Effects of Using a Grid versus a Sequential Form on the American Community Survey Basic Demographic Data *

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Abstract
The American Community Survey (ACS) has traditionally used a horizontal grid to collect basic demographic data. In other words, the household member names are listed down the left side of the page and the questions are listed across the top. Responses are provided in the cells of the grid formed by crossing the names by question. The 2010 Census collects these same data and plans to use a sequential format where each person's data are in a distinct column, and within each column, the names are at the top and the questions are listed down the page. Ideally, the Census Bureau would like to be consistent in the wording and presentation of these questions between the ACS and the 2010 Census. Therefore, the ACS survey methods research area tested whether changing the layout for these questions affects response. More specifically, does changing from the grid to the sequential format affect data quality indicators and the response distributions for the basic demographic questions?

Keywords: questionnaire design, grid, sequential, American Community Survey

1. Introduction

The ACS is a nationwide household survey conducted by the U.S. Census Bureau to collect demographic, housing, and socioeconomic data. This survey uses monthly samples to produce annually updated data for the same small areas (census tracts and block groups) as the decennial census long-form sample formerly surveyed. Initially, five years of samples are required to produce these small-area data. Once the Census Bureau has collected five years of data, new small-area data are produced annually. In addition to the five year data product, the ACS provides three-year and single-year data products for larger geographic areas.

The 2007 ACS grid-sequential test was designed to help determine which format to use for the basic demographic section of the 2008 ACS mail form. The data showed that the traditional ACS grid format for the basic demographic section of the mail form did not perform as well as the sequential format for select quality indicators. In addition, the sequential format did not produce major changes in the properties of the basic demographic response distributions as found with the grid format.

2. Methods

2.1 Data Collection
To determine the feasibility of changing to a sequential format for the ACS, a two-group experimental design was used to test whether the grid and sequential formats differed for select quality measures or for any of the response distributions for the basic demographic items. The grid-sequential test included a national sample of approximately 30,000 addresses equally allocated among the two treatment groups. The Census Bureau mailed the grid-sequential test questionnaires to the selected addresses in March 2007, which corresponded to the production ACS data collection schedule for the March 2007 panel.

The ACS collects data using three modes of data collection. In addition to receiving a mail questionnaire, for those households that do not respond within a timely manner, the Census Bureau attempts to contact the household via a telephone interview and/or a personal visit by a Census Bureau field representative. For the purposes of the grid-sequential study we restricted our data collection to the mail mode of data collection since our changes to the ACS

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survey only affected the paper questionnaire. The grid-sequential test used the same mailing strategy as the ACS which consists of four mail pieces – a pre-notice letter, the ACS questionnaire, a reminder postcard, and a replacement questionnaire if the original questionnaire is not returned in a timely manner.

2.2 Sample Design

The 2007 Grid-Sequential Test consisted of a national sample of 30,000 residential addresses in the contiguous United States (the sample universe did not include Puerto Rico, Alaska, and Hawaii). The sample design for the grid-sequential test was largely based on the ACS production sample design (multi-stage sample) modified to meet the test objectives. The modifications included adding an additional level of stratification by stratifying units into high and low mail response areas; selecting units with equal probabilities of selection within the high/low response strata; and sampling units as pairs. The high and low response strata were defined using Census 2000 long form mail response rates at the tract-level. Note that units within the low response strata were sampled at a higher rate to ensure an approximately equal number of mail responses from both strata. Sample units were selected in pairs by first systematically sampling an address within the defined sampling strata and then pairing that address with the address listed next in the geographically sorted list. Note that the pair may not be neighboring addresses. One member of the pair was randomly assigned to the grid treatment and the other member was assigned the sequential treatment. For more details on the grid-sequential test sample design, see Joshipura and Hefter (2007).

3. Limitations

The main objective of the 2007 Grid-Sequential Test was to determine the effects of changing the layout of the basic demographic items on the ACS paper questionnaire. To meet this objective, we used data collection and processing that differed from the production ACS. As a result, the estimates and distributions derived from the 2007 Grid-Sequential Test may differ from the same estimates and distributions derived from the production ACS. For example, the grid-sequential test was strictly a mail (respondent-completed) test. The other modes of data collection used in the production ACS for mail nonresponse followup, Computer Assisted Telephone Interview (CATI) and Computer Assisted Personal Interview (CAPI), were not used for this test. Therefore, characteristics of CATI and CAPI respondents that may influence the estimates or distributions are not incorporated. In addition, the grid-sequential test did not employ the editing and imputation methods used in production by design so that response issues were not masked. This may also contribute to differences in the estimates and distributions between the test and production.

The data processing for the grid-sequential test used in our analysis used a modified Key From Paper (KFP) system rather than the Key From Image (KFI) system being implemented for the 2008 ACS. A difference between the standard KFP system and the new KFI system is that the KFI system contains edits that clean the data. As a result, we modified the KFP system to include imaging of the grid-sequential test questionnaires so that we could achieve similar results to the KFI system by having the ability to verify those household or person records where we were not certain the records were valid. A "valid" person record required a name and a response to two of the five items in the basic demographic section of the form. A valid returned mail questionnaire required at least one valid person record or a phone number.

4. Research Questions and Results

4.1 Do changes in the layout of the basic demographic section of the mail form impact mail response?

The grid-sequential test mail response rates for each treatment were defined as the percent of "mailable" sample addresses that returned a non-blank questionnaire (either the first mailed questionnaire, the replacement questionnaire, or both). Note that the response rates calculated for the grid-sequential test do not mirror the response rate calculated for the production ACS as specified by Williams (2006) since followup for nonrespondents was not included in the test and therefore we were not able to identify and exclude vacant units or units on the frame ultimately determined to be ineligible for the survey (e.g., commercial or demolished units).

Reviewing the response rates for the grid and sequential treatments, the sequential layout resulted in a response rate equal to 37.6 percent and the grid layout resulted in a response rate equal to 39.1 percent. Therefore, the sequential

layout resulted in a 1.5 percentage point increase in response, significant at the 0.10 percent level (margin of error = ±1.1 percent). Note that a significance level of 0.10 is used for all hypothesis tests in this paper.

4.2 Do changes in the layout of the basic demographic section of the mail form impact item nonresponse?

The Item Nonresponse Rates (INRs) were calculated as follows. Since the ACS questionnaire provides only enough entries in the basic demographic section to collect data for the first 1-5 persons listed in a household, all rates were calculated using only data for these first 1-5 persons such that the minimum amount of data was provided for each person to qualify as a valid person record. A continuation roster is provided for the respondent to list additional persons (persons 6-12) so that the Census Bureau may collect the data for these persons at a later time through the Failed Edit Follow-Up operation.

The denominator of each INR was the number of all valid persons numbered 1 to 5, with the exception of the relationship INR. The denominator used to calculate the INR for the relationship item was the number of valid persons numbered 2 to 5 since the relationship question is not offered to the first person whose data is collected on the questionnaire (subsequent persons are asked how they are related to person 1).

The numerator of each INR also varied by question. For the relationship item, the numerator includes all valid persons that did not provide one and only one response to relationship question (i.e., the respondent marked multiple check boxes or provided no response). The numerator for the sex question was calculated in the same manner. For age and date of birth (DOB), the numerator includes all valid persons who did not give either a legitimate age or year of birth. For Hispanic origin, the numerator includes any valid person who did not check one or more of the boxes and did not provide a Hispanic group in the write-in. For race, the numerator includes any valid person who did not check one or more of the boxes and did not provide a race group in a write-in field.

Table 1 shows the INRs for all of the basic demographic items (note that the estimates in Table 1 and all subsequent tables are rounded to the first decimal place). Across all of the items, we observe that the sequential format maintained or reduced the incidence of missing data. Reviewing the items individually, we observe that the INR for the relationship item does not significantly differ by treatment. This is also the case for the sex item. However, for the age and DOB items, the sequential format produces a significantly lower INR. Similarly for the Hispanic origin item, we observe that the sequential format produces a significantly lower INR. Finally for the race item, the results show that the sequential format produces a significantly lower INR.

Table 1. Item Nonresponse Rates, Grid versus Sequential

Item	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
Relationship	1.5	1.3	0.1	± 0.5	No
Sex	2.2	2.0	0.2	± 0.5	No
Age/Date of Birth	3.1	2.4	0.7	± 0.7	Yes
Hispanic Origin	8.0	5.5	2.6	± 1.0	Yes
Race	7.5	3.8	3.7	± 0.9	Yes

4.3 Do changes in the layout of the basic demographic section of the mail form impact the "person incompleteness" rate (the proportion of people for whom we do not have an answer to all of the basic demographic questions)?

We defined a "person-incompleteness" rate as the percentage of persons for whom we did not have an answer to all of the basic demographic questions. The definition of "an answer" is the same as the response definitions used for our item nonresponse rates with the exception that person 1 is considered to have "reported" relationship. Note that the "person incompleteness" rate was calculated using only data from records recognized as persons numbered 1 to 5 since the basic demographic data are not fully collected for persons 6 through 12.

Reviewing our results for the "person incompleteness" rates for the grid and sequential treatments, the grid layout resulted in a person-incompleteness rate of 16.1 percent and the sequential layout resulted in person-incompleteness

rate of 12.4 percent. Therefore, the data indicate that the sequential format significantly reduces the "person-incompleteness" for the basic demographic section by approximately 3.7 percent (margin of error = ±1.4 percent).

4.4 Do changes in the layout of the basic demographic section of the mail form impact the proportion of respondents who inconsistently report the number of persons (i.e., the count on the cover differs from the number of persons with data in the basic demographic section)?

We defined the person count discrepancy rate as the percent of cases where the total number of valid persons listed in the basic demographic section (persons 1-5 and persons 6-12 on the continuation roster) was not equal to the total number of persons reported in the household's count on the cover.

Reviewing the person count discrepancy rates for the grid and sequential treatments, we observe that the person count discrepancy rate is equal to 3.7 for the grid layout versus 2.7 percent for the sequential layout. Therefore, the sequential significantly decreases the person count discrepancy rate by approximately 1.0 percent (margin of error = ±0.7 percent).

4.5 Do changes in the layout of the basic demographic section of the mail form impact the proportion of large households who inconsistently report the number of persons?

Now we restrict the previous comparison of person count discrepancy rates between the grid and sequential treatments to large households (households with 6 or more people) to isolate any effect due to the difference in the placement of the continuation roster between the grid and sequential forms. The continuation roster is provided to allow respondents in large households (greater than five persons) to list names of up to seven additional persons. We hypothesized that since the continuation roster was moved from the bottom of the grid layout on pages 2 and 3 to page 4 of the sequential layout, respondents for large households would be more likely to miss the roster, thus leaving it blank. To answer this research question, we compared between the question layouts the percent of large household cases (as indicated on the cover with a "total persons" count of 6 or higher) where the number of valid persons among persons 1 to 5 and persons reported in 6-12 is less than the number reported on the cover.

When we review the person count discrepancy rates for large households only, we find that the grid layout resulted in a person count discrepancy rate of 7.1 percent and the sequential layout resulted in a rate equal to 5.4 percent. This results in a difference equal to 1.7 percent. However, the difference is not statistically significant (margin of error = ±6.3 percent). Note that our sample was not designed to over-sample for large households. As a result, large households made up less than 1 percent of our sample (205 large households). This limited our ability to detect differences in the characteristics of large households as indicated by the large margins of error.

4.6 Do changes in the layout of the basic demographic section of the mail form impact the proportion of respondents who did not continue through the form to the housing section?

The ACS questionnaire can be divided into three sections, the basic demographic section, the housing section, and the detailed person section. The basic demographic section is presented first in the questionnaire followed by the housing section and then the detailed person section. The housing section collects housing data on question topics such as the type of building structure, the year the building structure was built, property value, and property taxes. The detailed person section collects additional person data not collected in the basic demographic section that include question topics such as citizenship, education, employment, and income.

To determine whether an effect exists such that the layout of the basic demographic section affects a respondents willingness to continue on to the housing section, we measure the rate at which respondents do not continue on to the housing section from the basic demographic section, we count in the numerator all occupied housing units for which there are no responses to the building type and year built items.

Reviewing the rates of discontinuation for both treatments, about 1.2 percent of the respondents provided basic demographic data but did not provide housing data (grid) versus 0.9 percent (sequential). This results in a difference of 0.3 percent between the two rates, however the difference is not significant (margin of error = ±0.4 percent). Therefore, we conclude that the sequential layout does not affect a respondent's willingness to continue on to the housing section.

4.7 Do changes in the layout of the basic demographic section of the mail form impact the proportion of respondents who did not continue on to the detailed person section?

To determine whether an effect exists such that the layout of the basic demographic section affects a respondent's willingness to continue on to the detailed person section, we measure the rate at which all valid persons from the basic demographic section do not have data reported for them in the detailed person section. Specifically, we count in the numerator all valid persons for which there are no responses in the place of birth/citizenship, education, ancestry, and the language series (the first two columns in the detailed person section).

Reviewing our results for the rates of discontinuation to the detailed person section between the grid and sequential treatments, of all the persons providing basic demographic data, 3.9 percent did not provide detailed data (grid) versus 4.3 percent (sequential). As a result, we have a difference of 0.5 percent between the two rates, however this difference is not significant (margin of error = ±0.7 percent). Therefore, the sequential layout does not influence a respondent's willingness to continue on to the detailed person section.

4.8 Do changes in the layout of the basic demographic section of the mail form between grid and sequential impact the distributions of the basic demographic items?

To form the response distributions for the basic demographic items by version of the form received, we recoded some of the response categories. For age, the following age ranges were used: 0-17, 18-24, 25-44, 45-64, and 65+. For race, the basic race groups were used (White, Black, American Indian or Alaskan Native (AIAN), Asian, Native Hawaiian or Other Pacific Islander (NHOPI), Other, and 2+ races). For the remaining items, relationship, sex, and Hispanic origin, the distributions were calculated using the checkbox items on the form.

To determine if the distributions were dependent on form type, we used a chi square test, adjusting for the complex sample design. In addition, we used individual t-tests to determine whether individual categories were significantly different.

4.8.1 Sex

Table 2 shows the sex item response distributions by treatment. Comparing the sex distributions between the grid-sequential treatments, we observed a significantly higher proportion of males and a lower proportion of females for the grid format. We cannot formulate a reasonable hypothesis as to why the differences in layout would affect the sex distribution other than differences in the question items themselves between treatments may have contributed to the difference. On the sequential format the sex response items were listed horizontally and the instruction "Mark (x) one box" was present. On the grid layout the response items were listed vertically and the "Mark (x) one box" was not present.

Table 2. Sex Response Distribution, Grid versus Sequential

Gender	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
Male	48.2	47.1	1.1	± 1.0	Yes
Female	51.8	52.9	-1.1	± 1.0	Yes
Total	100.0	100.0			

$\chi^2 = 3.54$ with 1 degree of freedom, significant at the 10.0 percent level

4.8.2 Relationship

Table 3 shows the relationship distribution with un-collapsed categories by treatment overall. Reviewing the chi-square test statistics for the relationship distribution, we observe no significant difference in the distributions between the grid and sequential treatments.

Recoding the detailed relationship categories into the collapsed categories of "related" versus "not related", we examined whether a dependency existed for these collapsed categories on the form type. Similar to the un-collapsed relationship distribution, we observe that the re-coded relationship distribution is not dependent on form type.

Table 3. Relationship Response Distribution, Grid versus Sequential

Relationship	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
Husband or Wife	43.9	44.2	-0.3	± 1.3	No
Biological son or daughter	41.6	40.8	0.7	± 1.7	No
Adopted son or daughter	0.9	1.2	-0.3	± 0.4	No
Stepson or stepdaughter	1.8	1.9	-0.1	± 0.6	No
Brother or sister	1.1	0.9	0.2	± 0.4	No
Father or mother	1.4	1.3	0.0	± 0.4	No
Grandchild	2.1	2.1	0.0	± 0.7	No
Parent –in-law	0.4	0.3	0.1	± 0.2	No
Son-in-law or daughter-in-law	0.4	0.2	0.2	± 0.2	Yes
Other relative	0.5	0.8	-0.3	± 0.3	No
Roomer or boarder	0.3	0.3	0.0	± 0.2	No
Housemate or roommate	1.3	1.5	-0.3	± 0.4	No
Unmarried partner	3.5	3.4	0.1	± 0.6	No
Other nonrelative	0.8	0.8	0.0	± 0.4	No
Total	100.0	100.0			

$\chi^2 = 8.2$ with 13 degrees of freedom, not significant at the 10.0 percent level

4.8.3 Age

Table 4 shows the age distributions by treatment. Based on the chi-square test statistic, we conclude that the age distribution is not influenced by the type of layout.

Table 4. Age Response Distribution, Grid versus Sequential

Age	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
0-17	19.7	19.9	-0.2	± 1.1	No
18-24	6.9	6.0	0.9	± 0.7	Yes
25-44	23.0	23.0	0.0	± 1.2	No
45-64	31.7	31.7	0.0	± 1.5	No
65+	18.6	19.4	-0.8	± 1.1	No
Total	100.0	100.0			

$\chi^2 = 5.4$ with 4 degrees of freedom, not significant at the 10.0 percent level

4.8.4 Hispanic Origin

For the Hispanic Origin item we used the available response categories to form the Hispanic origin distribution with the exception of recoding some cases where the respondent responded "Other" but wrote in a response in the write-in field that clearly mapped to one of the available Hispanic origin categories. Furthermore, if the respondent indicated two or more Hispanic origins we coded the response into a "two or more" category. Reviewing the Hispanic origin distribution in Table 5, we observe that the distribution is dependent on the questionnaire format.

In addition to reviewing the detailed Hispanic origin distributions, we collapsed the detailed categories into Hispanic/Non-Hispanic to observe whether the Hispanic/Non-Hispanic distribution is dependent on the questionnaire layout. Indeed, we observed a significantly higher reporting of Hispanics for the sequential treatment. Note that the effect that the grid-sequential layout has on the Hispanic/Non-Hispanic distribution may be related to the increase in item nonresponse produced by the grid layout observed in Section 4.2 for the Hispanic origin item. That is, we suspect that the grid layout is causing an increased number of Hispanics to skip the Hispanic origin question.

Table 5. Hispanic, Latino, or Spanish Origin Response Distribution, Grid versus Sequential

Origin	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
Non-Hispanic	94.4	92.7	1.8	± 1.0	Yes
Mexican, Mexican Am., Chicano	3.2	4.2	-1.0	± 0.8	Yes
Puerto Rican	0.7	0.9	-0.1	± 0.4	No
Cuban	0.4	0.7	-0.3	± 0.3	No
Other	1.2	1.5	-0.3	± 0.5	No
2 or more	0.1	0.1	0.0	± 0.1	No
Total	100.0	100.0			

$\chi^2 = 9.8$ with 5 degrees of freedom, significant at the 10.0 percent level

4.8.5 Race

The race item contained 15 response categories with three write-in fields for "American Indian or Alaska Native," Other Pacific Islander," and "Some other race." To calculate the race distributions, we recoded the response categories into seven race groups (white, black, American Indian or Alaskan Native, Asian, Native Hawaiian or Pacific Islander, other race, and two or more races).

Table 6 shows the race distributions by grid-sequential treatment. Reviewing these distributions, we observe that the distributions do not differ between the grid-sequential treatments.

Table 6. Race Distribution, Grid versus Sequential

Race	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
White	85.8	85.0	0.8	± 1.7	No
Black	5.8	6.3	-0.4	± 1.0	No
American Indian or Alaska Native	0.4	0.5	-0.1	± 0.3	No
Asian	4.9	4.4	0.5	± 1.1	No
Native Hawaiian and other Pacific Islanders race groups	0.0	0.2	-0.1	± 0.2	No
Some other race	1.1	1.2	-0.1	± 0.5	No
Two or more races	1.9	2.4	-0.4	± 0.7	No
Total	100.0	100.0			

$\chi^2 = 2.2$ with 5 degrees of freedom, not significant at the 10.0 percent level (Note that the categories for "Native Hawaiian and other Pacific Islanders" and "Asians" were combined to ensure sufficient cell sizes for calculating the χ^2 statistic. These combined categories are not reflected in the estimates above.)

4.9 Do changes in the layout of the basic demographic section of the mail form between grid and sequential affect household size?

To measure household size, two variables were taken into account - the count of persons reported on the cover and the number of persons listed in the basic demographic section. If the two variables were in disagreement, the larger of the two was taken as the household size value. To determine whether the change in questionnaire format produced an effect on the reported household size, we compared the household size distribution, average household size, and median household size between treatments.

Table 7 shows the household size distributions for the grid-sequential treatments. Reviewing the chi-square statistic, we find that the distribution of the number of people per household does not depend on the questionnaire format. In addition, we observe no significant differences between the grid and sequential formats for the individual household sizes (1,2,...,6, 7+ household sizes).

Table 7. Household Size, Grid versus Sequential

Household Size	Grid (%)	Sequential (%)	Difference (%)	Margin of Error (%)	Significant
1-person	27.9	28.0	-0.1	± 1.8	No
2-person	39.5	40.1	-0.7	± 2.0	No
3-person	14.4	14.6	-0.2	± 1.4	No
4-person	11.7	11.1	0.6	± 1.4	No
5-person	4.5	4.1	0.4	± 0.9	No
6-person	1.1	1.2	-0.1	± 0.4	No
7 to 12-person	1.0	0.9	0.1	± 0.4	No
Total	100.0	100.0			

$\chi^2 = 1.7$ with 6 degrees of freedom, not significant at the 10.0 percent level

Comparing the average household size between treatments, we found the average household size to be 2.34 for the grid treatment versus 2.31 for the sequential treatment. As a result, the difference equal to 0.03 was not significant (margin of error = ±0.4 percent). Furthermore, comparing the median household size between treatments, the median household size was 1.56 for the grid treatment versus 1.55 for the sequential treatment. The difference, equal to 0.01, was not significant (margin of error = ±0.04 percent). Based on our comparisons of the household size distribution, average household size, and median household size between treatments, we conclude that the questionnaire layout has no effect on the reported household size.

5. Conclusion

To determine the "best" layout for collecting the basic demographic data on the 2008 ACS questionnaire, the 2007 ACS Grid-Sequential Test compared a number of data quality indicators between the grid and sequential treatments. In addition, we tested whether any shifts in the response distributions were introduced through the layout change. For our defined data quality indicators, the sequential layout either maintained or improved the level of data quality produced. For example, the comparisons between the overall data quality indicators between the two layouts showed that the sequential layout increased the rate of mail response; reduced or maintained the level of missing data; reduced the "person incompleteness" rate and the person count discrepancy rate; and maintained the rate of discontinuation to the detailed person section and the rate of discontinuation to the housing section. When comparing the response distributions for the basic demographic items, changing from the grid to the sequential layout introduced no major shifts in the distributions excluding the sex and Hispanic origin distributions. Note that for the Hispanic origin item, we observed a substantial decrease in the level of missing data for the sequential layout. This likely changed the composition of respondents for this item, thus influencing the Hispanic origin distribution.

Given the relative stability between the grid and sequential estimates coupled with the improvement in some of the quality indicators, we recommended the sequential format for the ACS production questionnaire, starting in January of 2008.

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