RECENT RESEARCH IN REINTERVIEW PROCEDURES

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1. Introduction.

Reinterview procedures are used extensively by the Bureau of the Census for evaluating the quality of censuses and surveys. In particular after both the 1950 Census and the 1960 Census, a large-scale reinterview program was conducted to evaluate the quality of census results. There are two kinds of errors which can affect census data -- coverage errors and content errors. Coverage errors result from persons having been missed or having been counted more than once. Content errors result from the assignment of persons to incorrect classifications in the census tabulations on characteristics of persons who were counted. The reinterview programs conducted after the 1950 and 1960 Censuses were designed, in part, to measure content errors.

However, the kind of reinterview procedure used can itself affect the measurement of the quality of the original results. The purpose of this paper is to evaluate the different kinds of reinterview procedures used in measuring the quality of the 1960 Census and to identify a "best" procedure for use with a census or a nonrecurrent survey. In evaluating the reinterview procedures, two main problems are discussed:

a. The effect of the time lag between the census or survey and the reinterview -- A question frequently asked is whether the time lag between the census and reinterview has a deteriorating effect on the reinterview data. In order to get a partial answer to this question we tried to estimate the effect of having the reinterview three months rather than six months after the Census.

b. The effect of the reinterviewers having access to the original responses -- In many reinterview situations, the reinterview results and the original results are "reconciled." The reinterview responses are compared with the original responses for identical persons and where differences exist, an effort is made, with the help of the respondent, to decide upon the proper response. The reconciliation process may take place at the same time as the reinterview or it may take place at a later time. In the case where the reconciliation is to be done immediately following the reinterview, the reinterviewer is given the original results and told to conduct the reinterview without looking at the original responses. He is then required to compare the responses and to reconcile any differences. He is instructed not to change either the census or the reinterview response, but to enter the reconciled response in a separate place. However, it is thought that the accessibility of the original responses has an effect on the reinterview data. We tried to estimate the effect on the reinterview data and on the measurement of the quality of the census results.

In reference to the first problem, the time lag, our data show that for most characteristics -- age, school enrollment, and number of children -- the additional three months' time lag had no identifiable effect on the data. However, for mobility and income items, a reinterview closer in time to the original interview produced better results.

In reference to the second problem, the accessibility of the original responses, our data show that for characteristics such as age, mobility, type and level of school, and number of children, the situation where the reinterviewer had access to the original results had no identifiable effect on the reinterview data. For school enrollment, educational attainment, and income items, this kind of reinterview procedure had a decided effect on the reinterview data.

In summary, for the purpose of measuring the quality of a census or a nonrecurrent survey, the best kind of reinterview procedure to use is one in which the reinterview is close in time to the census or survey and one in which the reinterviewers are not given access to the original responses.

2. The Model.

The mathematical model underlying this study was developed by Hansen, Hurwitz and Bershad [2]. In this model, the term "survey" is used for either a census or a survey. The survey is regarded as being repeatable, under the same general conditions, in such a way that repetitions relate to the same point in time and such that the results of any one trial are not influenced by any earlier trial. A single census, then, is viewed as a random sample of one trial from among such a set of repetitions, even though, in practice, independent repetitions of the census may be impossible. A reinterview is also viewed as a sample from among this set of repetitions.

With these assumptions, x_{jtG} is defined as a random variable whose value is as follows:

$x_{jtG} = 1$ if the sample person, j, has the characteristic of interest in trial t in a survey conducted under general conditions, G.
$= 0$ otherwise.

Assuming an equal probability selection method, an estimate of the proportion of the population having this characteristic is:

$$p_{tG} = \frac{1}{n_t} \sum_{j}^{n_t} x_{jtG} \qquad (1)$$

where n_t is the number of persons in the sample in trial t, and G specifies the general conditions under which the survey takes place. The general conditions are composed of several factors -- the kind of questionnaire used, the training and instructions to interviewers, the method of payment of the interviewers, the time of the year during which the interviews were conducted, the sponsor of the survey, and other related items.

a. <u>The gross difference rate and simple response variance</u>[1].

Let $E\ p_{tG} = P_G$ be the expected value over all samples of persons and all trials. Now think of repeated measurements on one person in the population, say the j-th person. This conditional expected value is:

$$E\ x_{jtG} = P_{jG} \qquad (2)$$

The response deviation for a given sample person is:

$$d_{jtG} = x_{jtG} - P_{jG}, \qquad (3)$$

the difference between the measurement for the j-th person on the t-th trial and the expected value for that person over all trials.

Using this notation, Hansen, Hurwitz and Bershad defined the response variance as:

$$\sigma^2_{\bar{d}G} = \frac{1}{n} E\ d^2_{jtG} + \frac{(n-1)}{n} E(d_{jtG} d_{ktG}) \qquad (4)$$

Now, $\sigma^2_{dG} = E(d_{jtG} - E\ d_{jtG})^2$ by definition. From equation (3), it is obvious that $E\ d_{jtG} = 0$. So

$$\sigma^2_{dG} = E\ d^2_{jtG}. \qquad (5)$$

Also, $\rho_{dG} = \dfrac{E(d_{jtG} d_{ktG})}{\sigma^2_{dG}}$. With these definitions, equation (4) becomes:

$$\sigma^2_{\bar{d}G} = \frac{\sigma^2_{dG}}{n} + \frac{(n-1)}{n} \rho_{dG} \sigma^2_{dG} \qquad (6)$$

In the first term is the simple response variance which reflects the basic trial-to-trial variability in response. In the second term is the correlated response variance which reflects the correlation among the response deviations within a trial. In this study, we are interested only in the simple response variance.

From equation (5),

$$\sigma^2_{dG} = E\ d^2_{jtG} = E(x_{jtG} - P_{jG})^2 = E\ x^2_{jtG} + E\ P^2_{jG} - 2\ EP_{jG} x_{jtG}. \qquad (7)$$

Since x_{jtG} is a zero-one variate, $x^2_{jtG} = x_{jtG}$. Then the expected value over trials for a fixed person is

$$\begin{aligned} \sigma^2_{dG} &= E\ x_{jtG} + E\ P^2_{jG} - 2\ EP_{jG} x_{jtG} \\ &= E\ P_{jG} + E\ P^2_{jG} - 2\ EP^2_{jG} \\ &= E(P_{jG} - P^2_{jG}) \end{aligned} \qquad (8)$$

Now, when these values are averaged over all persons in the population, the simple response variance is:

$$\sigma^2_{dG} = \frac{1}{N} \sum_{j}^{N} P_{jG}(1 - P_{jG}). \qquad (9)$$

We are now interested in getting an estimate of σ^2_{dG}. For each person included in a reinterview study, we have the original census measurement (x_{jtG}) as well as the reinterview measurement ($x_{jt'G'}$). For each person, we can get the difference, $x_{jtG} - x_{jt'G'}$. Then, let

$$g = \frac{1}{n} \sum_{j}^{n} (x_{jtG} - x_{jt'G'})^2 \qquad (10)$$

$$E(g) = \frac{n}{n} E(x_{jtG} - x_{jt'G'})^2 \qquad (11)$$

$$= E(x^2_{jtG}) + E(x^2_{jt'G'}) - 2\ E(x_{jtG} x_{jt'G'}) \qquad (12)$$

Since x_{jtG} and $x_{jt'G'}$ are zero-one variates, $x^2_{jtG} = x_{jtG}$ and $x^2_{jt'G'} = x_{jt'G'}$.

Then, $E(g) = Ex_{jtG} + Ex_{jt'G'} - 2Ex_{jtG} x_{jt'G'}$ (13)

If the survey conditions, G and G', are the same, and if the two trials, t and t', are independent, then equation (13) becomes:

$$E(g) = 2\ E\ P_{jG} - 2\ E(P^2_{jG}) \qquad (14)$$

$$= 2\left[\frac{1}{N} \sum_{j}^{N} P_{jG} - \frac{1}{N} \sum_{j}^{N} P^2_{jG}\right]$$

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[1] The discussion of the gross-difference rate and simple response variance is based on <u>The Estimation and Interpretation of Gross Differences and the Simple Response Variance</u>, by Hansen, Hurwitz and Pritzker.

$$E(g) = \frac{2 \sum_{j}^{N} P_{jG}(1 - P_{jG})}{N} \qquad (15)$$

Thus, $E(g) = 2\,\sigma^2_{dG}$.

However, as pointed out after equation (13), $E(g) = 2\,\sigma^2_{dG}$ is true only when G and G' are the identical survey conditions and the census and reinterview measurements on identical persons are independent. Hansen, Hurwitz and Pritzker [3] point out that g/2 will be a poor estimator of σ^2_{dG} whenever there is a large positive correlation among the response deviations on the census and the reinterview. The reason for this is as follows. From equation (11) we have

$$E(g) = E(x_{jtG} - x_{jt'G'})^2$$

$$= E[(x_{jtG} - P_{jG}) - (x_{jt'G'} - P_{jG'}) + (P_{jG} - P_{jG'})]^2 \qquad (16)$$

$$= E(x_{jtG} - P_{jG})^2 + E(x_{jt'G'} - P_{jG'})^2 - 2E(x_{jtG} - P_{jG})(x_{jt'G'} - P_{jG'}) + E(P_{jG} - P_{jG'})^2 \qquad (17)$$

and the remaining two cross-product terms vanish. Then,

$$E(g) = \sigma^2_{dG} + \sigma^2_{dG'} - 2\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} + E(P_{jG} - P_{jG'})^2 \qquad (18)$$

where

$$\rho_{dG,dG'} = \frac{E(x_{jtG} - P_{jG})(x_{jt'G'} - P_{jG'})}{\sigma_{dG}\sigma_{dG'}}$$

Now, if the census conditions, G, and the reinterview conditions, G', are identical $P_{jG} = P_{jG'}$, and the last term will drop out. Also $\sigma^2_{dG} = \sigma^2_{dG'}$, so that

$$E(g) = 2\sigma^2_{dG} - 2\rho_{dG,dG'}\sigma^2_{dG}$$

$$= 2\sigma^2_{dG}(1 - \rho_{dG,dG'}) \qquad (19)$$

Therefore, where the reinterview measurements are not independent of the census measurements, g/2 is an understatement of the simple response variance by the amount of the between-trial covariance of response deviations. Estimates of this covariance are presented in Section 4.

Disregarding this covariance term, let us see how σ^2_{dG} can be estimated from the data available. The diagram below shows the results of the comparison of the census data with the reinterview data.

Diagram A.--COMPARISON OF RESULTS OF CENSUS AND REINTERVIEW FOR IDENTICAL PERSONS

Reinterview results	Census results		
	$x_{jtG} = 1$	$x_{jtG} = 0$	Total
$x_{jt'G'} = 1$	a	b	a+b
$x_{jt'G'} = 0$	c	d	c+d
Total	a+c	b+d	n

From equation (10) we have

$$g = \frac{1}{n}\sum_{j}^{n} x^2_{jtG} + \frac{1}{n}\sum_{j}^{n} x^2_{jt'G'} - \frac{2}{n}\sum_{j}^{n} x_{jtG}x_{jt'G'}$$

$$= \frac{1}{n}\sum_{j}^{n} x_{jtG} + \frac{1}{n}\sum_{j}^{n} x_{jt'G'} - \frac{2}{n}\sum_{j}^{n} x_{jtG}x_{jt'G'} \qquad (20)$$

Substituting the appropriate values shown in Diagram A for the quantities in equation (20) we have:

$$g = \frac{a+c}{n} + \frac{a+b}{n} - \frac{2a}{n}$$

$$= \frac{b+c}{n} \qquad (21)$$

This is the equation for the gross-difference rate.

b. Net-difference rate.

In evaluating a census statistic, we are interested in the square of the bias as well as the variance of that statistic. If we view the reinterview as providing a standard measurement, then the bias of a census statistic is the expected value of the census measurement minus the expected value of the reinterview measurement. (The reinterview may provide better measurements for items such as income, where the respondent is asked many detailed questions. He may tend to report things that he did not think of when answering the census question.) The bias then is $E\,p_{tG} - E\,p_{t'G'}$. The estimate of bias is $p_{tG} - p_{t'G'}$. However,

$$p_{tG} - p_{t'G'} = \frac{1}{n}\sum_{j}^{n} x_{jtG} - \frac{1}{n}\sum_{j}^{n} x_{jt'G'} \qquad (22)$$

Using the notation of Diagram A, equation (22) becomes

$$\frac{a+c}{n} - \frac{a+b}{n} = \frac{c-b}{n} \qquad (23)$$

This term, which is an estimate of the bias of the census statistic, is referred to as the net-difference rate.

Using the gross- and net-difference rates as estimators of the simple response variance and bias, respectively, we shall try to evaluate different kinds of reinterview procedures.

3. The Study Design.

The 1960 Census provided an opportunity to evaluate different kinds of reinterview procedures. Each person selected in one of the reinterview samples was a person who had been enumerated in the census. In fact, the person had been included in the 25 percent of the population who had been asked to give census information on migration, education, number of children, labor force, and income. So the original interview was the census interview taken under prevailing census conditions.

Because the reinterview samples were much smaller than the census, they could be handled on a more intensive basis. First, the reinterviewers were hired on a more selective basis than the census interviewers. Second, the training of these reinterviewers was carefully done by a few Washington personnel. Third, the reinterview questionnaire was a very detailed one. From a combination of superior interviewers with intensive training on a detailed questionnaire, we hoped to get answers which could be regarded as being of higher quality than those obtained in the census.

In order to evaluate the different types of reinterview procedures, three independent, multistage probability samples of the 1960 Census enumerated population were selected.

Sample I was a selection of 396 1960 Census Enumeration Districts (EDs) from a selection of 148 primary sampling units (PSUs).[2] Within each ED, a cluster of housing units was selected and all the persons within the housing units were included in the reinterview sample. The sample consisted of about 4,900 persons in 1,450 housing units.

A second sample of 1,003 EDs in 268 PSUs was selected. This sample was split into two parts, one housing unit being designated as Sample II and the next housing unit in the sample being designated as Sample III. Each sample was composed of about 5,450 persons in 1,650 housing units.

Following the sample selection, persons to do the reinterviewing were hired. Interviewers from the Current Population Survey (CPS) were given first priority. These people were part of a permanent staff of highly trained and closely supervised interviewers. If a CPS interviewer was not available, a census interviewer who had been recommended as doing a particularly good job in the census was hired. The reinterviewers were given intensive training on the reinterview questionnaire by Bureau of the Census personnel. This was in contrast to the training of the census interviewers which was several times removed from the original Washington training personnel.

In addition to the differences in the kinds of interviewers hired, the training given, and the type of questionnaire, there were also other differences between the census and the reinterview situations. For example, information at the reinterview was obtained from the best respondent in the household (usually the person himself), whenever possible, instead of just any responsible member of the household, as in the census. Also, interviewers were supervised more closely than in the census, and their pay was on an hourly basis rather than on a piece-rate basis.

In July, 1960, the reinterviews for Sample I were conducted. The reinterviewers had no knowledge of the census responses for the sample persons. After the field work was completed, a comparison of the census and reinterview responses for identical persons was made by regular census personnel. Where differences were found, a census subject-matter specialist reviewed the case. It was that specialist who decided whether a reconciliation of the census and reinterview answers was to be attempted by another interview with the sample person. However, even if there was a large discrepancy, the case was not always reconciled. The reconciliation was to be done in October, at the same time as the reinterviews for the other two samples. If the reconciliation case was in an area distant from the areas where the other samples were located, the reconciliation was not attempted.

In October, 1960, the reinterviews for Samples II and III were conducted. In Sample II, the reinterviewers were supplied with the census data for the sample persons. They were instructed to complete the reinterview questionnaire, then to look at the census responses and try to reconcile any differences between the census and reinterview answers. This was the "on-the-spot" reconciliation process.

In Sample III, the reinterviewers were not supplied with the census responses for the sample persons. They were instructed to complete the reinterview and leave the household. No reconciliation of census and reinterview data was ever attempted.

From the three samples, we have available five sets of data as shown below.

Samples	Unreconciled responses	Reconciled responses
Sample I	D_{11} (July)	D_{12} (October)
Sample II	D_{21} (October)	D_{22} (October)
Sample III	D_3 (October)	---

2 The 3,103 counties and independent cities in the United States were combined into 1,891 PSUs, each PSU being one or more contiguous counties. Three hundred and thirty-three of these PSUs were included in the Current Population Survey at the time of the 1960 Census. It was from these 333 that the sample of 148 PSUs was selected.

D_{11} refers to data from Sample I, before reconciliation; D_{12} to Sample I after reconciliation; D_{21} to Sample II before reconciliation, and so forth. The data fall into three categories: (1) gross-difference rates, (2) net-difference rates, and (3) standard errors of differences between gross-difference rates or between net-difference rates.

By making appropriate comparisons among the five sets of data, we have evaluated the reinterview procedures. However, there are limitations to the data. Some of these are as follows:

a. There was a difference among the samples in the number of non-interview cases. The percentage of non-interview cases by sample is shown below:

Sample I	6.2%
Sample II	11.4%
Sample III	10.1%

The non-interview rate for Sample I looks considerably lower than for Samples II and III. The non-interview rate for Sample I was originally very high. All households for which there were no responses in July were included with the enumeration of Sample II in October. Therefore, some Sample I cases were given two chances for responding.

b. Some differences among the samples arose in processing the data. Samples I and II were processed at the same time. All census, original reinterview, and final, reconciled, reinterview answers were coded to special FOSDIC[3] data sheets, which were, in turn, converted to magnetic tapes. A series of detailed computer edits were performed on the data in order to insure the quality of the transcription and coding process. Specially trained clerks checked the original documents for cases failing edit. A correction process was instituted for the cases needing correction after edit.

Two years later, data for Sample III were transcribed and coded. Instructions were altered to take into account the lack of reconciliation in Sample III. The same computer edits were performed on the coded data and, where possible, the same kind of edit correction process was carried out. However, the two-year gap, revised instructions, and different clerks may have caused a change in the results for some items.

All characteristics were studied carefully for possible processing differences. One item which was known to exhibit differences due to processing was omitted from the analysis which follows. With the exception of that item, the remaining characteristics did not show any differences which were known to have been caused by processing.

c. Because the data are based on samples, comparisons among them are limited by the sample size. Perhaps some differences which exist among the sets of data are not apparent because of the sample size.

[3] FOSDIC stands for Film Optical Sensing Device for Input to Computers.

d. Where there was no reconciliation of census and reinterview data, we assumed independence between the reinterview and census interview. The assumption is not correct due to the "conditioning" effect of repeated interviewing of the same household. (See [6] for some results on conditioning effects on collection of expenditures data.) However, the conditioning effect is probably small in comparison with the reconciliation effect.

4. Estimation of the Between-Trial Covariance.

As mentioned in Section 2, the estimates of the simple response variance provided by g/2 are poor whenever there is a high correlation among the response deviations on the census and on the reinterview. With the five sets of data available it is possible to get an estimate of an upper-bound for this between-trial covariance under different reinterview procedures.

Suppose we are given that G' is an improved procedure over G. In general, G' is an improved procedure over G when:

$$\begin{aligned} &\text{for} \quad P_{jG} > .5 \qquad P_{jG'} > P_{jG} \\ &\text{for} \quad P_{jG} < .5 \qquad P_{jG'} < P_{jG} \end{aligned} \tag{24}$$

Suppose, that G reflected the census conditions and G' the conditions of the reinterview.

Let g_{11} be the gross-difference rate estimated from the comparison of census responses with the responses from Sample I before reconciliation. Let g_{22} be the gross-difference rate estimated from the comparison of census responses with the reconciled Sample II responses. We shall view the reconciled reinterview as an improved procedure. Using equation (11) we have

$$\begin{aligned} E(g_{22}) &= E(x_{jtG} - x_{jt'G'})^2 \\ &= E[(x_{jtG}-P_G)-(x_{jt'G'}-P_{G'})+(P_G-P_{G'})]^2 \\ &= E(x_{jtG}-P_G)^2 + E(x_{jt'G'}-P_{G'})^2 + (P_G-P_{G'})^2 \\ &\quad - 2E(x_{jtG} - P_G)(x_{jt'G'} - P_{G'}) \end{aligned} \tag{25}$$

We have seen that

$E(x_{jtG}-P_G)^2 = P_G(1-P_G)$ and $E(x_{jt'G'}-P_{G'})^2 = P_{G'}(1-P_{G'})$. Then, adding and subtracting P_{jG} and $P_{jG'}$ in the last term of equation (25):

$$\begin{aligned} E(g_{22}) &= P_G(1-P_G) + P_{G'}(1-P_{G'}) + (P_G-P_{G'})^2 \\ &\quad - 2E(x_{jtG}-P_{jG})(x_{jt'G'}-P_{jG'}) \\ &\quad - 2E(P_{jG}-P_G)(P_{jG'}-P_{G'}) \end{aligned} \tag{26}$$

Since

$$\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} = E(x_{jtG}-P_{jG})(x_{jt'G'}-P_{jG'}),$$

the between-trial covariance of response deviations,

$$\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} = \tfrac{1}{2}[P_G(1-P_G)+P_{G'}(1-P_{G'})+(P_G-P_{G'})^2 - E(g_{22})]-E(P_{jG}-P_G)(P_{jG'}-P_{G'}) \quad (27)$$

Hansen, Hurwitz and Pritzker [3] show that

$$E(P_{jG}-P_G)(P_{jG'}-P_{G'}) > \sigma^2_{P_{jG}}+(.5-P_G)(P_{G'}-P_G) \quad (28)$$

where $\sigma^2_{P_{jG}} = E(P_{jG} - P_G)^2$

is the sampling variance. Since the total variance is the sum of response variance and the sampling variance

$$\sigma^2_{P_{jG}} = P_G(1 - P_G) - \sigma^2_{dG}. \quad (29)$$

Then,

$$\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} < \tfrac{1}{2}[P_G(1-P_G)+P_{G'}(1-P_{G'})+(P_G-P_{G'})^2 - E(g_{22})] - P_G(1-P_G) + \sigma^2_{dG} - (.5-P_G)(P_{G'}-P_G) \quad (30)$$

When all terms are multiplied out, equation (30) becomes:

$$\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} < \sigma^2_{dG} - \tfrac{1}{2}E(g_{22}) \quad (31)$$

From the data of Sample I before reconciliation, a good estimate of σ^2_{dG} can be made. This estimate is:

$$\tfrac{1}{2}E(g_{11}) = \sigma^2_{dG}. \quad (32)$$

Therefore, an upper bound for the between-trial covariance among response deviations can be estimated by:

$$\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} < \tfrac{1}{2}E(g_{11} - g_{22}) \quad (33)$$

We are able to get several estimates of this between-trial covariance since we have five sets of data. The sets can be ordered, in an arbitrary way, by the degree of dependence between the original interview and the reinterview. The assumption is made that the two sets of data before reconciliation are less dependent than the two sets of data after reconciliation and that the data from an "on-the-spot" reconciliation process are the most dependent. Diagram B shows the ordering.

Diagram B.
ORDERING OF SETS OF DATA BY ANTICIPATED DECREASING DEGREE OF DEPENDENCE OF REINTERVIEW ON CENSUS INTERVIEW

Set of data	Survey conditions	Gross-difference rate
Sample II: After reconciliation	G_{22}	g_{22}
Sample I: After reconciliation	G_{12}	g_{12}
Sample II: Before reconciliation	G_{21}	g_{21}
Sample I: Before reconciliation	G_{11}	g_{11}
Sample III:	G_3	g_3

G_{11} and G_3 were both survey conditions in which the reconciliation process did not affect the reinterview results. $g_{11}/2$ was selected to provide the estimate of σ^2_{dG} in the estimation of the upper bound for the between-trial covariance.

G_{21} was a set of survey conditions in which the reinterviewer had the census data with him during the reinterview. The estimate of the between-trial covariance provided by $(g_{11}-g_{21})/2$ will show the degree of dependence due to the reinterviewers having access to the census data. Similarly, $(g_{11}-g_{12})/2$ will show the effect of an independent reconciliation process; and $(g_{11}-g_{12})/2$ will show the effect of an "on-the-spot" reconciliation process.

Let us look at the results of this kind of comparison. Table I which follows shows this kind of comparison for two characteristics -- educational attainment and other income, females. The upper bounds for the covariance appear in columns (6), (7) and (8). The ratios shown in columns (9), (10) and (11) are estimates of $\rho_{dG,dG'}$ if the simple response variances under all the varying reinterview conditions are the same. We would expect the estimates from Sample II after reconciliation to exhibit the largest covariance estimates. This holds true for eight of the 15 educational attainment items and ten of the 15 income items.

Another thing apparent from this limited comparison is that, in some instances, Sample II before reconciliation exhibits more dependence (a higher covariance estimate) than does Sample I after reconciliation. For eight of the 15 education items, and 11 of the 15 income items, the covariance from Sample II before reconciliation is at least as large or larger than the covariance from Sample I after reconciliation. This is an indication that the reinterviewers having access to the census data, even before reconciling differences, provides a dependent situation. This corresponds to the findings in the Current Population Survey. Practically speaking, if g/2 is used as an estimate of the simple response variance, where g is estimated from a reinterview situation where the reinterviewers have access to the original responses, the value will be underestimated.

It may be of more interest to compare estimates of the upper bound for the between-trial covariance for an item as a whole, rather than for each category within an item. In order to get a gross-difference rate per item, the gross-difference rates over all categories within an item were averaged. Table 2 which follows shows the average gross-difference rates, estimates of the upper bounds for the between-trial covariances, and ratios of the estimates of the upper bounds to the estimate of the simple response variance for an item.

Table 1.--COMPARISON OF ESTIMATES OF THE UPPER BOUNDS OF THE BETWEEN-TRIAL COVARIANCE AMONG RESPONSE DEVIATIONS FOR DIFFERENT DEGREES OF DEPENDENCE BETWEEN CENSUS AND REINTERVIEW

Characteristics	Estimated gross-difference rates				Estimated simple response variance	Estimated upper bounds of covariance			Ratio of estimators		
	Sample I		Sample II								
	Unreconciled g_{11}	Reconciled g_{12}	Unreconciled g_{21}	Reconciled g_{22}	$g_{11}/2$	$\frac{(g_{11}-g_{12})}{2}$	$\frac{(g_{11}-g_{21})}{2}$	$\frac{(g_{11}-g_{22})}{2}$	(6)÷(5)	(7)÷(5)	(8)÷(5)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Educational Attainment:											
No school..............	.0132	.0094	.0120	.0104	.0066	.0019	.0006	.0014	.29	.09	.21
Elementary 1-2 years....	.0156	.0118	.0128	.0118	.0078	.0019	.0014	.0019	.24	.18	.24
3-4 years....	.0378	.0306	.0346	.0320	.0189	.0036	.0016	.0029	.19	.08	.15
5-6 years....	.0558	.0456	.0424	.0392	.0279	.0051	.0067	.0083	.18	.24	.30
7 years....	.0574	.0498	.0520	.0462	.0287	.0038	.0027	.0056	.13	.09	.20
8 years....	.1080	.0940	.0742	.0746	.0540	.0070	.0169	.0167	.13	.31	.31
High School 1 year.....	.0712	.0542	.0450	.0444	.0356	.0085	.0131	.0134	.24	.37	.38
2 years....	.0662	.0504	.0554	.0506	.0331	.0079	.0054	.0078	.24	.16	.24
3 years....	.0460	.0388	.0500	.0480	.0230	.0036	-.0020	-.0010	.16	-.09	-.04
4 years....	.0804	.0674	.0796	.0764	.0402	.0065	.0004	.0020	.16	.01	.05
College 1 year.....	.0346	.0270	.0236	.0230	.0173	.0038	.0055	.0058	.22	.32	.34
2 years....	.0354	.0294	.0180	.0190	.0177	.0030	.0087	.0082	.17	.49	.46
3 years....	.0202	.0160	.0130	.0116	.0101	.0021	.0036	.0043	.21	.36	.43
4 years....	.0216	.0204	.0152	.0140	.0108	.0006	.0032	.0038	.06	.30	.35
5 years or more....	.0154	.0122	.0104	.0059	.0077	.0016	.0025	.0047	.21	.32	.61
Other Income, Females:											
No income..............	.1604	.1482	.1314	.1152	.0802	.0061	.0145	.0226	.08	.18	.28
$1 to $499 or loss......	.1382	.1238	.1014	.0894	.0691	.0072	.0184	.0244	.10	.27	.35
$500 to $999............	.0724	.0674	.0544	.0470	.0362	.0025	.0090	.0127	.07	.25	.35
$1,000 to $1,499........	.0284	.0272	.0332	.0282	.0142	.0006	-.0024	.0001	.04	-.17	.01
$1,500 to $1,999........	.0224	.0192	.0162	.0146	.0112	.0016	.0031	.0039	.14	.28	.35
$2,000 to $2,499........	.0136	.0132	.0116	.0104	.0068	.0002	.0010	.0016	.03	.15	.24
$2,500 to $2,999........	.0092	.0092	.0034	.0026	.0046	.0000	.0029	.0033	.00	.63	.72
$3,000 to $3,499........	.0026	.0026	.0026	.0024	.0013	.0000	.0000	.0001	.00	.00	.08
$3,500 to $3,999........	.0024	.0024	.0012	.0010	.0012	.0000	.0006	.0007	.00	.50	.58
$4,000 to $4,499........	.0010	.0004	.0000	.0006	.0005	.0003	.0005	.0002	.60	1.00	.40
$4,500 to $4,999........	.0026	.0020	.0004	.0004	.0013	.0003	.0011	.0011	.23	.85	.85
$5,000 to $5,999........	.0006	.0006	.0012	.0012	.0003	.0000	-.0003	-.0003	.00	-1.00	-1.00
$6,000 to $6,999........	.0006	.0006	.0000	.0000	.0003	.0000	.0003	.0003	.00	1.00	1.00
$7,000 to $9,999........	.0000	.0000	.0012	.0012	.0000	.0000	-.0006	-.0006	.00	undefined	undefined
$10,000 and over........	.0000	.0000	.0006	.0006	.0000	.0000	-.0003	-.0003	.00	undefined	undefined

Table 2.--ESTIMATES OF THE AVERAGE GROSS-DIFFERENCE RATES AND OF UPPER BOUNDS FOR BETWEEN-TRIAL COVARIANCE BY ITEM FOR DIFFERENT DEGREES OF DEPENDENCE BETWEEN CENSUS AND REINTERVIEW

Characteristics	Estimated average gross-difference rates				Estimated simple response variance	Estimated upper bounds of covariance			Ratio of estimators		
	Sample I		Sample II								
	Unreconciled g_{11}	Reconciled g_{12}	Unreconciled g_{21}	Reconciled g_{22}	$g_{11}/2$	$\frac{(g_{11}-g_{12})}{2}$	$\frac{(g_{11}-g_{21})}{2}$	$\frac{(g_{11}-g_{22})}{2}$	(6)÷(5)	(7)÷(5)	(8)÷(5)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Sex..........................	.0121	.0081	.0092	.0096	.0060	.0020	.0014	.0012	.33	.23	.20
Color........................	.0082	.0051	.0041	.0037	.0041	.0016	.0020	.0022	.39	.49	.54
Male age.....................	.0049	.0043	.0059	.0055	.0024	.0003	-.0005	-.0003	.12	-.21	-.12
Female age...................	.0050	.0046	.0055	.0052	.0025	.0002	-.0002	-.0001	.08	-.08	-.04
White age....................	.0046	.0043	.0049	.0047	.0023	.0002	-.0002	.0000	.09	-.09	.00
Nonwhite age.................	.0077	.0063	.0123	.0110	.0038	.0007	-.0023	-.0016	.18	-.60	-.42
White male age...............	.0045	.0040	.0049	.0049	.0022	.0002	-.0002	-.0002	.09	-.09	-.09
White female age.............	.0047	.0045	.0047	.0045	.0024	.0001	.0000	.0001	.04	.00	.04
Nonwhite male age............	.0065	.0059	.0124	.0109	.0032	.0003	-.0030	-.0022	.09	-.94	-.69
Nonwhite female age..........	.0081	.0059	.0123	.0112	.0040	.0011	-.0021	-.0016	.28	-.52	-.40
1955 residence...............	.0248	.0220	.0308	.0264	.0124	.0014	-.0030	-.0008	.11	-.24	-.06
Type and level school........	.0176	.0164	.0222	.0130	.0088	.0006	-.0023	.0023	.07	-.26	.26
School enrollment............	.0246	.0214	.0394	.0145	.0123	.0016	-.0074	.0050	.13	-.20	.41
Educational attainment.......	.0453	.0371	.0359	.0338	.0226	.0041	.0047	.0058	.18	.21	.26
Number children..............	.0153	.0124	.0132	.0126	.0076	.0014	.0010	.0014	.18	.13	.18
Total income, all............	.0512	.0499	.0453	.0425	.0256	.0006	.0030	.0044	.02	.12	.17
Total income, males..........	.0549	.0568	.0515	.0496	.0274	-.0010	.0017	.0026	-.04	.06	.09
Total income, females........	.0449	.0427	.0387	.0359	.0224	.0011	.0031	.0045	.05	.14	.20
Self-employed income, males..	.0169	.0160	.0154	.0136	.0084	.0004	.0008	.0016	.05	.10	.19
Self-employed income, females	.0039	.0035	.0040	.0031	.0020	.0002	.0000	.0004	.10	.00	.20
Other income, males..........	.0383	.0355	.0312	.0277	.0192	.0014	.0036	.0053	.07	.19	.28
Other income, females........	.0303	.0278	.0239	.0210	.0152	.0012	.0032	.0046	.08	.21	.30

Some things are immediately apparent from Table 2.

a. The independent reconciliation process is an improved procedure over a process in which there is no reconciliation at all. This is illustrated by the figures in column (6) which show positive estimates of the between-trial covariance for all but one item.

b. Sample II age classifications behaved in a peculiar way, especially for nonwhite groups. This was probably due to some kind of processing difference.

c. For 13 of the 22 items, data from Sample II after reconciliation produced the highest covariance estimates. If the age items are omitted, data from Sample II after reconciliation produced the highest estimates for 12 of the 14 remaining items.

d. Again, omitting the age items, the estimates of covariance are higher for eight of the 14 remaining items for the Sample II data before reconciliation than the Sample I data after reconciliation.

It seems clear from the data above that the way to get a good estimate of the simple response variance is to use unreconciled data from a procedure where the reinterviewers had no knowledge of the original responses.

5. Effect of Time Lag Between Census and Reinterview.

It was thought that a reinterview that occurred several months after the original interview might not provide data as accurate as could be obtained by having the reinterview closer to the original interview. In this part of the study we were able to compare data based on a match of reinterview and census data for identical persons when the reinterview was three months after the census interview and when the reinterview was six months after the census interview.

As explained in Section 3, the persons in Sample I were reinterviewed in July, 1960 -- about three months after the census interview; the persons in Sample III were reinterviewed in October, 1960 -- about six months after the census interview. In neither of these samples did the reinterviewer have access to the census data. We can compare g_{11} and g_3 (gross-difference rates) and b_{11} and b_3 (net-difference rates) to measure the effect of the time lag.

Ideally we would like to be able to identify a reinterview procedure which is "better" than other reinterview procedures. However, determining what "better" is presents difficulties. We would prefer a reinterview procedure that had a smaller simple response variance than any other procedure. Let us return to some of the estimators of response variance in Section 2 for help in identifying what a "better" procedure is. The expected value of the gross-difference rate from equation (17) was:

$$E(g) = E(x_{jtG}-P_{jG})^2+E(x_{jt'G'}-P_{jG'})^2+E(P_{jG}-P_{jG'})^2 - 2E(x_{jtG}-P_{jG})(x_{jt'G'}-P_{jG'}) \qquad (17)$$

Adding and subtracting the same term and rearranging the terms gives

$$\begin{aligned} E(g) = {} & E(x_{jtG}-P_{jG})^2 + E(x_{jt'G'}-P_{jG'})^2 \\ & - 2E(x_{jtG}-P_{jG})(x_{jt'G'}-P_{jG'}) \\ & + [E(P_{jG}-P_{jG'})]^2 + E(P_{jG}-P_{jG'})^2 \\ & - [E(P_{jG}-P_{jG'})]^2 \end{aligned} \qquad (34)$$

The third term from the end is equal to the square of the bias $(B)^2$. The last two terms together are equal to the variance of $(P_{jG}-P_{jG'})$. Equation (34) may be expressed as:

$$\begin{aligned} E(g) = {} & \sigma^2_{dG} + \sigma^2_{dG'} - 2\rho_{dG,dG'}\sigma_{dG}\sigma_{dG'} + (B)^2 \\ & + Var(P_{jG} - P_{jG'}) \end{aligned} \qquad (35)$$

Then, making the assumption that $Var(P_{jG}-P_{jG'})$ is very small, we can express the expected value of the gross-difference rate from Sample I as:

$$E(g_{11}) = \sigma^2_{dG}+\sigma^2_{dG_{11}} -2\rho_{dG,dG_{11}}\sigma_{dG}\sigma_{dG_{11}} +B^2_{11} \qquad (36)$$

The expected value of the gross-difference rate from Sample III can be expressed in a similar fashion. However, for both these samples, the between-trial covariance is relatively small, since the reinterviewer did not have access to the census data. So, for the purposes of this section, we will drop the covariance term. Then we have:

$$\begin{aligned} E(g_{11}) &= \sigma^2_{dG} + \sigma^2_{dG_{11}} + B^2_{11} \\ E(g_3) &= \sigma^2_{dG} + \sigma^2_{dG_3} + B^2_3 \end{aligned} \qquad (37)$$

We have estimates of g_{11}, g_3, B_{11} and B_3 from the samples. Using those estimates in the following equations:

$$\begin{aligned} E(g_{11}) - B^2_{11} &= \sigma^2_{dG} + \sigma^2_{dG_{11}} \\ E(g_3) - B^2_3 &= \sigma^2_{dG} + \sigma^2_{dG_3} \end{aligned} \qquad (38)$$

we see that if $E(g_{11}) - B^2_{11}$ is greater than $E(g_3) - B^2_3$ this implies that the simple response variance of Sample I is greater than the simple response variance of Sample III.

We see, then, that if the gross-difference rates for the two samples are the same for a given item but one net-difference rate is much larger than the other, the procedure which produces the larger net-difference rate is the "better" procedure. Similarly, if the net-difference rates for a given item are about the same for both procedures, the procedure producing the smaller gross-difference rate is the "better" procedure.

In order to compare the gross- and net-difference rates of Sample I with those of Sample III the variances of the gross and net differences were computed. It has been shown [1] that an estimate of the sampling variance of the gross-difference rate is:

$$\mathrm{Var}(g) = g/n - g^2/n \qquad (39)$$

The assumptions for this estimate to be valid are: (1) simple random sampling, (2) independence of the two measurements on the elements, and (3) uncorrelated response deviations. These conditions are not fully met, so the estimates of variances will be underestimates. Since g^2/n is small in comparison with g/n, the last term was not used in computing the variance. The sampling variance of the net-difference rate is also g/n. Then, since Samples I and III are independent, the sampling variance of the difference between the gross-difference rates (or the net-difference rates) is the sum of the estimated variances for each of the samples.

The results of the comparison of gross- and net-difference rates for Samples I and III showed that for most items, we could detect no difference between Samples I and III. However, for some items, some very interesting differences were found.

First, gross-difference rates for all items for both samples were compared and then the net-difference rates were compared. The type of problem that arose in making the comparisons is shown in Table 3 which follows. In this table the gross-difference rates for "nonwhite male age" were compared. Consider the category "50 to 54 years." The difference between the gross-difference rates, as shown in column (5), was -.0004. This seems like a very small difference and we might immediately decide the two reinterview procedures did not differ very much for that item. However, the standard error of that difference, in column (6), is .0099. With a standard error that large, it is impossible for us to make any definitive statement about the difference between the gross-difference rates.

Now, look at the cateogy "40 to 44 years." Here the difference between gross-difference rates is -.0166. This looks like a very large difference and we might conclude that the two reinterview procedures are producing very different results for that category. However, a glance at the standard error of the difference, .0103, shows that even though the estimated difference is large, the standard error of the difference is so large that again we can't make any definitive statment about the difference between the gross-difference rates.

If two reinterview procedures actually produced gross-difference rates as different as those shown in Table 3, we would like to be able to identify the procedure producing lower gross-difference rates. However, in every case, we must say that the sample size is not large enough to permit us to identify differences between the gross-difference rates. The same kind of situation occurred for all age items studied. Since we were also not able to differentiate between the net-difference rates for age items, we have no reason to prefer one procedure over the other, at least for age items.

Table 3.--COMPARISON OF GROSS-DIFFERENCE RATES FOR SAMPLES I AND III FOR NONWHITE MALE AGE

Category	g_{11} [1] (1)	$s_{g_{11}}$ (2)	g_3 [2] (3)	s_{g_3} (4)	$g_{11}-g_3$ (5)	$s_{g_{11}-g_3}$ (6)
0 to 4 years.............	.0162	.0079	.0084	.0060	.0078	.0099
5 to 9 years.............	.0114	.0066	.0084	.0060	.0030	.0089
10 to 14 years............	.0076	.0054	.0000	.0000	.0076	.0054
15 to 19 years............	.0124	.0068	.0000	.0000	.0124	.0068
20 to 24 years............	.0000	.0000	.0082	.0060	-.0082	.0060
25 to 29 years............	.0090	.0059	.0166	.0085	-.0076	.0103
30 to 34 years............	.0042	.0040	.0124	.0073	-.0082	.0084
35 to 39 years............	.0042	.0040	.0082	.0060	-.0040	.0072
40 to 44 years............	.0042	.0040	.0208	.0095	-.0166	.0103
45 to 49 years............	.0152	.0076	.0168	.0085	-.0016	.0114
50 to 54 years............	.0118	.0067	.0122	.0073	-.0004	.0099
55 to 59 years............	.0098	.0069	.0082	.0060	.0016	.0085
60 to 64 years............	.0056	.0046	.0042	.0043	.0014	.0063
65 to 69 years............	.0056	.0046	.0000	.0000	.0056	.0046
70 to 74 years............	.0000	.0000	.0040	.0042	-.0040	.0042
75 to 79 years............	.0000	.0000	.0040	.0042	-.0040	.0042
80 to 84 years............	.0000	.0000	.0042	.0043	-.0042	.0043
85 years or over..........	.0000	.0000	.0042	.0043	-.0042	.0043

1 Gross-difference rate from Sample I where reinterview was in July, 1960.

2 Gross-difference rate from Sample III where reinterview was in October, 1960.

The next item studied was "1955 residence." For this item there were very large differences between the gross-difference rates for the two samples for every category but one. These estimated differences were also large in comparison with their standard errors as is shown below.

Table 4.--COMPARISON OF GROSS-DIFFERENCE RATES FOR SAMPLES I AND III FOR 1955 RESIDENCE

Category	g_{11} [1] (1)	g_3 [2] (2)	$g_{11}-g_3$ (3)	$s_{g_{11}-g_3}$ [3] (4)
Same house........	.0434	.0628	-.0194	.0090
Different house, same county.....	.0506	.0772	-.0266	.0099
Different county, same State......	.0126	.0274	-.0148	.0056
Different State...	.0136	.0266	-.0130	.0056
Abroad............	.0038	.0036	.0002	.0023

1 Gross-difference rate from Sample I where reinterview was in July, 1960.

2 Gross-difference rate from Sample III where reinterview was in October, 1960.

3 $s_{g_{11}-g_3}$ estimated by $\sqrt{\frac{g_{11}}{n_{11}} + \frac{g_3}{n_3}}$ was multiplied by 1.8 to account for sampling households rather than persons.

The differences between the net-difference rates for this item were not large in comparison to their standard errors. For this item, $\sigma^2_{dG_3}$ is larger than $\sigma^2_{dG_{11}}$. Therefore we see that by having the reinterview six months rather than three months after the census interview, the simple response variance was increased.

For two of the education items (educational attainment and school enrollment) we are again in the position of not being able to detect differences between the gross-difference rates or the net-difference rates. For the item on "type and level of school" Sample III gross-difference rates are higher. Let

$$\phi_{11} = g_{11} - b^2_{11}$$

$$\phi_3 = g_3 - b^2_3$$

Table 5 below shows ϕ_{11} and ϕ_3 for this item.

Table 5.--COMPARISON OF ϕ_{11} AND ϕ_3 FOR TYPE AND LEVEL OF SCHOOL

Category	ϕ_{11}	ϕ_3
Public elementary............	.0322	.0552
Private elementary...........	.0263	.0355
Public high school...........	.0228	.0374
Private high school..........	.0068	.0059
Public college...............	.0138	.0167
Private college..............	.0064	.0069

The values of ϕ were not affected much by the bias terms, so are based mostly on the gross-difference rates. Notice that ϕ_3 is larger than ϕ_{11} for all but one category. Thus, the reinterview later in time produced larger simple response variances.

Turning now to the income items, we find some very interesting differences. Most of the differences occur in the "no income" or "$1-$499 or loss" categories. There were no differences found in the self-employment income tables. Table 6 shows the items for which there was a large difference between the gross-difference rates or the net-difference rates.

Table 6.--COMPARISON OF GROSS- AND NET-DIFFERENCE RATES FOR SPECIFIC INCOME CATEGORIES

Item and category	g_{11} (1)	g_3 (2)	b_1 (3)	b_3 (4)	ϕ_{11} (5)	ϕ_3 (6)	$s_{g_{11}-g_3}$ or $s_{b_{11}-b_3}$ (7)
Total Income, All:							
No income..................	.1182	.1210	.0574	.0045	.1149	.1210	.0085
$1 to $499 or loss.........	.1012	.1142	-.0311	-.0021	.1002	.1142	.0081
Total Income, Male:							
No income..................	.0814	.0668	.0272	.0002	.0807	.0668	.0097
$5,000 to $5,999...........	.0386	.0874	-.0017	-.0093	.0386	.0873	.0089
Total Income, Female:							
No income..................	.1530	.1678	.0874	.0108	.1454	.1677	.0137
$1 to $499 or loss.........	.1408	.1552	-.0484	.0000	.1385	.1552	.0131
Other Income, Male:							
No income..................	.1812	.1876	.1239	.0651	.1658	.1838	.0156
$1 to $499 or loss.........	.1770	.1760	-.0990	-.0462	.1672	.1739	.0152
Other Income, Female:							
No income..................	.1604	.1532	.1010	.0492	.1502	.1508	.0137

Look at the first two categories. The gross-difference rates are not too different in comparison with their standard errors, but the net-difference rates are very different. The estimate of the bias from Sample I is very large. This pattern holds for all but one of the items shown in the table.

Notice that all but one of the items are "no income" or "$1 to $499 or loss." For each of these items, having the reinterview closer in time to the original interview permitted the detection of large biases in these items. Therefore, having the reinterview closer in time seems to be important in identifying persons with small amounts of income that are not reported in the census.

In summary, then, for most items we were not able to detect differences between the two reinterview procedures. In the cases in which the sample size was large enough to detect differences between procedures, the Sample I procedure, before reconciliation, seemed to be a "better" procedure than the Sample III procedure. So at least for mobility, type and level of school, and income items, we prefer a reinterview procedure which specifies that the reinterview be closer in time to the original interview. For other items, we do not yet have enough evidence to prefer one of these procedures over the other.

6. Effect of a Dependent Reinterview Situation.

There is evidence from the Current Population Survey (CPS) that an interviewing situation in which the reinterviewers are provided with the original responses does not insure independence of the reinterview data. A sample of the households included in the CPS every month is selected for reinterview. For 20 percent of the reinterview sample, the original CPS data are not supplied to the reinterviewer; for the remaining 80 percent, the original CPS data are supplied to the reinterviewer. A comparison of the results of these two samples shows that the gross-difference rates for the 80 percent sample were about one-half of the gross-difference rates for the 20 percent sample. (See Technical Paper No. 6, The Current Population Survey Reinterview Program.)

In the conference on Evaluation of the 1960 Censuses held on February 6-7, 1959, it was stated that an independent reinterview gives a more valid gross-difference rate and also a better indication of the bias. For this reason, it was planned for the evaluation program to provide a comparison between a completely independent reinterview and this potentially dependent reinterview. Sample II, for which the reinterviews were conducted at the same time of the year as the Sample III reinterviews, would provide such a comparison since, in Sample II, the reinterviewers were provided with the original census data. The comparisons which follow are based on the data from Sample II before reconciliation and Sample III. The comparisons are made between g_{21} and g_3 and between b_{21} and b_3.

We would like to be able to make the same kind of comparisons with these data as we did with Samples I and III data. However, the dependent reinterview situation somewhat complicates the matter. From equation (36) we see

$$E(g_{21}) = \sigma^2_{dG} + \sigma^2_{dG_{21}} - 2\rho_{dG,dG_{21}}\sigma_{dG}\sigma_{dG_{21}} + B^2_{21}.$$

Therefore, we have a comparison of the following quantities:

$$\begin{cases} E(g_{21}) - B^2_{21} = \sigma^2_{dG} + \sigma^2_{dG_{21}} - 2\rho_{dG,dG_{21}}\sigma_{dG}\sigma_{dG_{21}} \\ E(g_3) - B^2_3 = \sigma^2_{dG} + \sigma^2_{dG_3}. \end{cases}$$

We see that if $E(g_{21}) - B^2_{21}$ is greater than $E(g_3) - B^2_3$, then the simple response variance from Sample II is greater than that from Sample III. However, if $E(g_3) - B^2_3$ is greater than $E(g_{21}) - B^2_{21}$, we don't know if $\sigma^2_{dG_{21}}$ is smaller than $\sigma^2_{dG_3}$ unless we can estimate the size of the covariance term. Therefore, for the comparisons which follow, if we find differences of the latter kind, we will estimate the covariance term by $(g_{11} - g_{21})/2$ where g_{11} is the gross-difference rate from Sample I.

For the age items, there were no large differences between either the gross-or the net-difference rates for Samples I and II. The same thing occurred for the "1955 residence" item and "type and level of school." However the "school enrollment" item showed rather large differences between Samples I and II. Table 7 summarizes these differences.

Table 7.--COMPARISON OF GROSS- AND NET-DIFFERENCE RATES FOR SAMPLES II AND III FOR SCHOOL ENROLLMENT

Category	g_3 (1)	g_{21} (2)	b_3 (3)	b_{21} (4)	ϕ_3 (5)	ϕ_{21} (6)	$s_{g_3-g_{21}}$ or $s_{b_3-b_{21}}$ (7)
Kindergarten or elementary 1	.0158	.0288	-.0099	.0180	.0157	.0285	.0067
2	.0332	.0576	-.0014	.0062	.0332	.0576	.0097
3	.0386	.0670	.0059	.0013	.0386	.0670	.0099
4	.0432	.0690	.0032	-.0035	.0432	.0690	.0101
5	.0408	.0580	-.0021	-.0055	.0408	.0580	.0097
6	.0380	.0550	-.0130	.0093	.0378	.0549	.0093
7	.0370	.0560	.0101	-.0119	.0369	.0559	.0089
8	.0266	.0344	.0042	-.0060	.0266	.0344	.0081
High school 1	.0164	.0488	.0086	.0093	.0163	.0487	.0091
2	.0276	.0590	-.0176	-.0082	.0273	.0589	.0086
3	.0306	.0484	.0071	.0071	.0305	.0483	.0082
4	.0248	.0400	-.0019	-.0051	.0248	.0400	.0078
College.... 1	.0198	.0230	.0014	-.0098	.0198	.0229	.0059
2	.0072	.0064	.0072	-.0003	.0071	.0064	.0038
3	.0042	.0102	-.0042	-.0008	.0042	.0102	.0046
4	.0092	.0070	-.0025	.0000	.0092	.0070	.0034
Five or more	.0048	.0018	.0048	.0000	.0048	.0018	.0022

The categories for which there were large differences between the samples in either the gross- or net-difference rates were underlined. Note that for all categories below the college level, ϕ_{21} was greater than ϕ_3. For some reason, this dependent procedure produced larger simple response variances.

For the educational attainment item the differences went in the other direction and the covariance term was estimated. We still compute ϕ_{21} and ϕ_3 but then add $2\rho_{dG,dG_{21}}\sigma_{dG}\sigma_{dG_{21}}$ to ϕ_{21} before comparing it with ϕ_3. If ϕ_{21} plus the covariance term is still smaller than ϕ_3, we assume that the simple response variance of Sample II is smaller than that of Sample III. Table 8 shows these comparisons. The categories for which the gross or net differences for the two samples were very large in comparison with the standard errors of the differences are underlined. However, for 14 of the 15 items ϕ_{21} was smaller than ϕ_3.

Table 8.--COMPARISON OF GROSS- AND NET-DIFFERENCE RATES FOR SAMPLES II AND III FOR EDUCATIONAL ATTAINMENT

Category	ϕ_{21} (1)	$\frac{g_{11}-g_{21}}{2}$ (2)	$\phi_{21}+2(\frac{g_{11}-g_{21}}{2})$ (3)	ϕ_3 (4)
No school....	.0120	.0006	.0132	.0124
Elementary...				
1-2	.0128	.0014	.0156	.0197
3-4	.0346	.0016	.0378	.0432
5-6	.0424	.0067	.0558	.0718
7	.0520	.0027	.0574	.0708
8	.0742	.0169	.1080	.1043
High school..				
1	.0450	.0131	.0712	.0571
2	.0554	.0087	.0728	.0714
3	.0500	[1]	[1]	.0478
4	.0796	.0004	.0804	.0806
College......				
1	.0236	.0055	.0346	.0256
2	.0180	.0087	.0354	.0362
3	.0130	.0036	.0202	.0146
4	.0152	.0032	.0216	.0210
Five or more	.0104	.0025	.0154	.0132

[1] Estimate of covariance was negative.

Now the values in column (3) are almost the same as the gross-difference rates estimated from Sample I for those underlined. When we compared the gross-differences from Samples I and III in the previous section we found no significant differences. Therefore, after accounting for the covariance term we see that the simple response variances from Samples II and III are not really different. However, the gross-difference rate is substantially reduced in Sample II and should not be used as an estimate of the simple response variance.

Turning to the income items, we found a few categories for which there seemed to be large differences between the gross-difference rates or net-difference rates. For these items, even after accounting for the covariance term, as shown in Table 9, the simple response variances were smaller for Sample II, except for the "no income" category for "total income, males."

Table 9.--COMPARISON OF GROSS- AND NET-DIFFERENCE RATES FOR SOME INCOME CATEGORIES

Item and category	ϕ_{21} (1)	$\frac{g_{11}-g_{21}}{2}$ (2)	$\phi_{21}+2(\frac{g_{11}-g_{21}}{2})$ (3)	ϕ_3 (4)
Total Income, All:				
No income..................	.1069	.0046	.1161	.1210
$1 to $499 or loss..........	.0813	.0099	.1013	.1142
Total Income, Males:				
No income..................	.0800	.0000	.0800	.0668
Total Income, Females:				
$1 to $499 or loss..........	.1120	.0142	.1404	.1552
Self-employment Income, Males:				
$1 to $499 or loss..........	.0202	.0054	.0310	.0438

We see that in a dependent reinterview procedure, for most items there was no reduction in the simple response variance. However, there were significant reductions in the estimated gross-difference rate due to a large positive between-trial covariance. If the gross-difference rates from this procedure were used for estimating the simple response variance, the estimates would be too low.

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