Dietary Intake: Data Collection and Processing

Helen Smiciklas-Wright, Pennsylvania State University

When George Beaton spoke at the First International Conference on Dietary Assessment Methods he began by saying, "In the past decade there has been a great deal published about the errors in dietary data... this is understandable but unfortunate because it can easily leave the impression that dietary data are worthless" (Beaton, 1994, page 2535). He reminded us that dietary intake cannot, and never will be estimated without error; he contended, however, that a serious limitation is not the errors themselves but failure to understand the nature of the errors and their impact on specific strategies of data analysis.

Many publications in recent years have reviewed dietary methodology and the error structures associated with different methods (LSRO, 1986; Bingham, 1987; Dwyer, 1988; Pao et al. 1989). Sheila Bingham (1987) described nine potential sources of error ranging from sampling bias to food tables. The list includes errors that are consequent to the information that clients/subjects provide about their food intake (i.e. weights or portions of foods, recall and reporting of food items, frequency of consumption) and the errors associated with data processing (e.g. coding).

Unquestionably, as Beaton noted there has been criticism about the quality of dietary data with much of the criticism centered on the accuracy of self-reported dietary data. Several recent reports have focused on the relation between self-reported energy intake and intake determined to maintain body weight (Mertz et al. 1991) or energy expenditure measured by the doubly- labelled water method (Schoeller, 1990). The work of Mertz and his colleagues which indicated that, on the average self-reported estimates of energy intake were about 20% less than amounts needed to maintain body weight, received considerable attention in the professional and lay press.

Before we consider some factors that may contribute to errors in self-reported data, let me share a quote that I find useful in putting the issue into perspective. It is taken from a paper that appeared in the 1984 Annual Review of Anthropology and states, "Surely our informants are not to blame for being inaccurate. It is not even their problem. People everywhere get along quite well without being able to dredge up accurately the sort of information that scientists ask them for". (Bernard et al., 1984, page 613). In that regard we should be impressed that some people do as well as they do in providing dietary information (Mertz et al., 1991).

Memory. Most self-reported/recalled data depends on memory; we have gained understanding about memory and dietary recall from cognition research which describes memory as the combination of the encoding and storage of information as well as its retrieval.

Encoding is the consequence of several events, beginning with sensory memory in which information is initially registered before being sent to short-term memory (10-20 seconds) and transmitted to long-term memory (Schaie and Willis, 1986). How the information is encoded and how deeply it is processed impacts on subsequent retrieval. The methods for retrieval include free recall, cued recall and recognition. Free recall is the most demanding process involving active searching of memory to locate information, In cued recall active memory searching is guided by cues or clues to where information is stored. Recognition, or matching of information with what is already stored, involves minimal search.

Several examples from the nutrition literature illustrate the applicability of these issues to dietary recalls. An example of free recall was presented in a paper that Helen Guthrie published in 1984 (Guthrie, 1984). She invited young adults to participated in a free breakfast or lunch, to select foods from a buffet and immediately after the meals describe what foods they ate and the amounts. About one-half of those who had milk as a beverage at breakfast failed to mention it; more than one-half forgot sugar added to cereal and about 20% forgot salad dressing. Another example is Campbell and Dodd's (1969) early work which demonstrated the difference between cued recall and recognition when they interviewed younger and older subjects, institutionalized predominantly for tuberculosis. The subjects were asked to recall food eaten in the previous 24 hours. Then the interviewers probed for additional information using a printed menu of the foods served during the post 24 hours. The recognition task or probe added substantially to estimated nutrient intake, more so for older than younger adults suggesting that the 24-hour recall elicited less accurate information from older persons.

Bethene Ervin (1993) recently tested the memory model in order to determine whether findings based on typical cognition experiments apply to a performed activity like eating. She worked with older adults who were served a dinner meal and asked to recall intake 24 hours later. She reasoned that the least accurate recall should occur if there was no intervention encoding and if retrieval was by free call (see Figure 1); the most accurate should occur if encoding occurred with deeper processing and retrieval was by way of recognition. Subjects in the deeper processing treatment group were asked to estimate the serving sizes of foods served to them before they began to eat. In the recognition task, the foods that were served at the meal were embedded in a longer list of foods. The data supported the hypothesized results with the best recall of items occurring with deeper processing and recognition and the least with no intervention at encoding followed by free recall.

Many factors can contribute to incomplete and distorted memory including attention to the event, personal encoding and retrieval strategies, as well as mood status at both encoding and retrieval (Dwyer et al., 1987). Nutritionists have developed and improved strategies for retrieval of information. These strategies include multiple pass methods for 24-hour recalls and structured systems for probing such as those used in the Minnesota Nutrition Data System (Freskonich et al., 1988).

We have paid less attention to strategies that might affect deeper processing. Recently, Chianetta and Head (1992) reported that there was some improvement of dietary recall when older adults received prior notification of the interview.

Portion Size. There is a growing literature on the errors associated with the estimation of amounts or portions of foods consumed. Many papers have reported results similar to Guthrie's previously cited study (Guthrie, 1984) in which young adults were asked to estimate portion sizes after a breakfast or lunch. No portion size aids were provided. There was considerable variables by food in the accuracy of estimations. The percentages of people who estimated within 25% of actual serving size varied from 73% and 68% for orange juice and milk to 13% for salad dressing and 8% for butter on toast. While deviations of 25% or more seem to be large, more accurate estimations would demand subtle distinctions by participants. Several studies that we have conducted recently as part of the USDA Northeast Regional Study on diet assessment persuade us that those are difficult distinctions to make.

We have recently conducted studies with younger and older adults in which they were presented with pairs of food items with some pairs containing the same amounts and some containing different amounts of the foods. There are variable abilities among respondents and by food in detecting whether food portions are the same or different. Data for young adults are shown. (see Table 1).

Ervin's work has added to our understanding that there is a memory component to portion size as well as to item recall (Ervin, 1993). She introduced a portion size memory test in her work with older adults who were served a dinner and asked to recall dietary intake 24-hours later. At the time of the recall they were shown three different portion size of foods served at the meal. For each food one of the portion sizes shown was the same as that which was served. Memory for the "correct" portion size varied (see Figure 2).

A number of portion size estimation aids are used in dietary assessment including the two-dimensional food portion charts developed by Posner et al. Posner et al. (1992) reported recently that mean energy and nutrient intake were similar when the two-dimensional models or equivalent three-dimensional models were used in 24-hour recalls. We are currently doing some work in association with the NHLBI funded Diet Effects on Lipids and Thrombogenic Activity (DELTA) Study in which we are comparing self-reported food intakes using the two-dimensional models and known intakes of clinical trial participants.

Frequency of consumption. Issues of memory and portion size estimations are relevant to food frequencies questionnaires (FFQs) as are frequency of consumption data. The work of Flegal and her colleagues (Flegal et al.) 1988) is one approach to understanding the source of errors in FFQs. They used 16 days of food records completed by adults and converted the data into a 116-category food frequency format. They compared the "created" FFQ with their participants' responses on an actual FFQ. Their analyses partitioned for the sources of difference between the two FFQs. They reported that frequency differences had the most marked impact on the relative ranking of individuals and were the main source of poor agreement between the two methods. They argued further that in the context of a FFQ, frequency may be more difficult to estimate than serving size, requiring complex mental calculations for which aids are generally not available. They propose cross-checking procedures such as asking respondents for global estimates of frequency for major good groups.

We have a greater understanding of respondent-related error terms and we continue to develop strategies to reduce the errors. We need more information about random errors in population subgroups and their impact on intended analyses. Larkin and her colleagues (Larkin et al., 1989) using the same data cited in the work of Flegal et al., (1988) compared nutrient intakes estimated from 16 food records and a FFQ and partitioned data by race, age, education and other variables including BMI. The smallest relative differences occurred for white men, the largest for black women, other variables including education and also BMI in the whites. Whether the differences are accreditable to under-reporting on the records or over-reporting on the FFQ needs further consideration.

Processing. The final and very brief comments are about data processing particularly coding. The brevity of the discussion does not reflect the importance of the issue. All of us have seen the literature documenting the potential coding-related error sources. One example is the work of the North East Regional group, directed by the University of Massachusetts investigators, who reviewed the coding decisions of 20 coders each given 30 records varying in quality from poor to excellent. Records in all categories presented problems to coders; coefficients of variation were small for some of the 30 records but considerable for others (Lacey et al., 1990). We have various opportunities for reducing these errors with standardized data collection procedures and consistent decision-making rules about data unavailable in data bases or unknown to respondents. Our own work in collaboration with the University of Minnesota's Nutrition Coordinating Center (Smiciklas-Wright et al., 1994) indicates that it is possible to achieve highly reliable interviewer/follow-up data management procedures.

Summary. This paper began with George Beaton's contention that dietary intake cannot be estimated without error and probably never will be (Beaton, 1994). He argued that improved estimation of error terms and appropriate analytical methods for coping with them will have more input on dietary assessment than will further improvements in dietary methods. I believe that we must continue to improve the methods as well as to develop appropriate statistical methods of coping with error terms. The challenge is not to be concerned with minutiae but to understand those errors which may contribute most, and for which groups of persons, to inaccurate dietary assessment.

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TABLE 1

Percentages of persons who correctly identified sameness and difference of amounts when presented with pairs of food items

Food	Standard Amount	Same Amount	Different Amounts: Large Diff.-50%	Large Diff. +50%	Small Diff.-25%	Small Diff. +25%
Corn	1/2 c.	96	99	95	98	68
Steak	4 oz.	84	100	42	83	59
Salad	1 c.	75	88	74	68	34
Cream Cheese	2 T	92	99	94	70	33

		No Intervention	Deeper Processing
Retrieval	Free Recall	Least Accurate	In between
	Recognition	In between	Most Accurate

Figure 1. Memory model and hpothesized results

From: Ervin, 1993

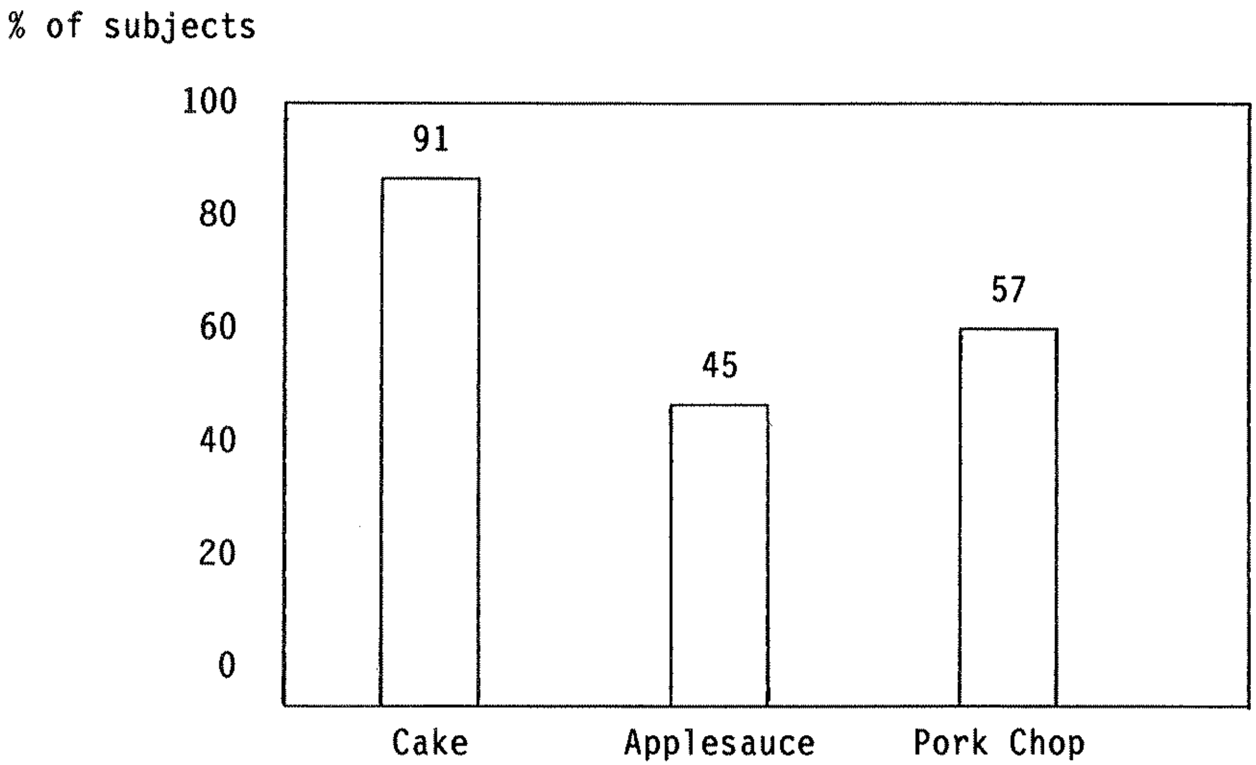

Figure 2. Recognition of serving size

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