt referring participants to an earlier SMS containing the questionnaire.

This was the first study to directly compare SMS and app response behaviour for self-report psychological research. The difference between the two response modes was made clear by controlling the demographic to only undergraduate students, and the response platform to only iPhones. However, this limits the generalisability of findings. Further investigation is warranted to see how SMS and apps compare in a wider population sample, likely to own different types of mobile telephones, and importantly, across a wider range of ages. Engagement with mobile telephone differs on the basis of age (Devitt & Roker, 2009; Ling, 2002, 2010), which may in turn impact on the viability of using SMS or apps for data collection with a particular age group. For example, teenagers and young adults use SMS heavily in their daily lives (Charlton, Panting, & Hannan, 2002; Pain et al., 2005), and have experience with apps – only a tenth of individuals aged 18-35 have never downloaded an app (Deloitte, 2013). Conversely, older adults use SMS more sparingly (Lobet-maris & Henin, 2002; Mallenius, Rossi, & Tuunainen, 2007), and almost a third of those aged 65 and over have never downloaded an app (Deloitte, 2013). It would be educative to establish whether the relative efficacy of apps and SMS reflect these differing levels of pre-existing mastery.

This paper directly contrasted SMS and app in terms of response rate, response completeness, response delay, and participant evaluation of privacy and convenience. In a self-report, repeated measures paradigm, apps outperformed SMS in terms of data completeness, and positive participant perceptions of the research experience. All else being equal, this suggests that researchers should consider using apps rather than SMS for repeated measures self-report data collection.

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