NONRESPONSE BIAS IN MAIL SURVEYS: THE CASE OF THE DEPARTMENT OF DEFENSE POST-SERVICE SURVEY

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The bias cuased by nonresponse to mailed questionnaires is difficult, and sometimes impossible, to remove. This paper examines several approaches to identifying and correcting survey data thus biased; it concludes that neither the direction nor the magnitude of the bias can be known with confidence unless either (1) the investigator already has considerable information about the sample population; or (2) it is possible to track down and interview an adequate sample of those who did not response. Of these two conditions, the first is rare and the second, expensive. The paper uses questionnaire data collected from former service men (of whom a great deal of information was already available from service records) to demonstrate the alternative procedures for identifying and removing nonresponse bias purely by statistical methods. (KR)

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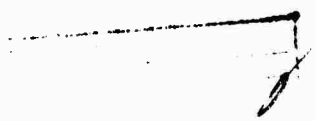

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PREFACE

This Report was prepared as part of Rand's DoD Training and Manpower Management Program, sponsored by the Human Resources Research Office of the Defense Advanced Research Projects Agency (ARPA). With manpower issues assuming an even greater importance in defense planning and budgeting, it is the purpose of this research program to develop broad strategies and specific solutions for dealing with present and future military manpower problems. This includes the development of new research methodologies for examining broad classes of manpower problems, as well as specific problem-oriented research. In addition to providing analysis of current and future manpower issues, it is hoped that this research program will contribute to a better general understanding of the manpower problems confronting the Department of Defense.

Policy analysts are relying increasingly on sample survey data collected through mail questionnaires. The present report tries to alert mail survey users to the common sources and effects of nonresponse and to inform them of alternative ways of dealing with nonresponse bias. It does this by examining data from an on-going Department of Defense survey of all enlisted men who were separated from active service after 30 June 1968.

SUMMARY

Mail surveys have several noteworthy advantages (especially low cost), but bias due to nonresponse poses a significant threat that users of mail questionnaires must deal with either by maximizing returns (and thus obviating the possibility of nonresponse bias) or by exercising statistical controls to attenuate the bias. The two components of nonresponse bias are: (a) *noncontacts* (e.g., invalid addresses), and (b) *nonreturns* (refusals). The general strategy for detecting nonresponse bias is to compare respondents and nonrespondents on a variety of dimensions in order to identify the direction and magnitude of differences between the two groups, and this is typically accomplished in one of three ways. In one case, a subsample of people who did not respond to the mail questionnaire is tracked down and interviewed, and then their responses are compared with the responses of those who answered the mail questionnaire. A second strategy is to compare the responses that came in before and after follow-up letters went out; the assumption here is that "early" and "late" respondents are ordered along a response continuum, and that nonrespondents are merely "super late" respondents. And finally, nonresponse bias can be detected by comparing respondents and nonrespondents on dimensions for which there are data available for all potential respondents.

Using the third strategy, it has been found that nonresponse is related to a number of factors including: (a) ethnicity, (b) education, (c) income, (d) age, (e) marital status, (f) family size, (g) geographic location, and (h) interest in the topic of the survey. Interest in the survey is by far the most important variable.

The replacement of missing respondents or the oversampling of low response groups are examples of the substitution solution to nonresponse bias, but these procedures, unfortunately, simply replace missing respondents with people like the ones who initially responded. Thus, substitution strategies increase the sample size which has been reduced by nonresponse, but they do not correct the biased composition of the sample.

Another approach is to weight subgroup results in order to attenuate nonresponse bias, but this strategy is based on the same tenuous assumptions as the direct substitution methods. Weighting involves three steps: (a) selection of the weighting dimensions -- practical considerations usually limit the number of variables which can be used to five or less; (b) computation of the weights -- this involves finding the reciprocals of the response proportions for each of the subgroups which are created by cross-partitioning the population on the weighting variables; and (c) application of the weights to the raw data in order to find the adjusted estimates.

INTRODUCTION

In 1839 the British provoked the *Opium Wars* with China and after three years of fighting, won commercial concessions and the right to govern Hong Kong. During the same period, Upper and Lower Canada were joined by the *Act of Union*, Dr. Livingstone began his explorations of Africa, Freidrich Engels was scratching out *Situation of the Working Class in England*, and Ireland was swept by the potato blight which by 1851 had left ver one million people dead of starvation and disease. Amidst these events, the first scientific report of a mail survey went unnoticed to all but the most careful readers of the *Royal Statistical Society Journal*, and although the respectability of this method has varied over the years, mail questionnaires still offer the same advantages that led the English clergy to conduct a mail survey of parish resources in 1838.

This brief paper describes the advantages and disadvantages of mail surveys and then focuses on the chief problem with this data collection technique, nonresponse bias. Specifically, we will look at the common characteristics of nonrespondents, and then we will describe alternative methods of detecting and correcting nonresponse bias.

ADVANTAGES AND DISADVANTAGES OF MAIL SURVEYS

Briefly summarized, the features of mail surveys which make them so widely used are:

- o Ability to cover a wide geographical area. Interviewing over a wide area is difficult and extremely expensive. Getting the interviewer to the respondent's location is a major cost factor in personal interviews, especially where two or three call-backs must be made in order to make contact. In effect, the mail questionnaire respondent serves as his own interviewer.

- Speed. Mail questionnaires clearly are a faster data collection method than personal interviews, and if the sample size is very large, mail surveys may be faster than telephone interviews.
- Lack of Interviewer Bias. Much research has demonstrated that the interviewer is not a neutral element in face-to-face interviews. A classic case, reported by Rice in 1929, illustrates well the problem of interviewer bias. Two trained interviewers, one a socialist and one a prohibitionist, were sent to interview men on skid row in order to find out the cause of their destitution. Men interviewed by the socialist interviewer blamed their plight on the ills of the economic system, and those interviewed by the prohibitionist attributed their fate to overindulgence in alcohol. Racial differences are especially important sources of interviewer bias. Respondents tend to vary their answers depending upon the race of the interviewer. Mail questionnaires obviate the problem of interviewer bias.*
- Anonymity. Under certain circumstances, self-administered questionnaires may produce more accurate answers than supposedly higher-quality face-to-face interviews. This is especially true when the subject of the questionnaire is very sensitive or controversial. Knudsen, Hallowell and Irish (1967), for instance, found that over 80 percent of the unwed mothers they interviewed agreed with the statement "Premarital sex is never alright" [sic] whereas only 69 percent of another group of unwed mothers agreed with this statement when it was asked in a self-administered questionnaire.

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*For a summary of the literature on interviewer bias, see Cannell and Kahn (1969). An extensive bibliography on interviewer bias is available from Dr. Carol Weiss, Bureau of Applied Social Research, Columbia University, New York, 10027.

- o Ability To Consult Records. The mail questionnaire does not have to be completed within a fixed period of time as does an interview, and this means that respondents can take time to consult their records or friends before answering a complex question. This is especially useful in gathering data about income and expenses, health histories, and similar factual information.
- o Low Cost. Mail questionnaires are relatively inexpensive, and this is the main reason they are so widely used. The average cost of a mail questionnaire is about $1.50 to $3.50, depending upon the number of follow-ups, the initial response rate and the overall quality of the materials used. Compare this with the typical cost of $35.00 to $100.00 for a personal interview (again depending upon the number of call backs, the length of the questionnaire and the distance between respondents), and the cost of $3.50 to $7.50 for a telephone interview.

The chief disadvantage of mail questionnaires is the problem of bias due to nonresponse. If the survey does not achieve a high completion rate, the results may not represent the entire target population well. If only fifty percent of the potential respondents reply, the sample data probably generalize well to 1 out of every 2 people in the population, but which one out of two?

The problem of self-selection or self-assignment to conditions in true experiments is well known, and few researchers would accept as valid an "experiment" that permitted either self-assignment to conditions or a high attrition rate from conditions. But we are more generous when it comes to accepting self-selection artifacts in surveys or field experiments because we realize the tremendous difficulties in achieving a truly random sample of noncaptive populations. Nonetheless, the self-selection artifacts are there; and simply admitting that these problems are difficult to eliminate does not reduce the threat they pose.

The problem of nonresponse bias is well illustrated by an old study of commercial peach production which was conducted in 1946 by Finkler (1950). Three mailings were used to survey 3116 growers in North Carolina, and one of the survey questions asked how many trees the grower owned; fortunately, the actual number of trees was already known. Finkler's results, as summarized by Cochran (1963, p. 356), are shown in Table 1. The presence and direction of nonresponse bias are obvious here: Growers with large holdings were more likely to respond than owners of small orchards. Population estimates based on the sample returns improved (i.e., came closer to the true population mean) as the number of returns increased, but even with a return of 41 percent after three mailings, the sample estimates greatly overestimated the number of trees that the average grower owned.

Table 1

RESPONSES TO THREE REQUESTS IN A MAILED INQUIRY

(Cochran, 1963, p. 356)

	Number of Growers	Percent of Population	Average Number of Fruit Trees per Grower
Response to first mailing	300	10	456
Response to second mailing	543	17	382
Response to third mailing	434	14	340
Nonrespondents after 3 mailings	1,839	59	290
Total Population	3,116	100	329

COMPONENTS OF NONRESPONSE

By definition, nonresponse bias occurs whenever a nonrandom sample of potential respondents does not complete and return the mail questionnaire. In mail surveys, the two major sources of dross, that is wastage or loss, are *invalid addresses* (noncontacts) and outright

refusals (nonreturns); and in computing response rates, both of these sources of dross must be included in the denominator along with the number of completed returns. The reason we include invalid addresses in figuring response rates should be clear. If we cannot get the questionnaire into a potential respondent's hands, he cannot complete the questionnaire and return it. If he does not return it, he is not included in the survey results, and his particular responses are therefore ignored in making population estimates. It is obvious that noncontacts are just as dangerous in mail questionnaires as outright refusals (nonreturns) *unless the noncontacts occur randomly with respect to the dependent variables of interest.*

DEALING WITH NONRESPONSE BIAS

There are basically two ways of dealing with the potential problem of nonresponse bias in mail surveys. The first approach is to do everything possible to maximize the return rate and thus to obviate the whole problem of nonresponse bias. Years of experience have produced a large bag of tricks for maximizing response rates.* Among the important factors are: incentives, follow-ups, forewarnings (preview notices), questionnaire characteristics (length, color, subject matter), cover letter characteristics (length, type of appeal, format, ethnicity and status of signer), deadlines, time of posting, type and amount of outgoing and return postage, and respondent anonymity.

A second way of dealing with nonresponse bias is to examine the returns in order to detect potential bias (hoping, of course, that none is found) and estimate its direction and magnitude. In the event significant bias is detected, the only strategy left is to fall back on statistical controls to offset the bias.

DETECTING NONRESPONSE BIAS

General lore among users of mail surveys is that a return of 80 percent is sufficient to eliminate major nonresponse bias; at that point, getting the entire sample population to respond would not change the sample estimates significantly.

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*Erdos (1970) provides a summary of these techniques for maximizing response rates.

When returns fall below 80 percent (but above the obviously low minimum of 50 percent), efforts are made to detect the possible bias, and there are basically three ways in which this can be done. They are, in the order of their elegance:

a) Draw a subsample of the nonrespondents and make every effort to complete telephone or personal interviews with these people, and then compare their responses with those of regular respondents to see if there are any obvious differences. This, and all of the other attacks on response bias, suffer from a particular version of the matching fallacy. We can never be sure that we have tapped all of the relevant dimensions in our matching or comparisons (Campbell and Stanley, 1966; Gross, Collins, and Bryan, 1972, p. 16).

b) Compare the responses from "early respondents" (prefollow-up letters) with those collected from late respondents" (post-follow-up letters) to see if there are any obvious trends operating. E.g., are "late" respondents younger or less educated than "early" respondents? This of course assumes that trends are operating and that nonrespondents are simply super-late respondents; both assumptions are questionable.

c) Compare respondents and nonrespondents on dimensions for which complete data are available for all elements of the sampling frame. For example, we can usually infer the potential respondent's sex, so response rates for males and females can be compared.*

A number of studies have used these three methods, particularly the latter, to estimate the direction of nonresponse bias. Some of

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*The availability of 1970 Census data (Fifth Count Summary Tapes) coded to ZIP Code zones presents a new source of aggregate data which can be used to estimate some demographic characteristics of respondents and nonrespondents, or at least their neighborhoods

the dimensions on which respondents and nonrespondents have been compared include the following:*

- o Education. In general, education is positively correlated with the return rate (Baur, 1947; Britton and Britton, 1951; Gaudet and Wilson, 1940; Benson, Booman and Clark, 1951; Lundberg and Larsen, 1949; Sobol, 1959; Robins, 1963; Suchman and McCandless, 1940), but in some cases, highly educated people (e.g., physicians and lawyers) are hard to contact in mail surveys.
- o Income. Income and response rates appear to be curvilinearly related; low income persons are especially difficult to contact, and even among those contacted there is typically a very low response rate. At the other end of the income continuum, rich people are also difficult to reach because they live ensconced behind a screen of secretaries and aides. (Parten, 1950; Harding, 1944; Ferber, 1956; Stonborough, 1942; Vincent, 1964).
- o Age. Young people are difficult to contact because of their frequent shifts in residence and their active life style. Elderly people are also difficult to survey, because they tend to have a low response rate to mail questionnaires, even though they can be located fairly easily. This probably reflects a general narrowing of interests in matters beyond their immediate day-to-day environment.

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*For an excellent summary of the differences between respondents and nonrespondents in mail surveys, see Ursula Dibble and Charles Kadushin, "Factors Which Contribute to Response Bias in Surveys and Panels," New York: Market Research Corporation, 1967, (Mimeo). For a more general bibliography on mail questionnaires, see R. G. Bridge, *Mail Questionnaires*, Los Angeles, UCLA Survey Research Center, Technical Paper No. 7002, 1970.

- Ethnicity. At least one study (Davis, 1964) found that blacks had a lower response rate than whites in a panel mail survey. But simple generalizations must be avoided here, for at this point in American history, ethnicity is highly correlated with income; and income, not ethnicity, may be the variable which actually affects response behavior.
- Rural vs Urban Location. People living in rural areas generally show a higher return rate than city dwellers (e.g., Reuss, 1943). This parallels evidence that personal interviews are harder to complete in cities than in rural areas because city dwellers spend less time in their homes and are therefore more difficult to contact. On the other hand, the growing number of "security buildings" that exclude outsiders -- including interviewers -- is making the mail questionnaire relatively more attractive for surveys of urban populations. Mail can get in where an interviewer cannot.
- Family Size. Young children keep parents close to home, and therefore it should not be surprising to find that people with young children are easier to contact than those with older children (Hilgard and Payne, 1944) or couples with no children (Ferber, 1956; Lowenstein, Colombotos and Elinson, 1962).
- Marital Status. Unmarried people generally show a lower response rate than married persons, but this of course is because marriage is confounded with a host of other factors including age and family size.

Other variables on which respondents and nonrespondents have been compared include: sex, letter writing activity, socioeconomic status, size of company, and interest in survey topic. The single most important factor is the topic of the survey; if the topic interests the respondent, and he has something positive to report about himself, he is very likely to complete the questionnaire. Ball (1930), for

example, found that postcard questionnaires sent to families of juveniles on probation were most often returned by parents who had something positive to report about their child and least often returned by those parents who were having trouble with their children. Edgerton, Britt, and Norman (1947) found that winners in a science fair contest were most likely to respond to a follow-up survey, honorable-mention recipients were next most likely to respond, and "also rans" were least likely to respond. In an earlier study, Pace (1939) found that alumni who had graduated from a university were more likely than dropouts to respond to a questionnaire from the university, and furthermore the likelihood of responding was directly related to the number of quarters the individual had spent at the school. Similarly, Shuttleworth (1941) found that successful alumni were more likely than unsuccessful graduates to respond to a university survey. And, finally, Stanton (1939) found that teachers who used radios in the classroom were most likely to respond to a survey about the educational use of radio.

The list of examples is endless, but the important thing to remember is that *the dross in most mail surveys is not random.*

ILLUSTRATION: A POST-SERVICE SURVEY OF ENLISTED MEN

This section provides an illustration of nonresponse bias in a large mail survey. The data were collected in an on-going Department of Defense survey of all enlisted men who were separated from active duty after 30 June 1968. These data were gathered in order "to evaluate the effectiveness of such programs as Project One Hundred Thousand . . . and to determine the extent of utilization in the civilian economy of skills developed during military service (DoD Instruction 1125.5, 1968, page E-2)." The results of these surveys are especially important now that the American military is constrained to operating an all-volunteer force (AVF); military manpower decisions have taken on a new urgency and margins for error have been reduced greatly in this no-draft environment. The post-service surveys are an important source of information about the effects, if any, of the military's large scale compensatory education programs (e.g., Project 100,000).*

The post-service questionnaire is sent to each enlisted man approximately ten months after he separates from active duty, and if no reply is received, at least one follow-up letter is sent by registered mail. The completed mail questionnaire yields nine elements of information including: (1) current reserve status, (2) marital status, (3) number of dependents, (4) highest year of education completed, (5) employment status, (6) hours of work per week, (7) civilian occupation (DOT classification), (8) income, and (9) educational or training program status.

The questionnaire responses are merged with extant records from an End of Service file in order to create a Post-service File. The End of Service File provides information about each potential respondent, and this is particularly important to methodological researchers because it means that the attributes of respondents and nonrespondents can be compared. For each potential respondent, the

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*For a brief description of Project 100,000, the program under which "unqualified" recruits were taken into the Army and given special training, see Wool and Flyer (1969).

End of Service file provides 23 pieces of information including: (1) service, (2) date of birth, (3) race, (4) whether he was inducted or enlisted, (5) home and mailing addresses, (6) AFQT percentile score, a measure of aptitude, (7) primary and secondary military specialties, (8) pay grade, (9) date of separation, (10) marital status, (11) number of dependents, (12) educational background, (13) total months in the military, (14) whether or not he participated in special military programs, and (15) whether or not he saw duty in Southeast Asia.

The illustrations used in this paper are based on data for 163,666 of the 176,018 Army, Air Force and Navy enlisted men who were separated from active duty during Fiscal Year 1971, and who served in selected military occupations.* The 12,352 cases were omitted for the following reasons: Some 3099 men were not required to participate in the survey, AFQT scores were not available for 8,568 men, and the educational backgrounds of 446 men were unknown. For convenience, 239 men who were not classified as either Caucasian or Negro were omitted. Using these data, we will first look at the bias introduced by invalid addresses, and then we will examine the combined effects of noncontacts and nonreturns.

INVALID ADDRESSES (NONCONTACTS)

The FY71 post-service survey proves to be no exception to the general rule that dross occurs nonrandomly. Here, invalid addresses were related to the potential respondent's service affiliation, race, AFQT class, education and enrollment in special programs (Project 100,000 or Project Transition**). Table 2 shows the percentage of invalid addresses according to those categories. Briefly, these data suggest that:

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*The sample includes all enlisted men in Military Occupational Specialty classifications 1 (electronics), 2 (communications/intelligence) and 3 (medical), plus those in Primary MOS categories 11 (infantry) and 68B (aircraft engine repair) and all Navy aircraft mechanics (AD, ADJ), and Air Force jet engine mechanics (432x0), and all with classification number 400, 610, 661, 702, 712, 721, 780, and 800.

**Project Transition, a voluntary program that began in 1967, makes job counciling, entry level skill training, and placement services available to enlisted men anticipating discharge.

- The Navy evidently had the best set of records, for they turned up only about one percent invalid addresses in their mailing. In contrast, the Army mailing lists contained almost six percent invalid addresses. (No data are available for the Air Force). But from these differences in the percentage of invalid addresses we should not infer that the Navy does a better job of record keeping than the Army. While this may be true, there is another reason that the records for these two services should differ in accuracy; the populations in these two services are markedly different, and these differences are related to stability of residence.
- About five percent of the enlisted men could not be contacted because of invalid addresses, and this dross is strongly related to race. Four percent of the white enlisted men could not be reached, but for black enlisted men the rate was 11-1/2 percent. One out of nine black respondents never even received the questionnaire, so clearly the survey results will underrepresent this group (or overrepresent white respondents); but the issue is not simply one of racial differences for it is undoubtedly true that the 11-1/2 percent of the black population which did not receive a questionnaire is not a random sample of all black respondents.
- Invalid addresses were related to education. Almost ten percent of the potential respondents with less than a high school education could not be contacted; the noncontact rate dropped to 4-1/2 percent for high school graduates, and for those who had one to three years of college, the noncontact rate was three percent. For college graduates, the figure was only two percent.
- The dross due to invalid addresses was a monotonically decreasing function of AFQT scores. Only two percent of the highest AFQT scorers (Class I, centiles 93 - 99)

were lost due to invalid addresses; in contrast, ten percent of the lowest AFQT scorers (centiles 0 - 10) were lost.

- o People who participated in Project 100,000 were harder to locate than people who participated in Project Transition (or both programs). The observed differences probably reflect differences in the populations served by the two programs, however the important point is that one out of every ten participants in the military's chief compensatory training program, Project 100,000, could not be located. Thus, we have a built-in under-representation of the participants in Project 100,000.

We may conclude that noncontacts (invalid addresses) did not occur randomly in this mail survey. This is a significant source of nonresponse bias, but nonreturns, i.e., outright refusals, represent an even larger component of nonresponse bias, and in the next subsection we will consider the combined impact of noncontacts and nonreturns.

NONRESPONSE (NONRETURNS)

Altogether, 163,666 questionnaires were mailed out to this sample of enlisted men, and 109,875 were returned either partially or totally completed. This represents an overall response rate of 67 percent, but this overall figure masks some important subgroup differences. Table 3 shows the percent of people who responded, broken down by Service, race, AFQT class, education, marital status, and source of accession (enlistment/induction). We find that the nonreturns were anything but random.

- o The Air Force turned in the best response rate, 75 percent; and the Army, with a much larger population (n = 131,108) was close with a return of 72 percent. The Navy, with the smallest population of the three

Table 2

PERCENT AND NUMBER OF RESPONDENTS NOT CONTACTED BECAUSE OF INVALID ADDRESSES PRESENTED ACCORDING TO SERVICE, AFQT CLASS, RACE, EDUCATION, AND PARTICIPATION IN SPECIAL PROGRAMS

Category		Percent of Addresses Invalid[a]	Number of Addresses Invalid	Total (N)
Service	Army	5.6	7,366	131,108
	Navy	1.2	280	23,171
		5.0	7,646	154,279
Race	Caucasian	4.1	5,511	135,704
	Negro	11.5	2,135	18,575
		5.0	7,646	154,279
AFQT Class	Class I (93-99 centile)	2.3	272	11,857
	Class II (65-92 centile)	3.0	1,461	49,216
	Class III (31-64 centile)	5.1	2,808	55,452
	Class IV (10-30 centile)	8.2	3,012	[illegible]01
	Class V (below 10 centile)	9.8	93	953
		5.0	7,646	154,279
Education	Less than 8 yr	8.3	100	1,205
	8 yr	10.0	352	3,530
	9 yr	9.5	497	5,227
	10 yr	10.1	760	7,519
	11 yr	9.5	816	8,579
	12 yr	4.5	4,149	92,237
	1 yr college	3.1	442	14,081
	2 yr college	2.8	267	9,570
	3 yr college	2.4	104	4,334
	4 yr college	2.0	146	7,341
	M.A.	1.5	5	328
	Ph.D.	2.4	8	328
		5.0	7,646	154,279
Special Programs	Project 100,000	10.4	607	5,823
	Project Transition	3.4	517	15,124
	100K and Transition	2.5	27	1,080

[a]This table excludes Air Force enlisted men, for whom no data are available on invalid addresses.

services, turned in the lowest response rate, a miserable 38 percent.*

- Returns were related to race. For whites the rate was 69 percent, while for black enlisted men the rate was 51 percent. Black enlisted men were underrepresented for two reasons: first they were contacted less often than whites, and second they were less likely to respond than whites. The result is that the population estimates based on the survey responses will be very much biased against black respondents.
- AFQT scores were also related to response rates, but the relationship was weak. Sixty-nine percent of the enlisted men with AFQT scores in Classes I, II, and III (centiles 31 through 99) responded whereas only 61 percent of those with scores in Classes IV and V responded.
- Married men were more likely than single men to respond; the response rate was 77 percent for married men versus 57 percent for unmarried men.**
- Upon first examination, it appears that draftees were more likely than enlistees to respond to the questionnaire; the return rates for inductees and enlistees were 75 percent and 58 percent, respectively. But this apparent difference is an artifact of the low

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*The Navy's relatively low response rate is somewhat surprising, because it would appear that the Navy population should have a generally higher propensity to respond. Relative to the Army and Air Force populations, the Navy population has a higher average AFQT score, more education, a larger percent Caucasian, and more people at higher pay grades. All of these variables--intelligence, education, ethnicity and income--are usually positively correlated with response behavior. Probably the best explanation for the differences between the Services' response rates is that they each used different survey procedures (e.g., number or type of follow-ups), but this is only speculation; unfortunately, the precise survey procedures which were used were not well documented.

**Divorced and never-married men were classified as single.

response rate for Navy personnel. The inductees served in the Army; in fact, draftees account for 66 percent of all the Army men in the sample. Their return rate of 75 percent is very close to the all-Army return of 72 percent, and therefore we may conclude that there was no important difference between the response rates of Army enlistees and inductees in this particular sample. A potential respondent's educational background was also a good predictor of his likelihood of responding. Sixty percent of those with less than 12 years of school responded, whereas the rate for those with a high school diploma was 67 percent, and the rate for those who had one to three years of college was 71 percent. The highest response rate, 83 percent, came from college graduates.

- Participants in Project 100,000 were less likely to respond than nonparticipants, but those men who participated in Project Transition were more likely than nonparticipants to respond. Again, these differences reflect differences between the populations which are served by Project 100,000 and Project Transition.

CONCLUSIONS

The dross in the post-service file, at least for the FY71 survey, clearly was nonrandom. Invalid addresses were most likely to cut out nonwhites, the less educated, and the less intellectually endowed men. Overall response rates also were lower for nonwhites, the less educated, lower AFQT scorers, single men, and participants in Project 100,000. The underrepresented subgroups within the population undoubtedly differ from the respondents in their post-service histories. Note that this analysis views noncontacts (invalid addresses) as one component of nonresponse bias, and therefore return rates are somewhat lower than they would be if the computations omitted invalid addresses. But this procedure is entirely consistent with the idea that *nonresponse bias accrues from any nonrandom loss of respondents, whether through their refusal to participate or through our inability to contact them.*

Table 3

PERCENT AND NUMBER OF SEVERAL CATEGORIES OF ENLISTED MEN RESPONDING TO QUESTIONNAIRE

Category		Percent Responding	Number Responding	Population (N)
Service	Army	71.7	94,032	131,108
	Air Force	74.6	6,998	9,387
	Navy	38.2	8,843	3,171
		67.1	109,875	163,666
Race	Caucasian	69.3	100,181	144,534
	Negro	50.7	9,694	19,132
		67.1	109,875	163,666
AFQT Categories	Class I	67.7	8,692	12,845
	Class II	69.6	37,139	53,380
	Class III	69.1	40,596	58,778
	Class IV	60.7	22,871	37,708
	Class V	60.4	577	955
		67.1	109,875	163,666
Marital Status	Married	76.5	50,310	65,799
	Single	56.9	50,568	88,853
	Unknown[a]	99.8	8,997	9,014
		67.1	109,875	163,666
Entrance Status	Enlisted	57.6	41,686	72,354
	Inducted (all Army)	74.7	68,189	91,312
		67.1	109,875	163,666
Education	Less than 8 yr	66.4	800	1,205
	8 yr	62.5	2,208	3,531
	9 yr	61.7	3,225	5,239
	10 yr	57.7	4,339	7,524
	11 yr	58.2	5,022	8,624
	12 yr	66.8	66,796	99,960
	1 yr college	68.2	10,138	14,873
	2 yr college	72.3	7,265	10,053
	3 yr college	74.3	3,347	4,506
	College graduate	82.4	6,183	7,503
	M.A.	81.5	268	329
	Ph.D.	86.9	285	328
		67.1	109,875	163,666

[a]Evidently all men who returned a questionnaire but did not indicate marital status were classified as being of Unknown Marital Status. In contrast, the marital status of those men who did not return a questionnaire was assumed to be the same as indicated in the End-of-Service file.

Clearly the post-service mail questionnaire data contain a generous dose of nonresponse bias. The issue is, what can be done about it?

SOME POSSIBLE REMEDIES FOR NONRESPONSE BIAS

The worse a mouthwash tastes, the more we conclude it works. The more we pay for something, the less dispassionately we can see its flaws, and the more severe the initiation required to gain membership in a group, the more we value the group. These are all examples of the dissonance theory proposition that we cherish things which require great effort to attain.* The more effort we expend, the more we seek to justify our efforts.

Researchers who use mail questionnaires are no strangers to cognitive dissonance. Once a great deal of time, energy and money have gone into a mail survey, it is difficult to admit that nonresponse bias may have made the effort all for naught. Faced with a low response rate and evidence of nonresponse bias, the researcher must make some painful decisions.

One option is to give up any hope of estimating population parameters. In this case, estimates are computed for those subpopulations which showed an adequate response rate, and no attempt is made to aggregate these subpopulation estimates into sample estimates of population parameters. This may be a technically safe way to handle the problem of nonresponse bias, but it certainly is not very appealing to the researcher who has spent a great deal of time and effort trying to estimate population parameters; and it may be an unnecessarily severe waste of data. It is very likely that the survey can be "patched up."

One often suggested way of patching up a mail survey is to *replace missing respondents either through direct substitution or oversampling.* If, for example, 1,000 questionnaires are mailed out, and only 500 are returned, we can still get a total of 1,000 completed questionnaires simply by sending questionnaires to another 1,000 people and trusting that their response rate will also be something like 50 percent. This

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*There is a substantial amount of laboratory and field research supporting aspects of this theory, but it is not without flaws; and the simple effort justification hypothesis requires qualification. See, for example, Festinger (1957), Aronson and Mills (1959), Gerard and Mathewson (1966), and Doob, et al. (1969).

illustrates the *ex post facto* replacement of missing respondents. If prior experience has shown that a particular subgroup has a low response rate, we can oversample at the outset. That is, we can send out more questionnaires to people in the low response subgroup. For example, say we have two equal size subgroups, *A* and *B*, within a population; subgroup *A* usually has a 100 percent return rate, but subgroup *B* typically shows only a 50 percent response rate. To make the final returns reflect the population split, we can oversample members of subgroup *B*; to be precise, we can sample twice as many members of subgroup *B* as of subgroup *A*.

Replacement strategies have the effect of narrowing the sample estimate of the population variance, and thus the *precision* of survey estimates is improved, but this does not reduce the nonresponse *bias* which impacts upon the overall *accuracy* of survey estimates. It is important that we not confuse the problem of sample size reduction due to nonresponse with the more central problem of *bias* due to nonresponse. (Cf. Kish, 1965, p. 549). Oversampling merely replaces missing respondents with people who are just like the ones who responded in the first place! We still have a biased sample; it is simply larger, and this ignores the heart of the matter. The problem is not the *size* of the sample; it is the *composition* of the sample.

Weighting returns is another strategy for handling nonresponse bias; but, alas, it relies upon the same assumptions as the replacement strategy. It is, in effect, a kind of pretend replacement strategy, however, when the decision is made to patch up the survey data, weighting is usually preferred to other strategies even though we would prefer to have the larger sample size that replacement strategies produce.

WILL WEIGHTING SOLVE THE PROBLEM OF NONRESPONSE BIAS?

Weighting is usually preferred to replacement methods because weighting (a) costs less, (b) can be implemented after the survey is completed, and (c) eliminates many of the problems of field substitution. And, although weighting is not guaranteed to eliminate bias, it will, under some circumstances, attenuate the bias in estimates of central tendency and variance.

The Logic of Weighting

Weighting schemes amount to counting some cases more than others in order to compensate for the underrepresentation of certain subgroups. Consider this simple illustration: Mail questionnaires are sent to 100 Cadillac owners and 100 Volkswagon owners. All of the Cadillac owners respond, but only 25 of the VW owners reply. The returns clearly underrepresent small car drivers, so we weight the VW drivers' data by the reciprocal of the response rate for this subgroup, that is, 4. In effect, every VW owner who responds gets four "votes" in figuring population estimates, whereas Cadillac drivers get only one vote apiece.

Weighting gives an arithmetically pleasing solution to the problem of nonresponse, but it can sometimes produce disastrous results because *all weighting schemes assume that (a) the respondents represent a random sample of their subgroup and (b) we have taken all the relevant differentia between respondents into consideration in defining subgroups.* Both assumptions are tenuous.

First, the reason for weighting is to eliminate the nonresponse bias which has resulted from the nonrandom attrition (self-selection) of respondents. By definition, the respondents are not a random sample of all potential respondents; if they were, we would not have a nonresponse bias problem in the first place and there would be no need for adjustment! For example, in the survey of car owners, it may be that the VW owners who responded use their small cars as a second car; they are probably wealthier, more educated, and older than VW owners who use their cars as basic transportation. Thus the weighting scheme would overestimate the average wealth, education, and age of VW owners relative to Cadillac owners.

Second, we can never identify all of the dimensions that are "relevant" in weighting; and as in stratified sampling, it is rarely possible to consider more than two or three dimensions. The problem of weighting on all relevant dimensions is not unlike the problem of matching to achieve group equivalence; matching is never a substitute for randomization because we can never be sure that we have taken all of the relevant variables into consideration. (cf. Campbell and Stanley, 1966).

On a less theoretical plane, there are also some practical constraints to weighting. For one, we rarely have enough data about all potential respondents to make weighting possible. The efficacy of weighting is determined by the amount of variance in the dependent variable that the weighting variables can collectively explain. For example, age and education may account for ninety percent of the variance in the income of VW owners, but will these variables explain most of the variance in other dependent variables such as number of miles driven per year? It may be necessary to weight the returns differently for different dependent variables.

In sum, weighting strategies rest on tenuous and unverifiable assumptions, and while weighting on multiple dimensions can *reduce* the magnitude of nonresponse bias, it is probably safe to say that weighting schemes can rarely *eliminate* nonresponse bias. But situations sometimes arise in which any estimate, even a very biased one, is better than no information at all, and when this is the case and some data are available for all potential respondents,* weighting may be a tolerable strategy for attenuating, but not eliminating, nonresponse bias. This is illustrated in the next section where we return to the post-service survey data to demonstrate the mechanics of weighting.

The Mechanics of Weighting

Weighting involves three steps. First, the best set of weighting variables must be identified. This can be done through regression analyses in which linearity is assumed and response/no response is taken as a dummy dependent variable. Second, weights are created by figuring the reciprocal of the response rate for all of the subgroups which are defined by cross-tabulating the weighting variables. And, finally, the weights are applied to the distribution of raw scores in order to produce adjusted estimates of population parameters.

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*We are probably much too quick to assign problems to this category when in fact incorrect information may be more harmful than no information at all.

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In most surveys we have little or no information about *all* of the respondents, and therefore the choice of weighting variables is greatly constrained. But in some cases, and the post-service survey discussed earlier is one of these rare cases, we have extensive information about respondents and nonrespondents alike; and this information can be used to create subgroups for weighting purposes. The issue then becomes one of finding that set of variables which best accounts for the variance in response/nonresponse. In the post-service data, for example, three variables account for almost 87 percent of the variance. These variables are Service, Race, and AFQT score, and they would seem to be good candidates for weighting dimensions in the post-service survey.

To compute the weights, we assign all potential respondents to mutually exclusive and exhaustive subgroups according to their value on the weighting variables, and then compute the response rate (proportion) for each subgroup. The weight for each subgroup is simply the reciprocal of its response rate. To grasp the mechanics of this procedure, see Tables 4 and 5. Table 4 shows what proportion in each subgroup responded to the post-service mail questionnaire, and, of course, the cells (subgroups) are defined by the three weighting variables: Service, Race, and AFQT class. Table 5 shows the same three-way cross-tabulation, but here the cell entries are the reciprocals of those in Table 4. These are the weights applied to the raw data to obtain, for example, weighted averages of post-service civilian earnings or weighted averages of other relevant dependent variables.

The pattern of nonresponse which occurred in the post-service survey of enlisted men was not random. Invalid addresses were related to service affiliation, AFQT class, ethnicity, education, and enrollment in special training programs (e.g., Project 100,000). Nonreturns were also nonrandom; response was related to service affiliation, AFQT class, ethnicity, education, marital status and participation in special programs. Taken together, the noncontacts and nonreturns led to the underrepresentation of nonwhites, the less-educated and the less intellectually endowed men. But the pattern of nonresponse in this particular survey had little impact on our estimates of the population central tendency or variance for any of the survey variates, because the subpopulation which produced the low return rate (i.e., the Navy)

Table 4

PROPORTION OF EACH SUBGROUP WHO RESPONDED WHERE SUBGROUPS ARE DEFINED BY SERVICE, RACE, AND AFQT CLASS

Service	AFQT	Caucasian		Negro	
			N		N
Army	Class I	.819	7314	.615	26
	Class II	.781	37437	.587	540
	Class III	.738	46171	.523	4708
	Class IV	.690	21996	.515	11966
	Class V	.679	470	.534	483
	Total	.748	113388	.520	17720
Air Force	Class I	.817	984	.750	4
	Class II	.779	4103	.590	61
	Class III	.736	3077	.422	249
	Class IV	.719	664	.482	243
	Class V	.000	2	****	****
	Total	.763	8830	.469	557
Navy	Class I	.417	4493	.250	24
	Class II	.388	11108	.221	131
	Class III	.369	4413	.281	160
	Class IV	.353	2302	.261	540
	Class V	****	****	****	****
	Total	.387	22316	.259	855

Table 5

SUBGROUP WEIGHTS (REFER TO TABLE 4)

Service	AFQT	Caucasian	Negro
Army	Class I	1.22	1.63
	Class II	1.28	1.70
	Class III	1.36	1.91
	Class IV	1.45	1.94
	Class V	1.47	1.87
Air Force	Class I	1.22	1.33
	Class II	1.29	1.69
	Class III	1.36	2.37
	Class IV	1.40	2.07
	Class V	****	****
Navy	Class I	2.40	4.00
	Class II	2.58	4.52
	Class III	2.70	3.56
	Class IV	2.84	3.83
	Class V	****	****

constituted a relatively small portion of the overall population (about 14.2 percent, to be exact). Nonresponse would have posed a problem in this survey only if (a) the high and low response subpopulations had been about equal in size, and (b) nonresponse was correlated with the dependent variables of interest. Nonresponse bias occurs when the pattern of nonresponse is correlated with the variables which the survey is designed to measure, and the problem is that we have no way of knowing when this is the case.

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