A COGNITIVE INVESTIGATION OF RESPONSES TO DIETARY SURVEYS

Albert F. Smith, Columbia University
Jared B. Jobe and David J. Mingay, National Center for Health Statistics

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ABSTRACT

Surveys of dietary intake are used to evaluate the relationship between diet and disease. Data from such surveys are used to formulate health policy and to develop hypotheses about the etiology of diseases. Questions on dietary surveys ask respondents for frequency and quantity information about the foods that they eat; these questions may impose a heavy cognitive burden on respondents. We report three studies that investigated what information about diet is available in respondents' memories, and whether certain contextual variables influence frequency and quantity estimates. Study 1 showed that absolute frequency estimates depend on "cognitive context". Frequency estimates for a specified period are significantly higher when subjects respond after thinking about "all of the occasions on which they eat a particular food" than after thinking about "the most recent time they ate the food". Study 2 demonstrated, however, that subjects are able to make consistent relative judgments of frequency. Study 3 showed that subjects are relatively insensitive to the portion size descriptions offered as response options on dietary surveys. We discuss the implications of these findings for survey assessment of dietary intake.

INTRODUCTION

Investigators from a number of disciplines have been concerned, for both theoretical and practical reasons, with people's memory for what they eat and with techniques for collecting information about individual diets. Such information is fundamental to epidemiologic efforts to identify relationships between diet and disease, and is used to formulate national health policy. Recently, nutritional epidemiologists have increasingly recommended food frequency questionnaires as the optimal way to collect dietary information: Investigators who conduct large-scale epidemiologic studies find such questionnaires particularly attractive because respondents can complete them without assistance from a trained interviewer and because they have been shown to be valid relative to other techniques (e.g., Willett et al., 1985). On a typical food frequency questionnaire, the respondent indicates the frequency with which he or she ate each of a large number of food items during a specified period of time, and indicates the size of his or her typical portion of each item. Quantity of intake during the reference period is assumed to be a joint function of reported frequency and portion size.

Consider some examples of questions that one might find on a food frequency questionnaire: "How often did you eat eggs during the past year?" "How big is your typical serving of spinach?" Such questions ask respondents to retrieve from memory information about seemingly trivial events that occurred over an extended period of time, and assume that respondents maintain accurate memory for size information.

The response to any survey question is the outcome of complex interactions between a stimulus presented to the respondent (i.e., the question), question-relevant information that the respondent retrieves from memory, and other cognitive processes that subserve the comprehension of the question and the formulation of a response. Survey methodologists have recognized that properties of questions may influence responses (Schuman & Presser, 1981; Sudman & Bradburn, 1974); cognitive psychologists have also begun to pay particular attention to the mental processes involved in responding to survey questions, and have proposed models that address the phenomena of interest to survey researchers (e.g., Bradburn, Rips, & Shevell, 1987; Fienberg, Loftus, & Tanur, 1985; Gruneberg, Morris, & Sykes, 1988; Jabine, Straf, Tanur, & Tourangeau, 1984; Neisser, 1982).

In this paper, we report three studies of cognitive processes that we presume are involved in responding to food frequency questionnaires. In Study 1, we found that the thoughts generated by respondents prior to making frequency judgments influenced those judgments, which implies that absolute frequency judgments are unstable and possibly unreliable. In Study 2, subjects made relative judgments about the frequencies with which they ate foods that they had declared that they eat with equal absolute frequency; we found high internal consistency in these judgments. In Study 3, we found that subjects' responses to questions about their typical portion sizes did not depend sensibly on the quantitative definition of the medium response.

STUDY 1: ABSOLUTE FREQUENCY JUDGMENTS

Survey questions often ask people about the frequency of occurrence of events. An individual might use any of several cognitive strategies to respond to frequency questions about behavioral events: He or she might enumerate remembered instances, or base an estimate on a subjective impression of rate (e.g., Blair & Burton, 1987).

Accurate responses to a frequency question should not depend on the context in which the question is asked (e.g., question order). However, reported effects of context on responses to attitude questions (see, e.g., Schuman & Presser, 1981) suggest that such effects might also be observed on responses to frequency questions, which are presumably matters of fact.

Thoughts generated by a respondent about a particular behavior might affect the mental availability of the information on which the respondent bases his or her response to a frequency question about that behavior (Blair & Burton, 1987; Lindsay & Johnson, 1987). Judgments about the relative frequencies of categories of events depend on differences in the ease with which instances of these categories are brought to mind (e.g., Tversky & Kahneman, 1973); absolute judgments of frequency might be similarly influenced. We describe the state of the respondent's mind as the cognitive context in which the judgment is made, and hypothesize that such a context might be established by instructing a subject to think about a specific topic, or by asking thought-arousing or thought-provoking questions.

We attempted to manipulate the cognitive context in which respondents answered frequency questions, and assessed the impact of this manipulation on frequency

judgments. Subjects were asked to think either about the most recent occasion, or about all the occasions, on which they had eaten a particular food, and then to indicate the frequency with which they ate the food during a specified time period. We were interested in whether and how the cognitive context established by engaging in the instructed thinking influences frequency judgments.

Method

Each of 417 introductory psychology students was asked how often he or she consumed a food item during a specified period of time. Responses to the questionnaire (along with data for Study 3) were collected during a "mass-testing" session in which the students completed various research instruments for a number of different investigators.

Six different frequency questions were formed by crossing three food items (apples/applesauce, chicken/turkey, and pizza) with two reference periods (1 month and 1 year). For example, one question was "Altogether, during the past month, about how many times would you say that you've eaten apples or applesauce?" Each subject answered one question.

Prior to answering the frequency question, about one third of the subjects were instructed to recall and make notes about the most recent time that they ate the food, and another third were instructed to think of and make notes about all of the occasions on which they eat the food. The remaining subjects simply answered the frequency question.

Results and Discussion

Fifteen questionnaires were not completed, and a judge who was blind to the purposes of the research excluded the responses of 21 subjects who failed to comply with the instructions of the preliminary task. Thus, the analyses in this section focus on the responses of 381 subjects.

Table 1 shows the geometric means of the frequency judgments. Inspection of Table 1 reveals that the ratios of mean 1-year frequency estimates to mean 1-month estimates are substantially less than twelve; these ratios range from 4.3:1 to 7.4:1, suggesting either that the 1-year estimates are underestimates or the 1-month estimates are overestimates.

The mean reported frequencies of eating the three food items differed significantly, and the mean 1-year estimates were significantly higher than the mean 1-month estimates; these findings are not discussed further.

Table 1. Geometric Means of Frequency of Intake Estimates as a Function of Reference Period and Thinking Instructions (Study 1)

Item	Reference Period	Cognitive Context		
		Control Occasion	Recent Occasions	All
Apples	1 month	5.5	4.8	6.0
	1 year	33.9	27.5	28.8
Chicken	1 month	14.8	8.1	14.5
	1 year	70.8	57.5	61.7
Pizza	1 month	9.8	7.1	11.7
	1 year	61.7	52.5	67.6

To test whether cognitive context influences frequency judgments, we contrasted the results of the two experimental conditions in which explicit context-establishing instructions were given. Over foods and reference periods, the mean of frequency estimates of subjects who had thought about the most recent occasion on which they ate the target food was 16.8 times; the mean of estimates of subjects who thought about all occasions on which they eat the food was 24.0 times. These differed significantly, $F(1,363) = 4.41$, $p < 0.05$. None of the interactions among the experimental variables was significant.

Several additional analyses confirmed the conclusion described above. First, the analysis was repeated using all data, including the responses of those subjects that were judged to have failed to comply with the instructions. The mean frequency estimates for the recent occasion and all occasion conditions were 15.4 and 22.1, respectively; $F(1,401) = 3.80$, $p = 0.052$.

In addition, a detailed examination of the frequency responses of the originally excluded subjects showed them to vary considerably, ranging from 0 to over 200. Because it is unlikely that the frequency estimates of subjects who have never eaten an item would be influenced by the experimental manipulation, we reanalyzed the data, omitting from the analysis the responses of 16 subjects whose frequency estimates were 0: Across foods and reference periods, the mean estimates for the recent occasion and all occasion conditions were 18.2 and 25.5, respectively; the contrast between these means was significant, $F(1,385) = 4.75$, $p < 0.05$.

Cognitive context influenced frequency judgments. Although subjects in the different experimental conditions answered the same frequency questions, thinking about the range of occasions on which a food is eaten elevated the frequency estimates relative to thinking of only the most recent occasion: On average, the estimates in the former condition were approximately half again as large as those in the latter.

The results of this study illustrate the susceptibility of respondents to an availability bias, that is, a tendency to base responses on information that is either physically present or readily available to mind. Two implications of these results deserve specific mention: First, different surveys may obtain different frequency estimates because the sets of questions that precede the frequency question differ in the extent to which they promote the retrieval of information relevant to the frequency estimate. Second, respondents will likely differ in the extent to which they retrieve from memory information relevant to a frequency question: Asking respondents to think about the range of occasions on which a behavior is performed might be useful in increasing the accuracy of estimates of frequency of heterogeneous behaviors (e.g., eating foods that are prepared in a variety of forms). In addition, exercising control over the pattern of respondents' thoughts, as in our experimental conditions, to homogenize cognitive processes and strategies over respondents, might effectively reduce some random measurement error in surveys.

STUDY 2: RELATIVE FREQUENCY JUDGMENTS

Given the potential instability of absolute frequency judgments illustrated in Study 1, we

consider next the potential usefulness of relative frequency judgments in surveys. In this study, we assessed indirectly the fidelity of cognitive representations of the frequencies of events for which validating data might be unavailable (e.g., the frequency with which an individual eats various food items). Absolute judgments of event frequency are often statements about rates (e.g., 2 times per week; 3 times per month). In this study, we investigated whether respondents can provide finer-grained estimates: For example, an individual might make the same absolute frequency judgment for two foods (e.g., twice per month), yet judge consistently that he or she eats one of them more often than the other. The purpose of this study was to assess whether such information could be elicited.

Our primary interest was in the internal consistency of relative frequency judgments for events with the same nominal frequency. If people can yield finer-grained judgments of frequency than are exhibited in absolute judgments, then relative judgments for events that have been assigned the same nominal frequency should be ordered transitively. We first asked each subject to assign assign absolute frequency-of-eating ratings to each of a large number of food items. We then presented pairs of items that he or she had assigned to the same absolute frequency category (as well as control pairs of items from different frequency categories) and asked him or her to indicate the more frequently eaten member of the pair. The data analysis assessed whether the relative frequency judgments were consistent within categories.

Method

Eighteen undergraduate subjects were recruited for a study on relative judgments. By participating, they fulfilled partially the research exposure requirement of their introductory psychology course.

Each subject completed both parts of a two-phase procedure: In the first phase, each subject responded to a computer-administered food frequency questionnaire. For each of approximately 200 food items, he or she indicated, on a 10-point scale that ranged from "never or very rarely" to "very frequently", how often he or she eats the item.

In the second phase, up to eight items from each absolute frequency category that included at least four items were selected, and all possible pairs of those items were generated. The subject was to indicate which member of the pair he or she eats more frequently. Note that these decisions were between items that the subject had declared, during the first phase, that he or she eats with equal frequency. Some pairs of items that had been assigned to different frequency categories were also presented.

Where possible, eight items were selected from each frequency category. These would yield 28 pairs for comparison. With 10 categories and between-category pairs, the total number of comparison judgments made by each subject was approximately 300.

Results and Discussion

We evaluated the internal consistency of the sets of frequency judgments by counting intransitivities. If a set of judgments contains intransitivities, then responses are inconsistent with an ordering of the judged items along a unidimensional scale (e.g., frequency). Consider, for example, three items, A, B, and C, that are ordered in frequency such that A > B > C, where ">" means "more frequent than". If a subject, when presented with the three possible pairs of items, judged "a > b", "b > c", and "a > c", there would be no intransitivities. A reversal of any one of these would result in one intransitivity in the set of judgments (which is the maximum number possible for a set of three; see Nelson & Narens, 1980).

Note that there is no necessary relation between internal consistency and validity. A subject could generate a completely transitive set of judgments that is unrelated to the true ordering of the events on the relevant scale.

In the following sections, all results are reported are proportions of the maximum possible number of intransitivities that could have been observed, given the number of items over which the set of judgments was made.

Between-category judgments. For relative frequency judgments of items assigned by subjects to different frequency categories in the first phase of the procedure, the observed proportion of possible intransitivities was 0.06.

That observed intransitivities represent a small fraction of possible intransitivities indicates only that the sets of judgments are consistent, not that the ordering implied by these judgments is correct. However, over subjects, the average correlation between the frequency-ordering implied by the relative judgments and the first-phase ratings, which are the best available estimate of reality, was 0.82. Thus, the data indicate a strong tendency for the implied order to resemble our best indication of the true order.

Within-category judgments. For pairs of items that subjects had assigned to the same frequency classes in the first phase, the average proportion of potential intransitivities observed in the relative judgments, across frequency categories and subjects, was 0.17. Although more intransitivities were exhibited within frequency categories than between categories, the relative judgments made by the subjects were nevertheless very orderly.

Without data to check the validity of the implied ordering, to what extent can that ordering be trusted? Although subjects could have concocted arbitrary orders and then responded according to those orders, this possibility seems unlikely for two reasons. First, subjects were not informed in advance about which items they would be making judgments, and, were particularly not informed about which items would be paired with which other items. This strategy would have required maintaining in memory and adhering to an arbitrary order for the items from each frequency class. Second, the results of the between-category judgments indicate a relationship between the ordering of items implied by the relative frequency judgments and our best estimate of truth.

In sum, although there is no necessary relationship between the correspondence of judged and actual frequency and the internal consistency of a set of judgments, such a relationship was found. These data suggest that consistency is related to accuracy. Obtaining relative frequency judgments, examining the set of judgments for internal consistency, and assigning credibility to internally consistent sets of judgments might be a useful way to elicit fine-grained frequency information from survey respondents.

STUDY 3: PORTION SIZE JUDGMENTS

Food frequency questionnaires ask respondents not just about how often various items are consumed, but also about the sizes of their portions of those items.

Usually, some quantity is specified as a standard against which the respondent is to report his or her intake. Are these quantities meaningful to respondents? Although people receive some exposure to quantitative measures of food (e.g., while cooking; in the nutritional labelling on food packages), these measures may not correspond to the units in which they think about quantities of prepared food.

In this experiment, we investigated people's mental representations of portion sizes by asking respondents to indicate whether their typical portion size of each of several foods was small, medium, or large, varying over subjects the quantitative definition associated with the response alternative medium. For some subjects, the term medium, for any food item, was defined as a relatively small portion; for others, medium represented a relatively large portion; for the remainder, it was intermediate. If subjects were sensitive to the defined portion sizes, then the distribution of responses over the response alternatives should depend systematically on the quantitative definition of medium: Respondents to questionnaires on which medium was defined to be relatively small should tend to respond "large" more often than do respondents to questionnaires with larger definitions of medium, and the reverse should be true of respondents to questionnaires on which medium was defined to be relatively large.

Method and Design

Responses were collected from 414 subjects who had also participated in Study 1.

Eight food items were selected for use on the questionnaires; for each food item, medium was defined, over questionnaires, by three different quantities. For example, for salty snacks (e.g., potato chips), the medium serving was defined, on different questionnaires as either 1, 2, or 4 handfuls. These represent the low, middle, and high experimental conditions for this item. For each food item, the ratio of the largest to smallest medium was at least 2:1.

Each subject completed a four-item food frequency questionnaire which asked for portion information. Thus, over 200 responses were collected for each food item, with approximately 70 responses per experimental condition. For each item, the subject was asked how many times he or she had eaten the specified food item during a specific period of time (3 months or 6 months), and then was asked to indicate whether the portion was small, medium, or large. Among the four items presented to each subject was at least one with a low definition of medium, one with a middle definition of medium, and one with a high definition of medium.

Results and Discussion

For simplicity, the data for each item are treated as the results of a separate experiment. The first three data columns of Table 2 show the distribution of responses into the three portion size categories for each definition of medium for each food item. Because the response alternatives are an ordered scale, ridit analysis was used to compare the response distributions (see Fleiss, 1986, pp. 80-84): For each experimental condition, the mean ridit shown in the fourth data column of Table 2 is an estimate of the probability that a typical response in that condition is higher (i.e., larger) than a typical response in the distribution of responses cumulated over all three conditions for that food item.

As was discussed above, if people are sensitive to the definitions of portion sizes presented as response alternatives in survey questions, then, assuming that the true average portion size is the same for all experimental conditions, as the quantitative definition of medium increases, responses should shift toward small. Referring to Table 3, given such sensitivity, as the definition of medium increases over conditions, the condition mean ridit should decrease. The fourth column of Table 2 shows that for only 4 of the 8 items (cream cheese, juice, pasta, salty snacks) was there such a systematic change in mean ridit over conditions. The last column of Table 2 shows that for only one of these items, juice, were the differences among the condition mean ridits significant ($\chi^2 < 0.05$). For a second item, ice cream, there was an omnibus significant difference among condition mean ridits, but their pattern was not consistent with the notion that people choose smaller responses to compensate for the increase in the defined size of medium.

These results indicate that people are not sufficiently sensitive to the quantitative definitions that were associated with the response alternative

Table 2. Judgments of Portion Size: Response Distributions by Food Item and Experimental Condition (Study 3)

		Response				
Food	Def	S	M	L	Mean Ridit	χ^2
Sliced Cheese	Low	24	35	13	.5333	2.01
	Mid	23	36	2	.4694	
	Hi	35	28	16	.4933	
Cream Cheese	Low	20	35	20	.5238	3.32
	Mid	24	26	23	.5171	
	Hi	18	28	6	.4416	
French Fries	Low	13	37	15	.5046	3.46
	Mid	8	47	16	.5369	
	Hi	18	38	12	.4571	
Fruit Juice	Low	5	28	33	.5690	10.56*
	Mid	3	39	23	.5131	
	Hi	14	42	20	.4289	
Green Salad	Low	10	3	20	.4824	0.69
	Mid	7	41	24	.5180	
	Hi	8	40	21	.4988	
Ice Cream	Low	18	31	17	.4995	6.47*
	Mid	10	42	19	.5551	
	Hi	19	41	8	.4429	
Pasta	Low	9	33	27	.5209	1.40
	Mid	7	40	24	.5079	
	Hi	7	45	18	.4714	
Salty Snacks	Low	6	39	27	.5413	4.69+
	Mid	9	37	23	.5077	
	Hi	15	31	17	.4444	

Note: The asterisk indicates $p < 0.05$. The plus denotes $0.05 < p < 0.10$.

medium to provide high-quality portion size judgments. Only the juice data conformed to the normatively expected pattern: For the juice data, the response distributions depended systematically, significantly, and sensibly on the provided definition of medium. People may routinely think about juice in the units used in the response alternatives: Ounces may be the natural cognitive units of juice. People often drink juice from containers whose size, in ounces, they know. In contrast, people do not routinely eat green salad from containers whose size, in cups, they know. That there are "natural" quantitative units of foods is intuitively plausible: For example, who has not been astonished by the price of a salad that is sold by weight? Many attempts by supermarkets to sell some produce items (e.g., lettuce) by weight rather than by the more traditional piece have been abandoned in the face of consumer opposition; consumers prefer purchasing lettuce by the head.

Response alternatives must provide respondents with an appropriate mechanism for communicating to the data collector; this can likely be achieved, at least in part, by identifying the format of mental representations of the information of interest and designing response options with corresponding formats. Studies like the one that was described in this section can help reveal the extent to which the response alternatives described in questions are meaningful to respondents.

GENERAL DISCUSSION

The purpose of food frequency questionnaires is to obtain information about the dietary intake of individuals; estimates of dietary intake are used in epidemiologic inference and in the development of health policy. The accuracy of estimates of dietary intake is constrained by the accuracy of respondents' answers to size and frequency questions. The accuracy of these responses depends, in turn, on characteristics of the questions to which the individual responds, characteristics of the context in which those questions are asked and answered, and the cognitive processes that subserve question comprehension and response formulation.

The studies reported in this paper revealed two classes of threat to the validity of frequency and quantity judgments on food frequency questionnaires. The results of Study 1 showed that frequency judgments are based not on pure retrieval, but rather depend on the cognitive context that is established by the thoughts in which respondents engage before making such judgments. The results of Study 3 showed that portion size judgments were not influenced in an orderly and appropriate way by seemingly large variation in the definitions of available responses, which indicates that the assumption that respondents can accurately remember and describe portion size information is wrong. Taken together, the results of these studies suggest the potential for substantial mis-estimation of dietary intake when estimates are based on responses to food frequency questionnaires. However, in Study 2, we demonstrated a potentially useful technique for obtaining high-quality frequency judgments, and this technique might be extended to judgments of portion size. The three studies demonstrated techniques that allow survey researchers and psychologists to test for effects of the sort we have examined, and potentially useful ways (e.g., relative frequency judgments) to extract information from respondents.

Among the objectives of investigators working at the interface of cognitive psychology and survey research is the synthesis of a consistent, comprehensive theory of the cognitive processes involved in survey responding (e.g., Jabine et al., 1984; Krosnick & Alwin, 1987). Such a theory would predict and explain that part of nonsampling error in surveys that is attributable to systematic functioning of cognitive processes. Development of such a theory will ultimately depend on the results of a large number of empirical investigations of respondent behavior under conditions that are relevant to various types of survey responding. The following remarks suggest how the studies that we have reported contributes information about the cognitive processes that must be characterized by such a theory.

The susceptibility of frequency estimates to the cognitive context that stems from prior thoughts is strikingly similar to several previously reported findings in the psychological and public opinion literatures. Thinking about the range of occasions on which a food is eaten likely makes more instances of eating the item active and available in memory (Lindsay & Johnson, 1987; Tversky & Kahneman, 1973); alternatively, particular thinking instructions may induce particular strategies used by respondents to answer frequency questions (Blair & Burton, 1987). Relative frequency judgments may provide a useful way to extract high-quality frequency information from respondents, especially if the judgments can be made relative to frequencies about which respondents are highly certain.

Respondents apparently either fail to think critically about the size terms presented to them or do not have available in memory representations of sufficient fidelity to permit discrimination among the response alternatives. It is essential that response alternatives be meaningful to respondents. Respondents will likely respond, regardless of whether the response alternatives are meaningful (see, e.g., Schuman, 1987). To the extent that meaningfulness can be enhanced, data quality can be improved. To collect quality portion-size data, we must try to determine whether people have a natural internal measurement system in terms of which they think about quantities of prepared food, and to identify what units are used for different items.

Experimental demonstrations that properties of questions influence the responses collected on dietary surveys are an initial step both toward understanding the cognitive processes used by respondents to answer questions and toward improving questions with the aim of collecting more accurate information. Sensitivity on the part of question designers to the potential influence of the methodological tools used to elicit information from respondents on the data that is collected is a necessary component of improving both the methods and the consequent data.

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