THE RANDOMIZED RESPONSE TECHNIQUE, THE INTERVIEW, AND THE SELF-ADMINISTERED QUESTIONNAIRE: AN EMPIRICAL COMPARISON OF FERTILITY REPORTS*

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Literature Review

In 1965, Warner devised the "randomized response" data-gathering technique as an attempt to increase the cooperation of respondents asked personal, confidential, or otherwise "sensitive" questions in an interview. Essentially, Warner felt that both refusal bias and response bias (i.e. due to untruthful answers) would be reduced if each respondent's privacy was protected by a method which randomized the appearance of the sensitive questions and concealed from the interviewer the exact question being answered. Thus, answers would "furnish information only on a probability basis" (Warner, 1965: 63).

The Warner technique consists of asking a respondent "one of two questions of the form: (1) I am a member of group A, and (2) I am not a member of group A" (Campbell & Joiner, 1973: 229). Since the probabilities associated with the selection of either question are known (i.e. built into the randomizing device), assuming truthful answers, an unbiased maximum likelihood estimate of the true proportion of the population in the stigmatized group can be made.

Let

π = the true proportion of A (the stigmatized group) in the population

P = the probability the randomized device chooses the sensitive question (1-P for the other question)

λ = the proportion of yes answers

Then

$$\lambda = P\pi + (1-P)(1-\pi)$$

Abul-Ela et al (1967) showed that this survey method of randomized response could be used to estimate t population proportions, where at least 1 and not more than (t-1) of them are stigmatizing. Of course one would need (t-1) simple random samples and (t-1) sets of different questions.

In an effort to further increase respondent cooperation, Simmons suggested a modification of the randomized response technique, whereby respondents select one of two unrelated rather than related questions (Horvitz et al., 1969). Two independent samples would be needed in order to estimate the population proportions in the two noncomplementary groups, unless the proportion of the population in the group mentioned in the unrelated question is known beforehand. In the latter case, which is the logical method to use, the estimating equation is:

$$\lambda = P\pi_A + (1-P)\pi_Y$$

where:

π_A = the true proportion of the population with sensitive attribute A

π_Y = the true proportion of the population with non-sensitive attribute Y (which is unrelated to A)

Horvitz et al. (1969) used this unrelated question randomized response technique, with π_Y known, to estimate the incidence of "illegitimate" births. Their estimate was very close to that obtained from information on the birth certificates from which the sample was chosen. Greenberg et al. (1969), after comparing the variances for estimates made using the Warner technique and those based on the unrelated question (with π_Y known or unknown) type of the randomized response technique, show that use of the latter will most likely entail greater statistical efficiency than the Warner technique. Moors (1971) also, in discussing the optimum model for the two-sample (i.e., π_Y unknown) unrelated question randomized response technique, shows that the unrelated question model is preferable to Warner's. Even when $\pi_Y = 1/2$ (i.e., the worst choice of π_Y), the variance of the estimates based on the optimized unrelated question technique is less than that of estimates derived using Warner's related question method.

Undertaking a massive field test of the unrelated question randomized response method, Greenberg et al. (1970) estimated one-year incidence of abortion, lifetime incidence of abortion, and use of oral contraceptives among North Carolina women. Their estimate of abortions in the previous year was similar (although obviously not comparable) to a 1961 Chilean survey estimate (Abernathy et al., 1970). This sample also produced an estimate of use of the birth control pill which was similar to one based on a national survey (Greenberg et al., 1970). Using another sample, two estimates of lifetime abortions were made - one assuming π_Y known and another assuming it had to be estimated. Estimates of π_A were found to be more accurate and less variable when π_Y is known than when it must be estimated. Finally, answers to several questions about the randomized response method itself showed that about 2/3 of the respondents believed their friends would not truthfully answer directly asked abortion questions. Moreover, 60 per cent of this North Carolina sample believed that their friends would not suspect a trick in the randomized procedure; 76 per cent said they themselves were convinced that the technique protected their privacy (Greenberg et al., 1970).

Another development in the history of randomized response data-gathering came when Greenberg et al. (1971) pointed out that quantitative information can be estimated as well. They proceeded to use the technique to derive reasonable estimates of the mean number of lifetime abortions as well as mean income. Perhaps the most important contribution of this method, and one reported by Greenberg et al. in this study, is the miniscule refusal rate accompanying use of the method.

Most recently Folsom et al. (1973) developed a new randomized response design which improves efficiency when two samples are required because π_Y is not known beforehand. The method consists of using two nonsensitive alternate questions in conjunction with the sensitive question. The authors also show the variance increases (around 50 per cent) when a weight = 1/2 is used instead of an optimal weight and conclude that their new design will never be more efficient than the simple alternate question model when π_Y is known. The practical significance of w = 1/2 lies in the fact that a coin can be used as the randomizing device, with all the advantages implied in interviewing response when compared with the mysterious box and differently coloured beads, required by the Warner technique.

Growth of Alberta Families Study

A stratified cluster sample of 1045 Edmonton women, between 18 and 54 years of age, was the basis of a comprehensive fertility study carried out between Nov., 1973 and Feb., 1974. Of the 2300 dwelling units originally selected, 794 either contained no eligible respondent or were vacant; the final sample of 1045 women represents 69.4% of the remaining sampled households. This sample was divided into three interpolated sub-samples in order to test the general data-gathering effectiveness of the randomized response technique. Respondents were either asked all fertility questions in the interview which included questions on abortion, were asked the "sensitive" questions by the randomized response method, or were given an anonymous mail-back questionnaire containing questions identical to those asked under the randomized response technique.

The specifics of the randomized response technique we used generally comprise a replication of those employed in the North Carolina studies. After an introduction to the randomized response method, instructions, and definitions (e.g., of abortion), 352 women were given a clear plastic box containing (35) blue and (15) red balls. The seven pairs of sensitive and unrelated statements (e.g. "I was born in the month of June") were printed on a card which was also handed to the respondent, blue marks appearing next to the former and red marks next to the latter. Respondents were told to shake the box, while the interviewer sat at a distance, and to answer the question marked with the color of the ball appearing in the window constructed in the box.

It was thus possible to compare the estimates obtained using the randomized method with those acquired by means of the anonymous questionnaire on the following seven variables: one-year incidence of abortions, lifetime incidence of abortions; incidence of premarital sexual intercourse, premarital pregnancy, "illegitimate" children, premarital use of contraceptives, and premarital abortions. In the interview, information on abortions within the previous year and lifetime abortions was acquired, and the estimates could be compared with those based on the randomized response technique and the questionnaire.[1] The purpose of our exercise was twofold: 1. to compare the estimates based on the three methods, to attempt to determine whether people directly asked "sensitive" questions on abortion were likely to lie (i.e., estimate response bias and its reduction using the randomized response technique) and to evaluate the accuracy of the randomized response-based estimates; 2. to compare the response rates for "sensitive" questions asked the three different ways. We hoped to be able to assess the usefulness of the randomized response technique.

Findings

In order to estimate the population proportions with the non-sensitive characteristics comprising the unrelated randomized response questions, we used either census data or data obtained in the GAFS survey. Four of the seven unrelated questions involved the statement that the respondent was born in a certain month. We averaged those proportions born in the specified months for the years 1925, 1935, 1945 (Canada, DBS). Another statement, "I was living in the same dwelling unit five years ago," was estimated using census figures which characterized five-year non-movers by age, sex, and province (Canada, 1961). For the quantity question, "How many children does your best friend have?" the distribution of children of the women in our sample was used (although we simply used the zero-non-zero proportions). Actually, there is no need to introduce the additional variance caused by these calculations into the estimating procedure. As Greenberg et al. (1969) point out, answers to the unrelated question can be built into randomizing device.

Before comparing the estimates based on the three data-gathering methods, we checked the similarity of our three samples. As table 1 shows, the samples are not significantly different in terms of their basic social profiles. Differences in the estimated population proportions should not, therefore, be due to gross differences in the composition of the three samples.

Our estimates using the randomized response technique are obviously similar to those based on responses to the self-administered questionnaire. In table 2 are reported the estimates.[2] Confidence intervals at the 95% level were placed around all of the point estimates although it is recognized that some of

the estimated proportions were close to zero, and thus the normal approximation to the binomial distribution may not be appropriate.[3] A test for statistically significant differences between all pairs of estimates revealed no significant differences at the .05 level between any of the randomized response-based estimates and those obtained from answers to the anonymous questionnaire.[4] Only the estimate of lifetime abortions based on the randomized response method and that based on the interview were significantly different in the statistical sense.

A comparison of the estimated proportions themselves reveals a greater tendency for women to report "sensitive" events if the questions are randomized than if they are part of a self-administered questionnaire, and a greater tendency in both of these cases than in the interview situation. The estimate of the incidence of life-time abortions is probably most important, since it allows a comparison of all three methods, and the estimated proportions are not as close to zero as those for one-year abortions. The three estimates of lifetime abortions point toward the conclusion that women tend to give incorrect information when questioned on personal issues, and feel safer answering truthfully in a randomized response situation. One could even venture the conclusion, based on the lifetime abortion estimates, that people feel safer answering randomized questions than those on anonymous questionnaires. On the other hand, if the self-administered questionnaire is assumed to be as private as the randomized response technique, the absence of a statistically significant difference between the estimate based on the questionnaire and that obtained by the interview prohibits the conclusion that substantial response bias was introduced in the interview. On the whole, the other estimates, based on the randomized response technique and the questionnaire, were close enough to confirm the reliability of the former method.

While we have not conclusively proven a reduction in response bias with the randomized response method, the data-gathering technique definitely increases response rates. The response rates using the randomized response method were substantially higher (97 and 95 per cent) than those resulting from use of the mail-back questionnaire (73 per cent). Since the former allows the researcher to gather as much information as he might in the traditional interview, the randomized response technique no doubt is more useful than the questionnaire for gathering "sensitive" information. The question remains, however, whether the randomized response "game" is necessary: is the introduction of additional variance justified by the reduction of bias due to an avoidance of "sensitive" questions?

Our replication of the North Carolina questions asked about the randomized response technique reveals some interesting insights to the question of the need for a "game" in order to gather confidential information. In direct contrast to the North Carolina women, 68 per cent of the Edmonton sample thought their friends would truthfully answer a direct question on abortion. However, they were not asked if their friends who had had an abortion would answer a direct question about it. Only 63 per cent of the women thought their friends would find no trick to the randomizing device. A person's judgement of her friend's likely behavior may be grossly inaccurate. However, only 58 per cent of our respondents said they were sure of the privacy guaranteed by the randomized response technique, while 28 per cent were not sure the interviewer did not know which question was being answered. Our estimation of the importance of the randomized response method was reduced in the face of the high proportion of respondents saying friends would answer a direct abortion question, and the sizeable proportion personally doubting the privacy assured by the randomized response technique. Interviewers estimated that younger, better educated Canadian women had no qualms about answering the questions directly, especially in the context of a comprehensive fertility interview. One perceptive interviewer reported that only a few of her interviewees did <u>not</u> indicate the question they were answering in the RRT "game."

Table 1. Comparison of the three samples

	RRT	Ques.	Interview	X^2	sig.
Proportion ever married:	.844	.823	.818	.78	.68
Proportion over 29 years:	.524	.566	.494	3.47	.17
Proportion pregnant fewer than four times:	.884	.855	.836	2.79	.24
Proportion of British Isles ethnicity:	.384	.373	.332	2.04	.36
Education - fewer than 9 yrs:	.113	.089	.085		
9 - 12 years:	.571	.529	.523		
>13 years:	.316	.382	.392	4.84	.30
N =	346	269	327		

Table 2. Comparison of the 95% confidence intervals around sample proportions based on the three data-gathering methods

	RRT	Questionnaire	Interview
1. Abortion in the past 12 mos:	.032 (±.032)	.008 (±.001)	.003 (±.003)
2. Abortion during lifetime:	.090 (±.068)	.038 (±.023)	.015 (±.013)
3. Unmarried, sexual intercourse:	.623 (±.076)	.605 (±.059)	
4. Unmarried, became pregnant:	.190 (±.055)	.213 (±.049)	
5. Unmarried, gave birth:	.078 (±.063)	.075 (±.032)	
6. Unmarried, used contraceptives:	.326 (±.067)	.281 (±.054)	
7. Unmarried, had an abortion:	.021 (±.030)	.034 (±.022)	
N =	342	269	327

ENDNOTES

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1. Between the final typing of the interview questionnaire and its original version, a change was made inadvertently which unfortunately omitted the month from the question on the date of marriage and thus precluded a rigorous comparison of all three techniques on all the questions. However, it should be possible to rescue some of the comparative information through approximations and the "no less than" approach.

2. These estimated proportions are not weighted and therefore should not be considered real rates in a strict sense. However, we compared the weighted and unweighted distributions on such variables as age, education, marital status, number of pregnancies, and ethnicity and found that they were not significantly different from each other (indices of dissimilarity were all quite small).

3. The variance of the RRT estimate, as reported in Greenberg et al. (1969) is: $\text{var}(\pi_{A\cap Y}) = \frac{\lambda(1-\lambda)}{nP^2}$ Although we did not have a simple random sample, we used this formula.

4. The variance of the difference between two independent random variables is the sum of their variances. We computed a z-score.

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