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An empirical test of the unrelated question randomized response technique

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An empirical test was conducted to determine the degree to which respondents, interviewed using the unrelated question randomized response technique (RRT), would truthfully answer the nonsensitive question when directed to by the randomization outcome if that answer could be jeopardizing should it pertain to the sensitive question. Depending on the sensitive question, between 2% and 10% of the respondents did not answer the unrelated question truthfully. However, these percentages were much smaller than were previously found for the directed response RRT.

Questionnaire data are often biased by the social desirability of the responses (Edwards, 1957). To eliminate evasiveness and untruthful responses to questions of a sensitive or potentially embarrassing nature, Warner (1965) developed the randomized response technique (RRT). Warner's RRT pairs the sensitive question (e.g., "have you ever cheated on your income tax?") with a second question that is the logical complement of the sensitive question (e.g., "have you never cheated on your income tax?"). The respondent, using a randomizing device (e.g., a die), is directed to answer the sensitive question with probability p and the logical complement with probability $1-p$. The respondent does not reveal to the interviewer either the outcome of the randomizing device or which question was answered. Warner argued that the RRT should eliminate the respondent's motivation to distort responses. Warner showed that provided p is not .5, an unbiased estimate of the population proportion could be obtained.

Because of the large amount of random error added by Warner's RRT procedure, it is highly inefficient statistically. Much of the subsequent research concerning the RRT has focused on developing variants that would improve statistical efficiency (see reviews by Fox & Tracy, 1986; Horvitz, Greenberg, & Abernathy, 1976). One such development is the unrelated question RRT (Greenberg, Abul-Ela, Simmons, & Horvitz, 1969; Horvitz, Shah, & Simmons, 1967). In this RRT model, an unrelated and nonsensitive question (e.g., "were you born in an even year?") is substituted for the logical-complement question in Warner's RRT.

The unrelated question RRT is much more efficient statistically than Warner's RRT and becomes even more so when the population parameters of the nonsensitive question are known. One way for the researcher to know what these parameters are is to build them into the randomizing device (Greenberg et al., 1969). For example, respondents may be told to answer the (sensitive) question if the roll of the die is 4 or less, to answer "yes" if the outcome is a 5, and to answer "no" if 6 turns up; the latter two answers are to be given regardless of the true answer to the sensitive question. We will refer to this version as the directed response RRT. Again, the procedure is intended to provide a guarantee of confidentiality, because only the respondent knows whether the answer was in response to the question or was directed by the randomizing device.

Empirical research suggests that respondents answer questions more truthfully when an RRT procedure is used. Validation studies, in which responses are verified against known records, have generally shown smaller error rates under RRT compared with direct questioning (e.g., Lamb & Stem, 1978; Locander, Sudman, & Bradburn, 1976; Tracy & Fox, 1981). In an experiment by Shotland and Yankowski (1982), subjects waiting to participate overheard information about a test that would be given to them in the experiment. After the experiment, they were questioned about whether they had received information about the test prior to its administration in the experiment. Only 24% of the subjects in a face-to-face interview, compared with 64% in an RRT condition, confessed to having received prior information.

When researchers estimate parameters by using the RRT, they usually assume that respondents will follow the instructions exactly. Noncompliance yields biased parameter estimates. Yet, in the directed response and unrelated question RRT models, the respondent's answer could place the respondent in jeopardy if it is applied to the sensitive question. The concept of respondent jeopardy has figured prominently in a number of theoretical discussions of the RRT (e.g., Bourke, 1974, 1984; Fligner, Policello, & Singh, 1977; Greenberg, Keubler, Abernathy, & Horvitz, 1977; Lanke, 1975; Leysieffer, 1975; Leysieffer & Warner, 1976). Some RRT methods have been advanced that incorporate less than complete truthfulness or compliance with instructions (e.g., Greenberg et al.,

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1969; O'Brien & Cochran, 1977, 1978). However, these models are not useful without some practical way of obtaining estimates of the proportion of respondents who are likely to lie or not comply.

Edgell, Himmelfarb, and Duchan (1982) conducted an empirical test to determine the degree to which respondents would follow the directions of a randomizing device in the directed response RRT. The randomization device was programmed to direct predetermined responses on certain trials. Despite their apparent acceptance of the device, a sizable percentage of the respondents did not give the directed response to a question if that response was a socially undesirable one and if the question was sufficiently sensitive.

The present study, analogous to the Edgell et al. (1982) study and with the same survey questionnaire, was designed to determine whether respondents, when answering under an unrelated question RRT, would follow instructions and truthfully answer the nonsensitive question when that response could be interpreted as a socially undesirable one if it pertained to the paired sensitive question. On seven selected questions, respondents were directed by the randomizing device to answer nonsensitive questions about which the true information had been previously collected. The nonsensitive question was worded such that the correct answer for the subject would be the socially undesirable one if it pertained to the sensitive question.

METHOD

Subjects

The subjects were 101 university students satisfying an introductory psychology course requirement. They were randomly assigned to one of three conditions. The three conditions differed only in that different nonsensitive questions were paired with the sensitive questions to ensure that the results were not unique to a particular pairing of nonsensitive and sensitive questions.

Apparatus

The randomizing device was a KIM-1 microprocessor mounted in its optional blue plastic case. It was identical to that used by Edgell et al. (1982). Two keys—one covered with green tape, the other with red—were used as control keys. The rest of the keypad was covered. The KIM-1 was programmed so that pressing the green key caused a random sequence of the digits 0 through 9 to flash in the display that was screened from the interviewer's sight. Pressing the red key halted the sequence; the digit then displayed was the outcome of the randomizing device. The subjects could not stop the sequence on any particular number because the display changed too quickly (.1 sec per character). On certain trials, the KIM-1 was programmed to stop on (and display) a predetermined number when the red key was pressed, regardless of which number was currently being displayed. This was not perceptible to the subjects. Since the questions were presented in a predetermined order to sustain synchronization and obtain the desired result on each trial, the respondents were instructed to use the device only once per question pair. The KIM-1 counted the number of green/red key presses. If, at the end of the interview, this count was not the same as the number of question pairs, the subject's data were discarded. Data from 5 subjects (not included in the count of the 101 subjects reported above) were eliminated because these subjects used the device more times than they should have.

Procedure

To obtain the true answers to certain nonsensitive questions, all students in introductory psychology classes were administered a 21-item questionnaire during class. The questionnaire, ostensibly on the topic of belief in astrology, was designed to elicit personal and biographical information about the respondent (e.g., place of birth, birthdate, class in school, etc.). The questionnaires were distributed and collected by instructors or others not associated with the present study. This background data was used to construct the nonsensitive questions for seven trials whose outcomes were fixed by the randomizing device.

All of the subjects were interviewed individually by the same female graduate student. The study was described as a survey of college student opinions and behaviors. The RRT was presented as a technique to preserve response confidentiality and was explained carefully until the subjects indicated that they understood the procedure. The survey consisted of 55 questions that ranged from quite innocuous to very sensitive and that required a response of either "yes" or "no" (see Himmelfarb & Lickteig, 1982). On a file card, each survey question was printed next to a nonsensitive question. The item cards were arranged on a two-ring binder attached to a clipboard, allowing the interviewer to flip easily through the question pairs. The seven item pairs, for which the randomizing device always directed the subjects to answer the nonsensitive question, had nonsensitive questions written so that the correct answer for the subject (determined from the astrology questionnaire) would be the socially undesirable answer if it pertained to the sensitive question.

The interviewer read aloud both questions. The subjects were instructed to silently determine their response to each question, generate an outcome from the randomizing device, and respond verbally as directed by the obtained outcome. The subjects were directed to truthfully answer the question on the left side of the card (sensitive) when one of the numbers 0-5 appeared in the computer display. They were told to truthfully answer the right-hand (nonsensitive) question when any of the numbers 6-9 appeared. To aid the subject in following instructions, a table specifying the required action for each outcome was taped to the bottom of the item-card clipboard. Thus, the probabilities of answering the sensitive and nonsensitive questions were .6 and .4, respectively. These values were equivalent to those used by Edgell et. al. (1982) with the directed response RRT.

RESULTS AND DISCUSSION

Inspection of the proportion of subjects who did not respond correctly to the nonsensitive questions in each of the pairings within the three combinations of question pairs revealed two cells with an exceptionally large proportion of incorrect responses. Both cells involved the nonsensitive question concerning the number of siblings the respondent had, and the question had been worded to obtain a "no" response. Pilot work had suggested that this question needed to be worded carefully to elicit the correct response. This question was reworded in the present experiment so that the respondents who had two or more siblings were asked if they had only one sibling or no siblings. Still, many subjects responded "yes," as if they had been asked whether they had any siblings at all. The respondents with one or no siblings appeared to have no trouble with the way the question was worded, and they reliably answered "no" when asked if they had two or more siblings. The respondents also had no difficulty with this nonsensitive question when it was phrased to elicit a "yes" response in a pairing with a different sensitive question. Evidently, the syntactic structure necessary to get a "no" response from the subjects with two or more siblings was simply too difficult for many of them to understand. Thus, all observations in which a negative response was sought to this question were eliminated from the analysis.

Table 1
Sensitive Questions and Percentages of Subjects Who Did Not Give Correct Answers

Sensitive Question	Correct Answer	% Not Giving Correct Answer	% From Edgell et al. (1982)	z score
1. Have you ever tried to make an elderly person feel less lonely by visiting with that person?	No	2	4	.632
2. Do you enjoy reading soft-core pornography (e.g., *Playboy*, *Playgirl*)?	No	3	4	.214
3. Have you ever had complete sexual intercourse?	No	3	6	.708
4. Do you approve of premarital sex for engaged couples?	No	8	6	−.550
5. Have you ever falsified your income tax report?	Yes	6	15	1.779
6. Are you in favor of building a nuclear power plant at Marble Hill?	Yes	3	11	2.015*
7. Have you ever had a homosexual experience?	Yes	10	26	6.471†

*$p < .05$ †$p < .001$.

Table 1 gives the percentages of subjects, combined across the three conditions, who did not give the previously determined correct answers to the nonsensitive questions. The percentages are based on 101 subjects for all questions except Question 2, for which the number of subjects was 67, and Question 3, for which the number was 68, because of the eliminated data discussed above. Comparable percentages reported by Edgell et al. (1982), who used the directed response RRT, and the results of significance tests for the differences between the two sets of data are shown in the two rightmost columns of Table 1. All of the percentages from the Edgell et al. study are based on 54 subjects. Although subjects were not randomly assigned between the present study and the Edgell et al. one, they should be similar, since they were drawn from the same subject pool within 1 year. Also, the interviewer was the same for both studies.

The nonsensitive questions paired with sensitive questions 1–4 should have been answered "no" by the respondents if they had followed the directions. Considering both the content of these sensitive questions and the results from Edgell et al. (1982), these sensitive questions appear to be only mildly jeopardizing. Table 1 shows that the percentage of the subjects who answered incorrectly ranged from 2% to 8%. These figures did not differ significantly from those found in the previous study, in which the directed response RRT was used. The nonsensitive questions paired with sensitive questions 5–7 were to be answered "yes." From their content and from the results of Edgell et al. (1982), these sensitive questions appear to be moderately to highly jeopardizing. Table 1 shows that 6% and 3% of the subjects in the current study failed to respond "yes" to the questions paired with sensitive questions 5 and 6, respectively. On Question 5, the percentage of incorrect responses was 9% less than in the Edgell et al. study. However, this difference was not significant. For Question 6, that difference was 8% less than in the Edgell et al. study and was significant. Question 7 is quite sensitive, as was found by Edgell et al., since 26% of the subjects in that study did not answer "yes" when directed to by the device. In the present study, 10% did not answer "yes" to Question 7 when responding to the nonsensitive question paired with it. This was the largest percentage of subjects who did not answer a predetermined nonsensitive question honestly. The difference of 16% between this study and Edgell et al.'s (1982) study was significant.

These results indicate that the unrelated question RRT is less susceptible than the directed response RRT to subjects' refusal to give a possibly stigmatizing answer even though it is not actually in response to the sensitive question. Although the directed response RRT is more statistically efficient, the present results and those of Edgell et al. (1982) suggest that the unrelated question RRT is to be preferred in practice. However, 10% of the subjects in the present study chose not to respond truthfully and in compliance with the directions when faced with the most sensitive question. These subjects were university students participating in research. They would be expected to be more cooperative than general survey respondents. Hence, it would be expected that in a general population, the percentage not following directions would only be larger. Whether this error rate is too large to accept depends not only on the situation but also on the increase in accuracy obtained by using the RRT. If this size of error rate cannot be accepted, then the alternatives are Warner's (1965) original RRT or the symmetric RRT models suggested by Bourke (1974, 1984) and Bourke and Dalenius (1976) (of which Warner's model is a special case).

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