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Web-CAPI sequential mixed mode design in a longitudinal survey: effects on participation rates, sample composition and costs

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Non-Technical Summary

There are different ways in which surveys can collect data. These include interviewing people, either face-to-face or by telephone, or asking people to fill in questionnaires themselves, either on paper or online. *Understanding Society* is a survey which has so far relied mainly on interviewing people face-to-face. However, plans are currently being developed to instead ask some of the sample members to complete a questionnaire online.

This paper compares two ways of collecting the survey data. The first is the established method of interviewing people face-to-face. The second involves first asking sample members to complete a questionnaire online and then following up those who do not do so and asking them to be interviewed face-to-face. Sample members are allocated at random to one of the two data collection methods and are then approached using that method for three interviews at annual intervals.

We compare the two methods in terms of the proportion of sample members who complete one, two, or all three of the interviews. We also compare the characteristics of the people who participate with each of the two data collection methods, to see if either produces a better balanced sample than the other. Finally, we compare the costs of the two methods in order to establish the extent of cost savings from introducing the online option.

The conclusions are that the choice of method does not make a difference in terms of either the proportion of people participating or the characteristics of the people who participate. Cost savings could be substantial, however, with the online option included.

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Abstract

Sequential mixed-mode surveys are often now used as an alternative to single-mode interviewer-administered designs, bringing benefits from each mode. We assess the effects of the introduction of a sequential web-CAPI mixed-mode design over three waves of a longitudinal survey in which members were previously interviewed by CAPI. Data come from a large-scale randomized experiment carried out on the *Understanding Society* Innovation Panel. No differences in cumulative response rates are found between the mixed mode design and CAPI design and only minimal differences are found in sample composition. Potential cost savings with mixed modes are evident.

Key words: attrition; total survey error; non-response bias; randomized experiment

JEL classifications: C81, C83

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1. Introduction

Combining different modes within a survey has long been thought to provide opportunities to benefit from the strength of each mode (de Leeuw 2005). Biemer and Lyberg (2003) assert that in U.S.A. and Western Europe mixing modes is now the norm. Since the development of web surveys, mixed mode data collection methods with a web component are increasingly considered as an efficient possibility by many organizations. Indeed, the inclusion of web into a mixed mode design has potentials to reduce costs, increase timeliness, and improve quality/sample composition (Groves and Lyberg 2010; Couper 2011; Kreuter 2013).

The opportunities for mixed mode data collection with web are particularly appealing for longitudinal surveys. Indeed, some of the constraints on implementing mixed mode surveys are reduced in the longitudinal setting, thanks to the diversity of information that can be collected from sample members at the recruitment/first wave. First, collection of contact information for sample members permit gains and cost savings to be made by approaching panel members in the most cost-efficient mode. For example, e-mail addresses can be collected at the first wave to facilitate subsequent invitations to complete web surveys. Second, knowledge about which sample members are more or less likely to respond in which mode allows targeting of particular mode strategies at specific

subgroups, in the framework of adaptive survey design (Lynn 2014; Calinescu and Schouten 2015). Finally, the study of the effects of different mode strategies can take advantage of the wide range of information available for each sample member from previous waves, thus providing a rather unique opportunity to identify detailed characteristics of respondents in different modes.

However, several issues may arise when using web and mixed modes for data collection and these are relevant in the longitudinal context as well. One important issue is related to non-response. Participation is usually low for web surveys (Fan and Yan 2010). The effect on response rates of including web in a mixed mode design is not completely clear, however. Several studies have found a lower response rate with a sequential mixed mode design including web than with the equivalent design without web (Griffin et al. 2001; Janssen 2006; Lagerstrøm 2008; Leesti 2010; Martin and Lynn 2011; Souren 2012), while others have found that adding web to an otherwise single-mode design does not affect response rate (Fong and Williams 2011; Klausch et al. 2015a). Furthermore, it is possible that subgroup differences in response propensity could differ between modes (Groves and Peytcheva 2008; Voogt and Saris 2005). Thus, a mixed mode survey may achieve a different sample composition to a single mode survey. Empirical knowledge on these aspects is rather limited, especially in the context of longitudinal surveys.

Jäckle et al. (2015) report on the effects at one wave only with reference to the same experiment we analyze. They found that individual response rates were lower with the mixed mode design and no subgroup could be identified where the reverse was true. They also found that the mixed mode design resulted in a lower proportion of households in which all individuals responded. We have not been able to identify any other experimental study comparing a mixed mode design including web with a single-mode design at a single wave or across waves of a longitudinal survey.

The possibility of differential measurement error is a very important concern when considering converting a single-mode interviewer-administered survey to a mixed-mode survey including web. Several studies have identified systematic differences in measurement between modes (Bowling 2005) and in some contexts this has been shown to result in measurement differences between CAPI single-mode and web-CAPI mixed-mode data collection (Jäckle 2016; Klausch et al. 2015b). However, effects on measurement are not the focus of this article.

Some other considerations in the introduction of mixed mode designs are specific to the longitudinal context. First, high response rates are essential to allow longitudinal analyses (Lynn 2017). This is because non-responding sample members cannot be replaced by new sample members. Thus, response rates and cumulative response rates are more important in the longitudinal framework than in cross-sectional surveys. Second, response behaviour may be affected by the time sample members have been in the panel (Uhrig 2008; Watson and Wooden 2014). Third, in an on-going panel that has previously been interviewer-administered, sample members have prior experience of the interview in another mode and prior knowledge of the survey content. these prior experiences might increase the chances of response in web mode, even in the absence of an interviewer (Jäckle et al. 2015), as the task of introducing the survey and the respondent task is greatly reduced.

The aim of this paper is to study the effect of a mixed mode design including web on non-response, attrition, and sample composition in a longitudinal survey, both overall and with reference to different groups. By “mixed mode” we refer specifically to a sequential mixed mode design, where web is offered first, followed by face-to-face follow-up of non-respondents to the web phase, with CAPI interviewing. We compare this mixed mode design to a simple face-to-face (CAPI) design. In both designs we allow the possible use

of different modes in a final “mop-up” step to boost response (e.g. Computer Assisted Telephone Interviewing (CATI)) as we believe this represents good practice and does not fundamentally affect the nature of the designs. Details of the specific designs upon which our analyses are based are presented below. To the best of our knowledge, no other study that investigates the effects of introducing a mixed mode design for the first time over multiple waves of a longitudinal survey has been conducted yet.

We analyse data from the Understanding Society Innovation Panel. The Innovation Panel is a longitudinal panel designed explicitly to enable methodological research. The size of the panel is large, which provides good statistical power. The survey aims to interview each adult member of the household. At wave 5, a randomised experiment was carried out, to inform decisions on whether and how the main Understanding Society survey (Buck and McFall 2012) might move from a single-mode CAPI survey to a mixed mode survey that includes web interviewing. Two-thirds of sample units were allocated at random to the mixed mode treatment (sequential mixed mode in which web was followed by CAPI), with the other one-third receiving the CAPI treatment. At the time of the experiment, the panel consisted of 1573 households and 3040 adults eligible for interview. The experiment continued at waves 6 and 7, so that respondents received the same treatment they were assigned to at wave 5. This structure of the experiment enables investigation of long term effects of mode treatments on panel attrition. Minor changes to the design were applied at waves 6 and 7, with reference to incentive levels and follow-up procedures. Particularly, at the end of the fieldwork a final ‘mop-up’ phase was included, which introduced CATI and web options in the CAPI treatment and CATI in the mixed mode treatment. Thus, in waves 6 and 7 the CAPI treatment was not strictly single-mode. However, as modes used in the ‘mop-up’ stage played a very small part in overall response (see section 3.1 below), we will use the term ‘primarily CAPI’ for the CAPI treatment in waves 6 and 7.

Positive effects of incentives on response rates have been found for web surveys (Göritz 2006; 2010; 2015). Incentives have found to be effective also in longitudinal surveys (Laurie and Lynn 2009; Jäckle and Lynn 2008). Thus, respondent incentives were provided in both treatment groups, though the level and nature of the incentives differed between the groups, reflecting the reality that sample members might require additional motivation in the absence of an interviewer. Each of the two mode treatments therefore represents a realistic overall design, though it must be taken into account that the unit cost of incentives is slightly higher in the mixed mode treatment. Details of the incentive strategies are set out in section 3 below and a cost comparison is presented in section 6.

We investigate whether there was a differential attrition effect in individual response between the mixed mode group and the primarily CAPI group, either overall or amongst important subgroups. Particularly, we investigate possible effects separately for individuals who have been in the panel for longer or shorter periods and for individuals who have or have not responded in the previous wave of the panel. Interest lies also in the potential for non-response bias, which we study by examining the effect of mode treatment on sample composition.

Since one of the main reasons for the implementation of mixed mode designs with a web component is related to cost reductions, we investigate some aspects related to survey costs. First, in the context of household panels such as the Innovation Panel where all household members need to be interviewed, a significant cost-saving may be obtained only when all household members respond by web, as this avoids the need for an interviewer to visit the household in the CAPI follow-up phase. In this respect and with reference to wave 5 only, Jäckle et al. (2015) found that one in five households fully responded online, suggesting the potential for useful cost savings. We investigate the extent to which households fully respond online over three waves in order to ascertain

whether cost savings appear to increase over time following the introduction of a mixed mode design. Also, we present an estimate of the unit cost of data collection in each mode treatment, taking account both of cost savings in the mixed mode design for any household in which all members respond online, and of the different incentive levels used in the two treatment groups.

In a Total Survey Error (TSE) perspective (Biemer 2010; Groves and Lyberg 2010; Lynn and Lugtig 2017), this paper represents a step towards the optimization of surveys by maximizing certain aspects of survey quality within a budgetary constraint. For example, if cost savings are found by the introduction of mixed mode with a web component, a larger sample could be afforded for the same budget, which in turns leads to lower variance of the estimates.

In section 2, our research questions are introduced. In Section 3, we describe the data and the experimental study. Next, we present results on participation (Section 4), sample composition (Section 5), and costs (Section 6). Sections 7 and 8 conclude.

2. Research Questions

We assess the possible effects of the introduction of mixed mode data collection on three important aspects of survey quality: participation, sample composition, and costs. These correspond to our research questions.

As outlined in Section 1, previous research suggests that mixed mode design with a web component might result in lower response rates than single mode interviewer-administered designs. Co-operation may be harder to maintain in the absence of personal interviewer contact. This may particularly be the case when the mixed mode design uses a lower

response rate mode first in a sequential design (Lynn 2013), as is the case here. Moreover, in the context of longitudinal surveys, different effects on participation could be expected depending on the number of waves individuals have been in the panel and on previous wave outcome. It is well known that wave-on-wave attrition rates in longitudinal studies are highest at the second wave and then decline over time (Lugtig 2014; Schoeni et al. 2013; Uhrig 2008). There is also evidence that the correlates of non-response may change over waves of a survey: for example, a study based on the British Election Panel Survey found that the strongest predictors of non-response were socio-demographics at wave 1 (age and level of education), interest in politics at wave 2 and, at subsequent waves, characteristics associated with the likelihood to move (Farrant and O'Muircheartaigh 1991). Furthermore, a study based on four waves of Understanding Society found that changes in correlates of non-response at each subsequent wave are lower compared to the previous one (Bianchi and Biffignandi 2017). Further, those who have been longer in the panel have more experience of the interview in another mode and prior knowledge of the survey content than those who have entered the panel more recently. These aspects might increase the chance of a successful transition to web interviewing. Thus, it is expected that more recent panel members will show higher levels of attrition/non-response. Jäckle et al. (2015) found that for longer panel members (original sample) the proportion of interviews of any form was lower with mixed mode, while there was no difference by mode treatment for more recent panel entrants (refreshment sample).

Previous wave non-respondents are known to have lower response propensities in subsequent waves (Watson and Wooden 2014). This result was found in the Innovation Panel as well (Jäckle et al. 2015). We thus expect higher attrition rates among previous wave non-respondents, which could result in greater sensitivity to mode treatment

amongst this group. Furthermore, an invitation to complete the interview by web offers the opportunity to at least make contact with some sample members who are very hard to contact face-to-face (due to being rarely at home at the times when interviewers visit). Jäckle et al. (2015) found that amongst previous wave respondents the mixed mode design resulted in a higher proportion of refusals than the CAPI design and amongst previous wave non-respondents it resulted in a smaller proportion of proxy interviews. Moreover, we consider subgroups with different characteristics. Jäckle et al. (2015) found several groups to be less likely to give an interview in the mixed mode treatment than face-to-face: men, white, in rural location, web users, those for whom an email address was available, age 21-30, in a household with children, and individuals who said they would definitely not do the survey by web. If these patterns persist over waves, then they are expected to lead to biases in the estimates of correlated variables. Moreover, persistent patterns could guide the implementation of targeted design features in mode assignments.

Our first research question is:

RQ1: Does the mixed-mode design affect participation rates, either overall or amongst important subgroups, compared to the primarily CAPI design?

With respect to nonresponse bias, heterogeneity across modes in response propensities would result in a more balanced response set with a mixed mode design, thus leading to smaller compositional biases than single-mode designs. This would be the case if different types of people tend to respond in each mode. However, literature is not conclusive on this issue. Voorpostel and Ryser (2011) in the implementation of a web-CAPI concurrent mixed mode design for refusal conversion in an otherwise CATI panel survey (the Swiss Household Panel) found that the group that completed the web questionnaire tended to have characteristics that were slightly different from the CATI group. They argue that, if

larger numbers had been reached, this would have diminished the bias in demographic characteristics. No significant differences in sample composition between a sequential mixed-mode design and single-mode CAPI were found by Lynn (2013), with respect to a CATI- CAPI design in the UK, or by Klausch et al (2015a), with respect to CATI-CAPI, web-CAPI or mail-CAPI. The relevance of sample composition measures depend on the substantive analytical objectives of data users. In case of multi-purpose surveys with many users, where there are no key estimates, it is essential that the response set remains as balanced as possible with respect to many variables. Our second research question is therefore:

RQ2: Does the mixed-mode design affect sample composition, compared to the primarily CAPI design?

Data collection cost savings are the motivating context for the implementation of a mixed mode design with web. As outlined in Section 1, in surveys that aim to interview all household members, substantial cost savings can only be made if there is no need to send an interviewer to visit a household. This requires that all household members respond by web. However, a realistic implementation of a mixed mode design with web requires higher incentive levels than interviewer administered surveys. The extent to which cost savings can be made by the implementation of a mixed mode design therefore depends on the relative cost of these two components for each mode treatment. So our third research question is:

RQ3: To what extent does the mixed-mode design reduce field work costs, compared to the primarily CAPI design?

3. Data

We use data from a randomized experiment carried out at wave 5 and continued at waves 6 and 7 of the Understanding Society Innovation Panel (Uhrig 2011). Section 3.1 describes the main characteristics of the panel, while Section 3.2 provides details on the experimental design underpinning the analysis reported here.

3.1 The Understanding Society Innovation Panel

The Understanding Society Innovation Panel is an ongoing longitudinal survey which has collected data in annual waves since 2008. The target population for the Innovation Panel is all individuals aged 16 or over and living in England, Scotland, or Wales. The sample had two components: those who were invited to take part at each wave since wave 1 and those who entered the survey at wave 4. We refer to these two sample components as the original sample and the refreshment sample, respectively. Another refreshment sample was added in wave 7, but is excluded from our analyses.

Both samples are stratified, clustered, probability samples of persons. Primary sampling units are postal sectors, secondary sampling units are residential addresses selected from the Postcode Address File (Lynn and Lievesley 1991) and sample elements are persons. The sample of persons is therefore initially clustered within households (though that clustering reduces over waves of the panel). Further details on the Innovation Panel sample design can be found in Lynn (2009).

The Understanding Society Innovation Panel involves interviews at 12-month intervals with the initial sample members and all members of the current household of each sample person. Household response at any wave can thus be complete if all household members answer the survey or partial, if only some of the household members participate. Only

sample members who were in participating households at the first wave for that sample were re-approached for interview at subsequent waves. Sample members were followed to their new location if they moved anywhere within Great Britain. From wave 2 onwards, non-response at one wave did not preclude an interview attempt at the next wave. Households in which no person responded at two successive waves are no longer issued to the field. Thus, in the sample issued to the field at wave 5 – which forms the base for most of our analyses - the original sample included all individuals who were in households that had responded at either wave 3 or wave 4 and the refreshment sample only included individuals in households that had responded at wave 4. Thus, at wave 5 it is only the original sample that includes previous wave nonrespondents.

Interviews cover a wide range of topics, such as household dynamics, economic activity, income, health, housing, and political attitudes. The survey is a multi-purpose survey intended as a major research resource, with thousands of users from different disciplines and no “key estimates” (Buck and McFall 2012).

Proxy interviews are allowed on behalf of individuals who cannot be interviewed in person, but only after considerable efforts have been made to obtain a personal interview. The decision to allow a proxy interview is made subjectively on a case-by-case basis by field staff. At waves 5, 6 and 7 – the field outcomes of which are the subject of our analyses – the proportion of interviews completed by proxy was 6.9%, 5.9% and 3.2% respectively. As for modes used in data collection, at waves 1, 3 and 4, all interviews were carried out by CAPI. Experimentation with a mixture of CAPI and CATI was carried out at wave 2 in 2009 (Lynn et al. 2010). The main conclusion from that experiment was that a CATI-CAPI sequential mixed modes design, if implemented in a way that would save costs, was likely to result in lower response rates (Lynn 2013). For that reason, CATI was not included as an initial mode at waves 5 to 7.

3.2 Experimental Design

At wave 5, all sample members were randomly allocated to one of two treatment groups. The allocation was at the household level, so all individuals in the same household received the same treatment. Interviewers are assigned to households based on geographic location, a factor that had no influence on the allocation to treatment, so each interviewer assignment therefore included households in both treatment groups. One third of the sample was allocated to the primarily CAPI treatment and two thirds were allocated to the web-CAPI sequential mixed mode design. The experiment was continued (with the same treatment allocation) at waves 6 and 7. The distribution of the issued sample of households across samples and mode treatments is summarised in Table 1.

Table 1. Allocation of households to experimental groups in wave 5 and distributions in waves 6 and 7.

Sample Component	Previous wave outcome	Wave 5		Wave 6		Wave 7	
		CAPI	MM	CAPI	MM	CAPI	MM
Original Sample	Responded	321	615	292	544	277	544
	Did not respond	43	111	41	89	21	37
Refreshment Sample	Responded	168	315	148	263	141	250
	Did not respond	-	-	17	29	12	15
Total	-	532	1041	498	925	451	846

Notes: Households ineligible at the respective wave (e.g. deceased, moved abroad) have been excluded; CAPI = computer-assisted personal interviewing; MM = mixed modes; Responded means that at least the household grid and either the household interview or an individual interview was completed at the previous wave.

At wave 5, the CAPI treatment involved standard Understanding Society procedures. Each adult sample member (aged 16 or over) was sent an advance letter with a prepaid unconditional incentive, after which interviewers visited to attempt CAPI interviews. In each household, one person was asked to complete the household enumeration grid and the household questionnaire. All household members aged 16 or over were asked for an

individual interview, including a self-completion component administered by computer-assisted self-interviewing (CASI).

In the mixed mode treatment group, sample members aged 16 or over were sent a letter with a prepaid unconditional incentive, inviting them to take part by web. The letter included the URL and a unique user ID, which was to be entered on the welcome screen. A version of the letter was additionally sent by email to all sample members for whom an email address was available (around half of the sample: of the emails sent, 10% bounced, 30% were opened by the recipient and 60% were left unopened). For people who had indicated at previous waves that they do not use the internet regularly for personal use, the letter mentioned that they would also have the opportunity to do the survey with an interviewer. Up to two email reminders were sent at three-day intervals. Sample members who had not completed the web interview after two weeks were sent a reminder by post and interviewers then started visiting them to carry out CAPI interviews. The interviewer visits began in the same week that the reminder letter would have been received. CAPI interviewers thereby had their full allocation at the start of their fieldwork, rather than having non-responding web individuals being passed to them during the fieldwork period. The web survey remained open throughout the fieldwork period.

The first household member to log on to do the web survey was asked to complete the household grid, which collects information on who is currently living in the household. The web grid included an additional question to identify who is responsible for paying bills. The household questionnaire could be completed by either this person or their spouse/partner. For these sample members the household questionnaire was displayed first, then leading on to the individual questionnaire. Once one partner had completed the household questionnaire, it would not appear for the other partner. The web questionnaire was based on the CAPI one, with some adaptations, e.g. incorporating interviewer instructions into

question wording, removing references to showcards, and making “help” screens more respondent-appropriate. There were no differences in questionnaire content, question order or routing. The web survey was not suitable for completion using a small mobile device. If a mobile device was used to access the log-on page, the respondent was automatically directed to a page requesting that they log on from a computer.

The same procedures were carried out in waves 6 and 7, with a few small differences. First, respondents accessing the survey from a mobile device were no longer blocked from completing it, though they were still presented with a warning message suggesting that it would be easier to complete the survey on a PC or laptop. In the mixed mode treatment group, the proportion of individual web interviews completed on a mobile device was 7% at wave 6 and 18% at wave 7. Second, the proportion of sample members in the mixed mode treatment who had supplied a valid email address and could therefore be sent a survey invitation by email increased at each wave, being around 60% at wave 6 and 65% at wave 7. Third, “nonresponse mop-up” procedures to obtain participation of individual who had not participated by the end of the fieldwork period were extended to include additional modes. This included non-responding individuals in partially responding households. Nonrespondents in the CAPI group were sent a letter offering the opportunity to participate by web. The letter included the URL of the web instrument and a unique log-on code. For those whose email addresses were available, this invitation was also sent by email. A few days later, an interviewer attempted contact by telephone with all those for whom a phone number was known in order to remind them of the web questionnaire, and to administer a CATI interview if possible. Telephone contacts were also attempted with all remaining nonrespondents in the mixed mode group. The telephone interviewer reminded the sample member that they could participate on the web, but was also able to administer the interview by CATI. Cases for which a telephone number was not known were not

contacted again at this stage. CATI was included in this final stage at waves 6 and 7 on the grounds that an additional contact mode might increase the chances of contact being made with some of the most difficult to contact sample members. At wave 6, just five individual interviews (0.7% of all interviews) in the CAPI treatment group were completed by CATI and fifteen (2.2%) by web. In the mixed mode group, fourteen interviews (1.0%) were completed by CATI. At wave 7, just one individual interview (0.1% of all interviews) in the CAPI treatment group was completed by CATI and 25 (3.2%) by web. In the mixed mode group, three interviews (0.2%) were completed by CATI. It is clear that these additional modes had only a minor impact on response outcomes.

At each wave all sample members received an unconditional incentive, enclosed with the advance letter. The value of the incentive was manipulated as part of a separate experiment. Allocation was at the household level, so all individuals in the same household received the same incentive. At wave 5, in both mode treatment groups original sample members received either £5 or £10, while refreshment sample members received £10, £20 or £30. Additionally, a conditional incentive experiment was carried out within the mixed mode group (fully crossed with the unconditional incentive experiment) to test ways of increasing web participation. Half of the households were offered an additional incentive of £5 per person conditional on all eligible household members completing the web survey within two weeks. This was mentioned in the advance letters to all household members in this treatment group.

At wave 6, the incentive experiment was restricted to the mixed mode part of the sample. Individuals were allocated in equal proportions to three treatments: £10 unconditional incentive, £30 unconditional, or £10 unconditional incentive with an additional £20 per individual conditional on all adult household members taking part online within the two-

week web-only period. For the primarily CAPI part of the sample, all sample members were provided a £10 incentive.

At wave 7, all continuing sample (original and wave 4 refreshment) members were again administered the same incentive as at wave 6.

The analyses carried out in Sections 4 and 5 are based on individuals aged 16 or over. Analysis is restricted to individuals who were issued to the field at wave 5 and eligible at waves 5, 6, and 7 – counting individuals not issued to later waves as (eligible) non-respondents (individuals in any household that did not respond at either wave *w*-1 or *w* would not be issued at *w*+1). For those individuals issued to wave 5 and not issued to later waves, non-response is classified using last wave available non-response classification. The sample size is 2756. For individuals, we use variables from the most recent available interview as covariates.

4. Participation

The first aspect that we consider is the impact of mixed mode data collection on participation (RQ1). Notice that all our analyses are conditional on being issued to the field at wave 5, which means that all wave 1 non-responding households and some who adamantly refused or were persistent non-respondents at waves 2 to 4, have been dropped from the sample. Our focus is on the effect of mode treatment on attrition at waves 5, 6 and 7, the waves at which the randomized experiment was carried out.

A particularly important outcome in the context of longitudinal studies is the cumulative response rate over waves, as this is related to the possibility of performing longitudinal analyses. For analyses of change, observations need to be available from each wave of

interest and different patterns of missingness across waves may lead to a large number of cases being dropped from the analyses.

Table 2 compares mixed mode data collection with primarily CAPI data collection in terms of the number of waves (out of 3) at which the sample member provides a full interview, as well as full interview response rate in each wave separately. No significant differences are found between treatments for the cumulative response rate over three waves (P=0.45). Looking at response in each wave separately, the effect of mixed modes on the proportion of full interviews went from -2.6 percentage points at wave 5 to +3.0 at wave 7, though none of these differences are statistically significance.

Table 2. Individual response rates (in %)

Response	CAPI	MM	P
Waves 5-7 response			
3 full interviews	47.3	49.1	0.45
2 or 1 full interviews	32.9	31.3	0.57
0 full interviews	19.8	19.6	0.92
Wave 5 full interview	71.0	68.4	0.30
Wave 6 full interview	69.3	70.7	0.52
Wave 7 full interview	56.1	59.1	0.21
N	940	1816	

P-values from Pearson χ^2 tests, corrected for the survey design (strata and clusters)

Turning to individual response by subgroups of interest (Table 3), no difference between the mixed mode design and primarily CAPI design was observed with respect to the cumulative response rate, in the original sample (P=0.86), the refreshment sample (P=0.30), the original sample wave 4 respondents (P=0.81), or the original sample wave 4 non-respondents (P=0.11). Amongst wave 4 non-respondents in the original sample, the mixed mode design resulted in a lower proportion of no interview over three waves than

CAPI (54.9% vs 66.5%, P=0.09). Separate analyses for each wave show that the proportion of full interviews did not differ significantly between treatments for either the original sample (P=0.16) or the refreshment sample (P=0.67) in wave 5. In waves 6 and 7, amongst wave 4 non-respondents in the original sample, the mixed mode design resulted in a higher proportion of full interviews than the CAPI design (32.9% vs 20.0%, P=0.06 in wave 6 and 28.0% vs. 18.7%, P=0.08 in wave 7). In wave 7, the proportion of full interviews is higher for the mixed mode group for both the original and the refreshment samples, even though the differences did not reach statistical significance.

Table 3. Individual response rates (in %) by subsample

	Original Sample									Refreshment Sample		
	Total			Wave 4 responding			Wave 4 non-responding			Total		
	CAPI	MM	P	CAPI	MM	P	CAPI	MM	P	CAPI	MM	P
Waves 5-7 response												
3 full interviews	46.5	47.0	0.86	61.0	61.9	0.81	8.4	13.4	0.11	49.0	54.0	0.30
2 or 1 full interviews	31.4	30.8	0.84	32.2	29.4	0.41	25.2	31.7	0.25	35.8	32.5	0.46
0 full interviews	22.1	22.2	0.97	6.8	8.7	0.39	66.5	54.9	**0.09**	15.2	13.5	0.61
Wave 5 full interview	68.6	64.4	0.16	85.2	80.3	0.12	20.6	26.3	0.21	75.8	77.6	0.67
Wave 6 full interview	67.3	68.6	0.65	84.1	83.5	0.79	20.0	32.9	**0.06**	73.2	75.5	0.56
Wave 7 full interview	55.2	57.9	0.37	68.7	71.3	0.46	18.7	28.0	**0.08**	57.7	61.9	0.39
N	630	1268		454	858		155	350		310	548	

P-values from Pearson χ^2 tests, corrected for the survey design (strata and cluster)

To investigate whether the mixed mode design had different effects on attrition for different subgroup characteristics, we fitted a logit model predicting full response over three waves (versus proxy or non-response in any one of the three waves) using individual characteristics and interactions of those characteristics with treatment as predictors. Individual characteristics were measured in wave 4 (or last available interview before wave 5). Results for the original responding sample are summarized in Table 4, which shows the

estimated coefficients from the model, together with p-values of t-tests for significance (adjusted for sample design). At the 5% level, the only significant interaction is between mode and web preference, with respondents who said at wave 4 that they would definitely/maybe respond to a web survey having higher probabilities to respond in the mixed mode group. The effect is stronger for those who declared they would definitely respond to a web survey.

In answer to the first research question on participation rates (RQ1), the mixed mode design does not appear to affect individual participation either overall or amongst those who have been in the panel for longer or shorter periods. The mixed mode design appears to have a positive effect for those who had not responded at wave 4, though statistical significance is borderline. As for other subgroups, which had been identified to be less likely to give an interview at wave 5 in Jäckle et al. (2015), only expressed preference to respond by web showed to have a positive effect on participation in the mixed mode group with respect to the primarily CAPI group. No other difference between mode treatments was found.

Table 4. Logistic regression: giving full interview in all three waves

Variable	Category	Coefficient	Std. Error	P-value
Intercept	-	-1.01	0.65	0.13
Mixed-Mode (MM)	Mixed-mode group	0.33	0.82	0.69
(Ref. CAPI goup)				
Gender	Male	-0.05	0.18	0.78
(Ref. Female)				
Race	White	0.76	0.48	0.12
(Ref. Nonwhite)				
Working Status	In work	0.03	0.28	0.93
(Ref. Not in work)				
Urbanicity	Urban	0.41	0.29	0.16
(Ref. Rural)				
Webuser	Yes	0.08	0.33	0.80
(Ref. No)				
Email given	Yes	0.52	0.28	**0.06**
(Ref. No)				
Age	16-20	-0.79	0.53	0.14
(Ref. 41-50)	21-30	-0.63	0.49	0.21
	31-40	0.31	0.34	0.36
	51-60	0.38	0.36	0.29
	61-70	1.52	0.45	**0.00**
	71+	0.20	0.49	0.68
Household type	Single	0.19	0.34	0.58
(Ref. Couple)	Single, children	-0.23	0.57	0.69
	Couple, children	0.22	0.42	0.60
	2+ unrelated adults	-0.08	0.44	0.86
	2+ unrelated adults, children	0.14	0.42	0.75
Web preference	Maybe	-0.42	0.33	0.20
(Ref. No)	Yes	-0.57	0.38	0.14
MM#Gender	MM#Male	-0.09	0.23	0.68
MM#Race	MM#White	-0.27	0.55	0.62
MM#Working Condition	MM#In work	0.20	0.35	0.56
MM#Urbanicity	MM#Urban	-0.04	0.35	0.91
MM#Webuser	MM#Yes	-0.22	0.42	0.61
MM#Email given	MM#Yes	-0.08	0.33	0.82
MM#Age	MM#16-20	0.65	0.62	0.30
	MM#21-30	0.22	0.63	0.73
	MM#31-40	-0.53	0.46	0.26
	MM#51-60	0.14	0.47	0.77
	MM#61-70	-0.71	0.53	0.18
	MM#71+	0.30	0.52	0.56
MM#Household type	MM#Single	-0.20	0.44	0.66
	MM#Single, children	-0.44	0.67	0.51
	MM#Couple, children	-0.71	0.52	0.18
	MM#2+ unrelated adults	-0.62	0.53	0.25
	MM#2+ unrelated adults, children	-0.86	0.54	0.12
MM#Web preference	MM#Maybe	0.84	0.42	**0.05**
	MM#Yes	1.09	0.45	**0.02**

Base is the original sample (wave 4 respondents only), *n*=1296, model includes allocated mode, characteristics of the sample members, and interactions between the mode and characteristics as predictors. The Nagelkerke R^2 is 0.119.

5. Sample Composition

In this section, we explore whether the two different mode treatments had different effects on sample composition (RQ2). More precisely, we investigate whether there is a mode difference in whether sample composition at each wave and, especially, in the sample that responded at all 3 waves, differs from the composition at the start of the experiment. We test this assumption by comparing the distribution of covariates collected at wave 4 (or last wave interview before wave 5) for different subgroups of respondents. The statistical test for differences in sample composition with respect to a variable is performed by fitting a logistic regression model predicting response in which predictors are mode treatment, the variable under consideration, and the interaction between mode and the variable. The Wald test on the interaction coefficients is a test of whether the association between the outcome and the variable differs by mode. We consider different groups of respondents: individuals responding at wave 5, individuals responding at waves 5 and 6, and individuals responding at waves 5, 6 and 7.

The variables that we considered are those where we expect the greatest chance of a mode difference, on the basis of results in previous studies. More precisely, we consider variables found to be related to response behaviour at wave 5 in Jäckle et al. (2015, Tables 8 and 9). All these variables are related to at least some substantive variable of interest. For example, ethnicity is an important predictor in studies on social inequalities (Wallace et al. 2016; Chng et al. 2016), while urbanicity figures prominently in research on commuting effects (Evandrou et al. 2016). Therefore any effect of non-response on sample composition in respect of these variables has the potential to introduce bias in substantive estimates of interest to researchers.

Results are shown in Table 5. For respondents at wave 5, only household type shows a significant difference between the mixed mode and CAPI group (P=0.04). As for respondents at waves 5 and 6 and respondents at all 3 waves, the only variable showing a mode difference in how sample composition differs from the composition at the start of the experiment is expressed web preference (P=0.06 and P=0.08, respectively). The proportion of respondents who said at wave 4 that they definitely would not respond to a web survey decreases by 2.6 percentage points in the mixed mode group for respondents at all 3 waves with respect to the initial sample, while it increases by 1.6 percentage points in the CAPI group.

Overall, and to answer the second research question (RQ2), we conclude that differences between the two treatment groups in sample composition are minimal.

Table 5. Distributions of each treatment group for the sample issued at wave 5, responding at wave 5, responding at two waves, and responding at three waves

		Wave 5 issued (1)		Wave 5 responding (2)			Waves 5 & 6 responding (3)			3 waves responding (4)			Difference (4)-(1)	
Variable	Categories	CA	MM	CA	MM	P	CA	MM	P	CA	MM	P	CA	MM
Gender	Male	46.7	46.8	44.9	45.4	0.73	44.1	44.7	0.61	45.0	44.3	0.56	-1.7	-2.5
Ethnic group	White	93.6	91.9	93.0	91.8	0.32	94.5	93.2	0.98	96.0	94.3	0.65	+2.4	+2.4
Working condition	In work	57.4	54.3	59.5	55.3	0.48	57.7	55.1	0.79	55.8	55.8	0.12	-1.6	+1.5
Urbanicity	Urban	76.4	75.3	76.3	75.1	0.92	76.2	75.0	0.96	78.7	74.2	0.14	+2.3	-1.1
Web user	Web user	67.2	69.0	69.2	70.9	0.93	69.0	70.0	0.44	68.6	71.3	0.61	+1.4	+2.3
HH internet	Living in HH internet	84.6	83.2	86.3	84.9	0.97	86.5	83.9	0.36	86.3	84.5	0.83	+1.7	+1.3
Age	16-20	7.6	8.4	5.9	7.1	0.51	5.2	6.7	0.27	4.6	5.1	0.47	-3.0	-3.3
	21-30	10.3	12.4	8.7	10.2		8.0	7.9		6.1	7.0		-4.2	-5.4
	31-40	14.7	13.3	15.4	13.5		15.6	13.0		16.1	12.8		+1.4	-0.5
	41-50	19.1	19.5	19.8	20.1		19.4	19.8		17.5	20.6		-1.6	+1.1
	51-60	19.1	19.5	20.3	18.3		19.6	18.9		19.8	19.7		+0.7	+2.9
	61-70	16.7	14.3	19.6	15.7		20.8	17.5		24.1	18.8		+7.4	+4.5
	71+	12.5	15.3	10.3	15.2		11.3	16.2		11.8	16.1		-0.7	+0.8
Household type	Single	10.3	13.9	13.4	15.2	**0.04**	13.5	16.9	0.35	13.0	17.7	0.85	+2.7	+3.8
	Single, children	5.5	4.6	4.8	4.4		5.3	4.8		4.9	4.0		-0.6	-0.6
	Couple	31.1	29.1	30.9	30.8		32.0	33.4		35.5	34.5		+4.4	+5.4
	Couple, children	22.8	21.7	24.0	21.0		22.9	19.7		23.4	20.3		+0.6	-1.4
	2+ unrelated	18.6	18.8	16.0	17.7		15.6	16.6		14.8	16.6		-3.8	-2.2
	2+ unrelated, children	11.7	11.9	11.1	10.9		10.8	8.7		8.3	6.8		-3.4	-5.1
Web preference	No	32.0	31.1	32.5	29.6	0.24	33.8	29.7	**0.06**	33.6	28.5	**0.08**	+1.6	-2.6
	Maybe	37.1	40.0	37.4	40.8		36.3	41.1		37.5	41.2		+0.4	+1.2
	Yes	30.9	28.9	30.1	29.5		29.9	29.2		29.0	30.3		-1.1	+0.8

Notes: CA = CAPI; MM = mixed mode; P-values from Wald tests, corrected for the survey design (strata and clusters).

6. Costs

As stated earlier, one of the main reasons for the use of web in a mixed mode design is to save costs. In this section we provide an indication of the scale of the difference in data collection costs between the two mode treatments (RQ3). The estimate can only be indicative as the realized cost saving from a mixed mode design such as this one in any particular situation will depend on several aspects of the survey context, survey design, and contractual and remuneration arrangements. Furthermore, focusing solely on data collection costs ignores the possibility that a survey agency might incur initial set-up costs in introducing a mixed mode system, and that the cost of some office-based tasks may be greater for a mixed mode survey. Despite these limitations, we believe that the analysis presented here gives a useful impression of the scale of cost-savings with a mixed mode design.

The main driver of the difference in data collection costs between the two mode treatments is the fact that some sample households do not require an interviewer visit in the mixed mode treatment. The proportion of households fully responding by web can therefore be used as an initial indicator of potential cost savings, as a full response by web negates the need to send an interviewer to visit the household. The proportion of fully responding households who fully responded by web increased over time, from 42.7% in wave 5 to 57.5% in wave 7 (Table 7). This increase over time is apparent for both the original sample (previous wave respondents) and the refreshment sample (results not shown), though at every wave the proportion of households fully responding by web is higher in the refreshment sample than in the original sample. For example at wave 7 the proportion of fully-responding households who fully responded by web was 56% in the original sample, compared to 72% in the refreshment sample. It is noteworthy that in waves 6 and 7 more than one-third of all households fully responded by web (37.1% and 35.1%, respectively).

Table 6. Proportion of households fully responding by web and proportion of households fully responding at waves 5, 6, and 7.

	Wave 5	Wave 6	Wave 7
Mixed-mode sample			
% fully responding by web (A)	23.8	37.1	35.1
% fully responding (B)	55.7	66.7	61.0
(A)/(B)	42.7	55.6	57.5
N	*1041*	*925*	*846*
Face-to-face sample			
% fully responding	58.8	62.8	52.8
N	*532*	*498*	*451*

If field costs per issued sample household– excluding the cost of incentives – were assumed to be approximately £110 with the primarily CAPI treatment, and £5 per household for the web phase of the mixed mode treatment, this would imply that costs in the mixed mode design would be around £5 for each household that fully responds by web and £115 for each other household. Applying these unit costs to the response outcomes in Table 6 would imply that the mixed mode design would bring about reductions in the cost per fully responding household of around 15% at wave 5, 37% at wave 6 and 40% at wave 7. However, these figures do not include the costs of incentives which, for waves 6 and 7, were higher in the mixed-mode treatment group. Table 7 shows the actual mean cost of incentives per issued household in each mode for each wave, taking into account the proportion of households in the mixed mode sample that qualified for the conditional incentives, as well as all unconditional incentives. Incorporating these into the overall data collection costs, the cost differential between mode treatments reduces, with the result that the mixed mode design is now estimated to bring cost savings of around 10% at wave 5, 14% at wave 6 and 23% at wave 7. It should be noted, however, that these estimated cost savings will not be directly generalisable to other surveys as realized savings will depend

on factors such as the cluster sample size, the geographical dispersion of sample addresses within the cluster, and whether interviewers are remunerated equally for interviewing a web-nonrespondent household as they would have been for interviewing a household in a single-mode CAPI survey.

Table 7. Mean cost of incentives (conditional and unconditional) per issued household for each treatment group and for each wave.

	Wave 5	Wave 6	Wave 7
Mixed-mode treatment	£29.74	£49.35	£41.91
CAPI treatment	£29.70	£24.58	£22.77

7. Conclusions

Regarding possible effects of the mixed mode design on response rates, either overall or amongst important subgroups (RQ1), for individual participation no difference between mode treatments was detected overall (both cumulative response rate and response rate in each wave). Also, no differences were found in either the original sample or the refreshment sample as a whole, while the mixed mode design performed slightly better amongst previous wave non-respondents in the original sample. We have identified only one sample subgroup for which the cumulative response rate was lower with the mixed mode design – those who declared previously that they would definitely not respond to a web survey. These are very useful results with respect to the implementation of a mixed mode design with web in a longitudinal survey. They suggest that such a design should not damage participation rates over several waves and may even improve participation amongst sample members who are otherwise less likely to participate. The finding regarding expressed mode preference suggests that answers to a question such as this

could usefully be taken into account as part of a strategy for targeted allocation of sample members to mode treatments (Lynn 2014).

As for household participation, no differences could be found in wave 5 and wave 6 overall, but the mixed mode design showed a better performance than CAPI in wave 7: higher household participation, higher complete household interviews, and lower non-contact rates. For those who had entered the panel more recently (refreshment sample), no difference in household participation could be detected in any of the three waves. For those who had been longer in the panel (original sample), the mixed mode design resulted in smaller proportion of households fully responding and higher proportion of non-contacts and refusals in wave 5; in wave 7, the situation was completely reversed.

With respect to possible effects of the mixed mode design on sample composition (RQ2), differences between the two treatment groups in sample composition are minimal. The data provide little evidence of mode treatment affecting sample composition.

With regard to possible cost savings related to the use of the web in the mixed mode design (RQ3), the mixed mode design appears to have potential to deliver substantial cost savings. At both waves 6 and 7, more than one-third of households issued to the field fully responded by web. Our estimates suggest possible field cost savings per fully responding household of up to one-quarter, compared to CAPI, though these savings do not accrue immediately but only after three waves of mixed mode data collection. The extent to which this saving would be realized in practice depends on, amongst other things, whether the amount of field effort required per household amongst the two-thirds of mixed mode households that need to be issued to a CAPI interviewer differs from that amongst the CAPI sample. Analysis of call record data (results not shown) suggests that in this study the mean number of interviewer visits to a sample household was actually lower in the mixed mode group (amongst households issued to a CAPI interviewer) than in the

primarily CAPI group. This suggests that the indicated cost savings could well be fully realized.

8. Discussion

The introduction of web-CAPI sequential mixed mode data collection as a cost-saving alternative to single-mode CAPI has been considered by many surveys but has generally been treated with caution due to concerns about possible negative impacts on non-response and measurement. This article has not considered measurement issues, but with regard to non-response we suggest that the concerns seem largely unwarranted, at least in the context of an ongoing panel survey. We have found no differences between the mixed mode and CAPI designs in cumulative response rates over three waves of the panel, nor were significant differences found in the composition of the responding sample. Meanwhile, the potential for worthwhile field cost savings is evidenced by the sizeable proportion of sample households in which all adult members completed the questionnaire by web. This study therefore paints a rather positive picture of the potential for mixed mode data collection in panel surveys.

However, some unresolved issues remain. A particularly important one is the question of whether, and in what circumstances, measurement can be considered to be equivalent between the modes. The considerable literature on mode effects suggests that certain question characteristics tend to be associated with measurement differences between modes, particularly between self-completion and interviewer-administered modes (Couper 2011; de Leeuw 2005; Krosnick and Alwin 1987; Schwarz et al 1991). For any particular survey considering the introduction of a mixed mode design, the questionnaire content could be reviewed in the context of this literature, while effects on non-response error

could be considered in the context of the findings of the current study, thus contributing to an overall evaluation of total survey error.

That said, it would be reasonable to question whether our findings would apply in different survey contexts (different topics of questioning, different study populations, different levels of prior survey engagement, etc.). Sensitivity to context is of course possible. However, we can draw some strength from that fact that our findings were broadly similar for the two different samples involved and for several demographic subgroups. The former suggests that our broad conclusions apply equally to sample members with only one previous wave and to those with four previous interviewer-administered waves, and therefore that the degree of prior survey engagement does not have a strong influence on the outcomes studied. The latter suggests that the results might equally apply to study populations with rather different demographic profiles. Taken together, these findings provide some indication that our conclusions are at least somewhat robust.

9. References

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