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Remembering Heads and Bushels: Cognitive Processes Involved in Agricultural Establishments' Reports of Inventories

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Two studies investigated how respondents in an establishment survey answer factual questions requesting inventory data from two ongoing U.S. Department of Agriculture's National Agricultural Statistics Service surveys. Verbal protocols indicated that respondents often answered without considering relevant parts of a question. For example, only 14 of 93 ranchers (15%) reported considering all three key, explicitly mentioned pieces of information in answering a question about how many cattle they were bringing to market. Another common error was for respondents to base their answers on what inventory they owned, rather than the inventory located on their operation as of a given date, as asked in the question. This error could lead to double counting and/or omissions. Respondents often reported that they retrieved inventory information directly from memory, and there was only a modest relationship between the size of an operation and whether the respondent reported using direct retrieval or an estimating strategy. Direct retrieval may be the most appropriate strategy for answering questions about quantities at a specific point in time, such as inventory questions, whereas estimating strategies may be more appropriate for answering other types of quantitative questions. Knowledge of the cognitive processes used by establishment respondents to answer inventory questions has prompted changes in methods of asking which should produce more uniform, and potentially more accurate, responding.

Key words: Cognitive interview; establishment survey; answer strategies.

1. Introduction

In establishment surveys, individuals are contacted to provide information not about themselves, as in individual or household surveys, but about the establishment they represent. Establishment surveys tend to include more complex questions, and respondents may have specialized expertise as well as access to written records (Osmint, McMahon, and Martin 1994). For example, respondents in a household survey might be asked to estimate their expenditures on restaurant meals for a given time period, whereas respondents in an establishment survey might be asked about total annual sales at a restaurant which they own or represent. In contrast to the growing literature on how individuals answer questions in household surveys (Sudman, Bradburn, and Schwarz 1996), there has been relatively little research on how respondents answer questions in establishment surveys (Edwards and Cantor 1991).

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The present studies investigated how respondents answered quantitative factual questions in an establishment survey. Specifically, we sought to determine how ranchers and farmers, without access to written records, answered inventory questions. These exact questions, or slight variants of them, have been asked millions of times in ongoing surveys.

Each year the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture surveys hundreds of thousands of ranchers and farmers on an ongoing basis in order to estimate current agriculture inventory and production, such as head of livestock or bushels of grain. The resulting estimates help set policies and prices which ultimately affect producers and consumers worldwide. Data are collected via sample surveys of agricultural establishments, and individual reports are weighted to produce both State and National estimates. As in many establishment surveys, the samples are drawn from a stratified list frame, which may result in extremely large weights for some establishments. Therefore, precise reporting at the individual level can be critical to accurate population estimates. This article investigates how these respondents report their establishment data and thus is part of recent efforts to investigate cognitive processes in answering survey questions (Jobe, Tourangeau, and Smith 1993; Schwarz and Sudman 1994; Schwarz and Sudman 1996; Sudman, Bradburn, and Schwarz 1996). The information requested in many NASS surveys is seldom in written records and understanding these cognitive processes may be useful in facilitating uniform reporting, increasing data accuracy, and reducing the burden on respondents who may be contacted several times a year. Although NASS surveys target individual farmers and ranchers, they almost always seek information about a farm or a ranch (the associated establishment) rather than about the individual respondent.

To answer survey or other questions, respondents engage in a series of cognitive processes (Tourangeau 1984). They must comprehend the questions, retrieve or generate the relevant information, judge the appropriateness of this information, and finally, communicate this information to the interviewer. In the survey interview setting, answers to questions can be affected in any or all of these four stages.

Some common comprehension problems such as poor wording or misuse of technical terms, can usually be detected in traditional pretesting with a subsample of potential respondents. Additional pretesting methods, such as behavior coding, may also be used to indicate when key terms and definitions are not consistently understood (Fowler 1992). However, a more subtle and potentially more damaging problem occurs when the individual comprehends the question, but not with the intended or pragmatic meaning (Sudman, Bradburn and Schwarz 1996). Such problems occur for many reasons, including regional differences in the meaning of terminology, misinterpretation based on the context of the question, and simply the ambiguous nature of language.

Nonuniform comprehension may be a particular problem in establishment surveys when common technical terms are not used consistently from one establishment to another (Edwards and Cantor 1991). For example, local police departments may be asked about the number of officers employed. Most likely, these figures will be available. However, different departments may include or exclude particular types of people, such as trainees or parking enforcement personnel, in their individual definition of ''police officer.'' Moreover some of these definitions of ''police officer'' will likely differ from the intended definition of the survey designers.

In large-scale surveys, the question writer is rarely the person actually collecting the data. If the intent of the question is not clearly understood or if the question is written in a framework inconsistent with the respondent's structured knowledge base about his or her establishment, there is little that can be done to improve reporting during the interview. Indeed neither the researcher nor the respondent may even realize that these more subtle comprehension errors have occurred.

Our data suggests that farmers and ranchers sometimes report information based on the corn and cattle that they **own**, regardless of location, whereas NASS tries to avoid inaccurate double counting and omissions by asking respondents to report based solely on what is at a given location as of a given date, regardless of ownership. This is because the list frame NASS uses to select samples is a list of land **operators**, not land owners. This list may include land owner/operators, but agricultural landlords who do not operate their land are sometimes unknown and may include corporations, partners, and others who are unfamiliar with the day-to-day operations and cannot report the desired information. The danger is that NASS may fail to realize that some farmers and ranchers are answering the questions based on ownership rather than location.

Once a question has been comprehended, the respondent must retrieve the appropriate information from memory. Early research in survey cognition (using household survey respondents) often assumed that specific facts were retrieved directly from memory (Bradburn, Rips, and Shevell 1987), and that questions about numerical quantities were relatively easy to answer (Blair and Williamson 1994). However, direct retrieval of existing facts from memory is just one of many possible question answering strategies (Bickart and Felcher 1996; Blair and Burton 1987; Menon 1994; Reder 1987). Instead, many questions are answered using cognitive strategies such as those based on ease of recall or availability, logical inference, anchoring on known information and adjusting, estimating based on partial samples, estimating based on rates of occurrence, and combining subgroups (Blair and Burton 1987; Sudman, Bradburn and Schwarz 1996; Tversky and Kahneman 1974). Direct retrieval may occur only for events which are particularly salient or infrequent.

When respondents are asked about the frequency of events and other numerical quantities, research suggests the most important factor determining whether household respondents directly retrieve and count versus estimate is the number of to-be-recalled events or items (Sudman, Bradburn, and Schwarz 1996). For example, Blair and Burton (1987) asked respondents to report their frequency of certain behaviors, such as dining at a restaurant within a given time period. Respondents generally reported directly retrieving and counting episodes only if there were three or fewer events, and used either counting or estimating for four to ten events. For more than ten events, respondents always used estimating strategies. Similarly we might expect that the size of one's inventory would influence whether one counts or estimates in reporting inventories.

Edwards and Cantor (1991) suggested that respondents' cognitive strategies would be similar in answering household versus establishment survey questions to the extent that the respondent must rely on recall, rather than written records. However, research on question answering strategies in households may not be directly applicable to establishment surveys. Strategies such as episodic enumeration would not apply if the ''episode'' refers to experiences of the establishment, rather than of the respondent reporting the data. For example, specific instances of interviewing and hiring employees are unlikely to be

Table 1. Examples of reporting strategies used by respondents, Cattle on Feed (COF), Grain Stocks (GS) and Storage Capacity (SC)

Strategy	Example:	
Direct retrieval (recall of the target information from memory without any estimation or modification to the figure)	COF:	''On February 1, there would be 21 head ... *how did you come up with that answer?* ... Well, that's what I got, I have that many.''
	GS:	''6,000 ... *how did you arrive at that 6,000?* ... that's what we got in the one bin here at home.''
	SC:	''Forty thousand ... *and now how did you arrive at that figure* ... Well, I been here for years, I oughta know what I got ... *so you just know its 40,000* ... yes.''
Addition of subgroups (summation of a number of smaller figures to arrive at the total)	COF:	''That would be everything I have here, 113 heifers and 89 steers ... *how did you arrive at that number?* ... I know how many I have in each yard.''
	GS:	''Right at 15,000 ... *how did you arrive at that 15,000* ... I had two bins plus what I had in a building, 13 and about 2 in the building.''
	SC:	''... the bin holds 6,000 bushel, I have capacity of 1,000 bushel ear corn that we use, and then I've got 1, 2, 3 gravity beds that hold 100 bushel of ear corn and I use that also. So then my answer would be 7,300 bushel of storage ... *ok, that's exactly what we're looking for* ... well, that's usually how we do it.''
Exclusion of subgroups (subtraction of one or more figures from a larger number to arrive at the total)	COF:	''About 115 ... *about 115? How did you come up with that?* ... I got about 140 calves and I kept off about 25 heifers.''
	GS:	''About 6,000 bushels ... *and now how did you arrive at that answer?* ... Well, I figure I used about 1,000 bushels of corn and sold 1,000 bushels of beans ... *so you used 1,000 and sold 1,000 and subtracted from what you had?* ... yes.''
	SC:	no strategies of this kind

recalled by establishment survey respondents in answering about the total number of employees. Often there may simply be no relevant ''episodes'' associated with reporting factual information about the establishment, such as its total annual sales. In such cases, the respondent must clearly employ other question answering strategies.

The studies described in this article use concurrent think aloud and verbal probing techniques (Bickart and Felcher 1996; Ericsson and Simon 1980; Willis, Royston, and Bercini 1991) to examine reporting strategies. Study 1 examined ranchers' reports of Cattle on Feed (COF), and Study 2 examined farmers' reports of grain stocks inventory and grain storage capacity. Based on pilot data, we classified three primary strategies which most respondents reported using to provide inventory figures: 1) direct retrieval of the figure from memory, 2) addition of several subgroups to arrive at a total, 3) exclusion of one or more subgroups from a larger total. We distinguished the second and third strategies because the second involved retrieving several subtotals and adding them, whereas the third involved retrieving a total and then subtracting out a subtotal. See Table 1 for examples of these strategies. Respondents in our samples seldom used written records.

The nature of the requested information should affect the use of different question answering strategies, with more estimation strategies for reporting larger values. Blair and Burton (1987) demonstrated that the magnitude of event frequencies affected reporting strategies for household respondents. In NASS surveys, factors affecting reporting strategies for level measures may be the size of the farm or ranch (and consequently the magnitude of the to-be-reported items), the type of item (e.g., crops are very different from livestock), and the stability and variability of the item over time. Because cattle and other livestock (such as hogs, sheep, goats, chickens, and so on) are discrete, countable, highly visible, and much higher in value per unit than are grains, individual animals should be more salient to respondents than quantities of grain. In addition, COF inventory can be quite volatile, including dramatic daily changes, whereas grain storage capacity rarely changes and grain stocks inventory varies in a periodic fashion throughout the year. If the strategies used by establishment respondents reporting quantities are similar to those used by household respondents reporting frequencies, then we can hypothesize that direct retrieval will be used more often for COF and reporting strategies using estimation will be used more often for grain stocks and storage capacity. Furthermore strategies should differ as a function of the size of the operation (similar to the number of events in frequency reporting), with direct retrieval being more common for smaller operations and more adding and excluding of subgroups for larger ones.

2. Study 1

2.1. Method

Sample. Ninety-three ranchers were interviewed in the first two weeks of February 1993. A rancher's operation was classified as small ($N = 30$; 1–99 head), medium ($N = 33$; 100–499 head) or large ($N = 30$; 500–999 head) based on previously reported maximum capacity. The classification was not based on current total inventory, which can vary considerably over time. Sample size was less than 93 for some analyses if respondents failed to answer a particular question.

Interviews. Experienced NASS interviewers were trained in cognitive interviewing techniques and conducted all interviews. The target questions were taken from the operational survey questionnaire and asked for the total number of cattle on feed, placements (additions to inventory), marketings (cattle sold) and other subtractions from inventory. The interviewers asked respondents to provide concurrent verbal protocols and to answer follow-ups about question comprehension and the perceived effect of receiving their previously reported total inventory. Eighty of the 93 interviews were tape recorded. Eight were not taped due to technical problems, and five respondents did not want their interviews taped. Interviewers took verbatim notes during untaped interviews.

2.2. Results and discussion

The COF questions were:

''We need to know about the cattle and calves on feed for the slaughter market. Their ration would include grain, silage, hay or protein supplement. Include cattle being fed

by you for others. Exclude any of your cattle being custom fed in feedlots operated by others and cattle being 'backgrounded only' for sale as feeders, for later placement on feed in another feedlot or to be returned to pasture.

How many cattle and calves were on feed February 1, 1993 that will be shipped directly from your feedlot(s) to slaughter market?

During January 1993 how many cattle and calves were:

Placed on feed in your feedlot?
Marketed for slaughter (shipped out of your feedlot)?
Of the other disappearance of cattle from your feedlot during January 1993, how many:
Were shipped to someone else's feedlot?
Were returned to grazing?
Died?''

Follow-up questions were used to determine if respondents had considered key points of the question introduction. Respondents were asked if they considered the first of the month reference date in formulating their answer (32% had not), whether they had considered the feed ration which determined if the cattle were ''on feed'' (59% had not), and if they had considered calves in their answer (56% had not). Indeed, only 14 of the 93 respondents (15%) reported considering all three of the explicitly mentioned items – the reference date (Feb. 1), the feed ration, and calves – in their answers. Failure to consider these items may or may not result in inaccurate reports, but the potential for inconsistent and possibly incorrect reporting is great.

Additional probes suggest that even if respondents considered these three items, they would not necessarily report inventories as NASS desires. Because cattle inventory is highly mobile (moving between pasture, different feedlots and processing plants), NASS ties reporting to a specific location on a given date and not to ownership. If the reference date is not considered, cattle moved between the reference date and when data are collected (up to two weeks) may be doubly counted or omitted completely. Consistent with the NASS definition, 43 of the 93 respondents (46%) stated that they considered cattle marketed on the day they were **shipped**. However, 36 respondents (39%) reported that they considered cattle marketed on the day they were **sold**, whether they left the lot or not. Thirteen (14%) stated that the sale and shipping always occurred on the same day, and one (1%) replied that he considered them marketed on the day he received payment. Thus at least 39% of respondents and perhaps as many as 54% counted COF based on ownership, rather than on physical location as NASS desires.

Follow-up questions also indicated that ranchers disagreed on the definition of cattle on feed. When asked about the difference between cattle on feed and other cattle, 42 defined it with the use of the cattle (breeding or slaughter), 22 with the destination of the cattle (slaughter market, another feedlot, or pasture), 31 mentioned the cattle's feed ration, and 14 used size or age of the cattle. These criteria were cited alone and in combination. Even when the same criteria were cited, respondents often disagreed on whether these animals were ''on feed'' or not. For example, 18% of the respondents defined cattle which were to be sent to another feedlot as ''cattle on feed,'' while 7% defined these cattle as NOT being ''cattle on feed.'' NASS does not consider cattle that will go from one feedlot to another feedlot as ''cattle on feed.'' Only cattle that are on a high protein feed ration and

Table 2. Reporting strategy by operation size, cattle on feed inventory

	Strategy		
	Direct retrieval	Addition of subgroups	Exclusion of subgroups
Small	17	3	5
Medium	20	7	3
Large	10	11	6

will go directly from the feedlot to the slaughter market are considered ''cattle on feed.'' The NASS definition of cattle on feed does not consider either weight or age of the cattle.

In addition, previous research (O'Connor 1993) has found that ranchers also disagree on the factors and criteria that define a calf. Thus ranchers use factors such as the animal's weight, weaning status, and age, either alone or in combination, to distinguish calves from other cattle. Even when they agree on a factor, ranchers may disagree about the criterion, such as whether a calf should weigh less than 500 or less than 700 pounds. Inconsistent definitions can have a substantial impact on COF estimates, as calves (defined as under 500 pounds) constitute about 15–20% of the 600,000 COF which are slaughtered weekly (U.S. Department of Agriculture 1998).

In order to investigate inventory answering strategies, the two authors independently rated transcripts of 83 strategies (45 for COF, 19 for grain stocks, and 19 for grain storage capacity). The inter-rater agreement was .86 (Cohen's kappa) for the three strategies of direct retrieval, addition of subgroups, and exclusion of subgroups. The disagreement were resolved and thereafter only the first author rated all transcripts.

The distribution of reporting strategies provided in verbal protocols for 82 respondents by operation size is shown in Table 2. Three respondents reported using written records to provide their current total inventory, and so were not included in the table or analyses. One respondent refused to provide a strategy and the remaining respondents' strategies were unrecorded. The most common reporting strategy ($N = 47$; 57%) was direct retrieval of the total inventory without any apparent mental calculations. Twenty-one respondents (25%) reported adding subgroups such as separate pens, separate types of COF (calves, steers and heifers) and separate shipments into the feedlot. Fourteen respondents (17%) reported exclusion of subgroups strategies in which they took an initial total group and subtracted various subgroups such as marketings and other disappearances, or subtracted cattle they considered **not** on feed from a base figure of all cattle.

There was a marginally significant association between the three principal strategies reported and operation size, χ^2 (4, $N = 82$) = 8.60, $p = .07$. As expected, the proportion of respondents using direct retrieval was somewhat larger in the small and medium size operations than in the large operations.

Respondents were also asked to recall their previous quarter's COF. Of the 68 respondents whose October 1992 data were available to us, 11 (16%) recalled this number accurately, 19 (28%) overestimated, 24 (35%) underestimated, and 14 (21%) claimed that they could not remember. Errors in recall for these operations (who were all classified as having 1,000 head or less capacity) ranged from underestimates of 180 to overestimates of 228 head. Many respondents commented that there was no reason to keep track of previous COF figures, which suggests that they are not used as anchors to derive the current total inventory.

Study 1 showed that there was considerable potential for misreporting COF figures. In addition, respondents reported relying primarily on direct retrieval to report total inventory. Because COF has characteristics distinctly different from other survey items, the second study examines farmers' reports of grain stocks and storage capacity. Strategies for reporting these numbers are likely to be quite different than for reporting COF.

3. Study 2

3.1. Method

Sample. Ninety-three grain farmers were interviewed in the first two weeks of March 1993. A farmer's operation was classified as small ($N = 50$; 0–19,999 bushels storage capacity), medium ($N = 29$; 20,000 to 49,999 bushels) or large ($N = 14$; 50,000 or more bushels) based on previously reported grain storage capacity.

Interviews. NASS research statisticians were trained in cognitive interviewing techniques and conducted interviews by telephone using a paper questionnaire. Seventy-two interviews were tape recorded, 16 were not taped due to technical problems, and 5 respondents requested that their interviews not be taped. The interviewers wrote verbatim notes for untaped interviews. The interviewer told respondents that they would be asked some of the regular survey questions but that they were to think aloud and explicitly state how they arrived at their reported answers. They were given several examples of verbal protocols and asked to think aloud while answering a practice question.

The two target questions were taken from the operational survey questionnaire and asked for the total amount of corn stocks and the total grain storage capacity. Following each target question, respondents were asked a series of questions designed to examine specific areas of question comprehension. They were also asked to recall their previous quarter's total inventory, and to judge whether knowing that figure would have affected their current answer.

3.2. Results, grain stocks

The question referring to grains stocks appeared as follows:

> ''Please account for whole grains and oilseeds on hand or stored March 1 on the total acres operated, whether for feed, seed or sale. They may have belonged to you or someone else, or been stored under a government program (loan, farmer owned reserve or CCC). Include whole grains or oilseeds on hand or stored even if not in structures normally used for storage.
>
> On March 1, was any whole grain corn on hand or stored on the total acres operated? How many bushels?''
>
> (This is followed by additional questions about other grain crops, depending on the state.)

Five follow-up questions examined whether respondents had considered specific types of grain in their reported inventory and if they had included or excluded that grain in their answer. For NASS reporting purposes (as specified in the questionnaire), all grain on the total acres operated (land owned, plus land rented from others, minus land rented to others)

Table 3. Reporting strategy by item, combined over operation size

	Strategy		
	Direct retrieval	Addition of subgroups	Exclusion of subgroups
COF	47	21	14
Corn Stocks	15	22	24
Storage Capacity	36	50	0

should be reported regardless of ownership. In addition, any grain NOT on the total acres operated (such as grain stored at an offsite elevator) should not be included, even if it is owned by the respondent. This prevents double counting and/or omission of reported grain.

More than 10% of the eligible respondents answered incorrectly on two of the five comprehension questions. Six of 16 respondents (38%) who stored grain on acres other than the total acres operated reported that they included that grain in their total. Also 2 of 14 respondents (14%) who had grain stored by others, including the landlord's, on the total acres operated failed to include this grain in their estimates. Both of these reporting errors are related to the same underlying concept of ownership. Similar to ranchers' misreporting for COF, grain stock respondents were misreporting based on the ownership of the grain, whereas NASS requires reporting based on the location (acres operated) of the grain. Indeed, depending on the time of year, prices, and other factors, 30–50% of corn stocks may be stored off the farm (USDA, 1998). (Data are collected from farmers to estimate on-farm grain stocks. Commercial storage facilities are contacted in a separate survey to estimate off-farm grain stocks.)

Table 3, row 2 shows the answering strategies used by the 61 respondents who reported currently having corn. Fifteen (25%) respondents used direct retrieval, 22 (36%) used addition of subgroups, and 24 (39%) used exclusion of subgroups. The distribution of the three reporting strategies did not vary as a function of operation size, χ^2 (4, $N = 61) = 4.80$, $p = .31$.

Respondents were asked what they reported for total grain inventory in the previous quarter (December 1992). Of the 92 respondents whose data were available to us, 35 (28%) could not recall a figure. Of the respondents who did recall a figure for their previous quarter's inventory, only 13 (14%) respondents recalled this figure correctly, 21 (23%) underestimated their previous report and 24 (26%) overestimated. It is unlikely that respondents are using the previous quarter's data as an anchor, and if they are, it is probably not a very accurate anchor.

3.3. Results, storage capacity

The question about grain storage capacity appeared as follows:

> ''On March 1, what was the total storage capacity of all the bins, cribs, sheds, and other structures normally used to store whole grains or oilseeds on the total acres operated?''

The predominant strategy of 87 respondents (six strategies were unrecorded) is shown in Table 3, row 3. Thirty-six (41%) respondents used direct retrieval of the total inventory figure, 50 (57%) respondents used addition of subgroup strategies such as adding the

capacity of several different bins (each of which was reported by direct retrieval). One respondent (1%) estimated capacity by referring to the size of another, known storage structure, but this answer was not included in the table or analysis. Finally, none of the respondents used either exclusion of subgroups or written records to report. The distribution of strategies did not vary across operation size, χ^2 (4, $N = 86$) = 1.98, $p = .74$.

Certain inventory items, such as grain storage capacity (or number of acres of cropland or peak number of cattle), are expected by both respondents and NASS to remain relatively stable and thus are used to stratify operations once a year for survey sampling. When asked to recall their previous quarter's (December) total storage capacity, 72 of 80 respondents (90%) recalled the same quantity as what they had just reported for their current capacity, thus indicating no change over the quarter. In fact, however, the December capacity equalled the currently reported capacity for only 22 of these 72 respondents (31%). Errors ranged from underestimates of 25,000 bushels to overestimates of 70,000 bushels. Indeed the discrepancies for six respondents (7.5%) were so large that the current reported capacity would classify their operation in a different stratum. Because stratification affects how current reports are weighted, a misclassified operation can affect population estimates even if the respondent now reports accurately during the year.

4. Comparing Study 1 and Study 2

We hypothesized that respondents would use different cognitive strategies to answer the different inventory items. Table 3 shows the distribution of the three principal reporting strategies for the three items, combined over operation size. The favored strategies were significantly different in answering about COF versus Grain Stocks, χ^2 (2, $N = 143$) = 16.65, $p < .001$, and COF versus Storage Capacity, χ^2 (2, $N = 163$) = 24.22, $p < .001$. As predicted, the percentage of respondents using direct retrieval was larger for COF (57%) than for corn stocks (25%) and storage capacity (42%).

Using the Stuart test for marginal homogeneity (Marascuilo and Serlin 1988), there was also a significant difference in strategy used by the 59 farmers who answered both the Grain Stocks and Storage Capacity questions. The farmers reported using direct retrieval equally often for the two questions ($z = 1.04$), but used addition of subgroups significantly more often for storage capacity than for grain stocks ($z = 3.53$, $p < .01$), and exclusion of subgroups more often for grain stocks than for storage capacity ($z = -4.80$, $p < .01$). Thus the selected strategy is related primarily to characteristics of the item, and not to an individual farmer's preference to use a particular strategy.

5. General Discussion

The present study used verbal protocols and extensive concurrent and retrospective probing in order to understand how respondents in an establishment survey comprehend and answer factual questions about their establishment's agricultural inventory. We found that the questions were difficult to comprehend as intended, contained too much information, and sometimes forced respondents to retrieve information in an unfamiliar way, based on location rather than ownership of inventory. Nonuniform comprehension greatly increases the potential for inconsistent and possibly inaccurate estimates of inventory.

5.1. Comprehension

Problems with comprehension go beyond simply not understanding terms, although that too occurred. The lengthy and complex introductions to the inventory questions included potentially important and problematic information, but our data indicated clearly that respondents often failed to consider this information in formulating an answer. For example, the COF inventory question required respondents to consider such diverse information as February 1, cattle, calves, slaughter market, custom fed, backgrounded, placement in another feedlot, returned to pasture, feed ration, silage, hay, protein supplement, fed by others, etc. The amount of information may have taxed and perhaps exceeded the respondents' working memory capacity (Miller 1956), especially when having to answer the questions over the telephone. Most likely respondents attempted to provide a reasonably satisfactory answer but without effortfully using all of the information (Krosnick 1991). Such minimal effort responding may be particularly common in repeated interviews or in interviews with respondents who have distinct mental models of their establishment and information related to it. Indeed the interviewers themselves may read the questions quickly or even skip some of the details, perhaps because they suspect that respondents are not using all the information (Stanley 1993a, b).

The introductions to the agriculture inventory questions likely grew in complexity as developments such as government programs and commercial feedlots tended to separate ownership from the location of inventories. The introductions were modified so that the actual inventory question would remain unchanged and would appear comparable to historical data. There was probably little consideration at the time as to whether and how the additional cognitive burden imposed by the lengthy introduction might affect the quality of the resulting data.

A subtle comprehension problem occurs when there is a mismatch between the respondents' and the survey designers' model of the target domain, in this case an agricultural establishment. Many farmers and ranchers organize their knowledge based on what they **own**, and not on the location of the crops or livestock on a specific day, which is what is being asked. Thus COF respondents often failed to count cattle which were on-site if they had already been sold, and some farmers incorrectly included grains owned at other sites and excluded unowned grains stored on the operated property. These respondents answered the inventory questions based on a pragmatic understanding of the workings of their establishment, rather than on what was specifically asked. We suspect that respondents in other establishment surveys may similarly answer inventory-like questions based on ownership, even when the questions attempt to define establishment activity as being at a single physical location.

5.2. Answering strategies

Respondents generally reported answering inventory questions using one of three strategies – direct retrieval, adding subgroups, or excluding subgroups. Few respondents used written records. The preferred strategy appeared related to the type and stability of the inventoried item, rather than to the size of the respondent's operation. As predicted, direct retrieval was much more common in reporting cattle than grain stocks. However, contrary to our predictions, operation size was only marginally related to the strategy

reported for answering COF and was unrelated to strategy for grain stocks and grain storage. Perhaps the respondents' familiarity with their establishments and the importance of the inventory to the establishment made operation size a less important determinant of reporting strategy.

Previous research had suggested that respondents would use estimating strategies for quantities larger than ten. Blair and Burton (1987) had respondents indicate how many times they engaged in behaviors such as dining at a restaurant, attending movies, and buying clothes within a given time period. They reported that subjects were likely to use estimating strategies if they engaged in the behavior more than about ten times within the time period. In contrast, we found that respondents appeared to directly retrieve relatively large, discrete quantities, such as the number of COF, which were considerably larger than ten. There is even more impressive evidence for direct retrieval if we consider that the two other strategies, adding subgroups and excluding subgroups, apparently involved direct retrieval of relatively large numbers which were then added or subtracted in order to answer a specific survey question. The Blair and Burton findings may be limited to situations where individuals estimate behavioral frequencies of events which are not normally enumerated. Our respondents seldom reported using estimation strategies in answering questions about current inventories of valuable commodities. They knew, or thought they knew, the relevant numbers, and so they tended not to report different strategies for retrieving a large number versus a small number. Thus, contrary to the suggestion of Edwards and Cantor (1991), the cognitive processes used by household and establishment respondents to answer questions may differ even if both groups are relying on recall.

In discussing cognitive processes in answering survey questions which ask for counting and estimation, Bradburn, Sudman, and Schwarz (1996) distinguish between questions asking about frequency of events (''How many times did you eat in a restaurant last month?'') and questions about numeric quantities at a specific point in time (''How many aunts and uncles and cousins do you have?''). However, they do not suggest any implications of this distinction, and they only discuss the cognitive processes involved in answering frequency questions. We suggest that cognitive processes may differ in answering behavioral frequency versus point-in-time questions such as agriculture inventories. For both frequency and point-in-time questions, one may be able to recall small numbers of specific occurrences or items and then count them. However, in many cases, answers to frequency questions are estimated using rates of occurrence, and they may be subject to problems associated with event dating, such as telescoping beyond the designated time period. In contrast, answering point-in-time questions may involve direct retrieval of information from memory for domains where the respondent believes that he or she is an expert, and therefore simply knows the answer. Indeed, for many factual point-in-time questions, there may be no relevant ''episodes'' to recall and no relevant rate of occurrence information.

If, as argued above, direct retrieval of information underlies both the adding subgroups and excluding subgroups strategies, then there was almost no evidence for any other strategy for either cattle or grain questions. Indeed, we had initially expected anchor and adjustment strategies, such as ''Last time, we had 100 and we have about 5 more now'' or ''We are usually around 100, but we are a bit below that now.'' Respondents clearly

did not remember their previous answers about COF or grain inventories, nor did they appear to use any other anchor. Stanley and Safer (unpublished) found that providing the previous quarter's COF inventory as an anchor did not significantly change current reports of COF inventory.

Herrmann (1994) observed that cognitive psychologists have generally not studied direct retrieval, and that it may be difficult to distinguish direct retrieval of information from rapid, unconscious inference. Nonetheless he suggested that direct retrieval may be more common than inference. Direct retrieval occurred in answering questions about current agriculture inventories which were crucial to one's livelihood. Similarly, we suspect that direct retrieval of information, with relatively little inferential reasoning, may also occur in answering factual quantitative questions in other establishment surveys.

5.3. Suggestions and limitations

We offer four suggestions, based on our analysis of the cognitive aspects of responding, to try to increase the uniformity of reporting over time and across respondents in other establishment surveys. First, pretest the questionnaires to ensure that respondents can understand and will follow the instructions and questions (Fowler 1992). Whereas traditional pre-testing would find that everyone understands what February 1 means, our think-aloud and verbal probing techniques indicated that respondents frequently did not consider the date in formulating their answers. Indeed, many new techniques have recently been suggested to augment traditional pretesting methods (DeMaio and Rothgeb 1996; Esposito and Rothgeb 1997; Forsyth and Lessler 1991).

Second, change the interviews, where possible, so that the requested information can be more easily retrieved from the respondent's mental model of his/her establishment. If the questioner's model cannot be changed to match the respondent's, it is imperative to explicitly inform the respondent of the difference. Additional questions, not simply additional instructions, may be necessary to clarify differing models for reporting.

Third, change the interviews to include shorter introductions and, if necessary, **briefer but more** questions, each of which includes less information. This latter recommendation is in contrast to Bradburn, Sudman, and Schwarz (1996, p. 225) who advised lengthening brief questions about quantity in order to allow time for respondents to strategically estimate the correct number. Our recommendation is for briefer questions because establishment survey respondents appear to retrieve quantity information directly with little or no cognitive inference.

Fourth, change the interviews so as to consider the respondent's limited working memory as well as mental models. It may be particularly easy to exceed the capacity of working memory in telephone interviews.

NASS has used this research and these suggestions to change both COF and grain stocks questions. Question introductions were shortened, replacing detailed lists of examples with concept definitions and eliminating other information altogether. For example, the introductory statement for the COF question now contains 23 rather than 69 words: ''We need to know about all cattle and calves on feed for the slaughter market, regardless of ownership, on the total acres operated.'' Similarly, the introduction to the grain stocks question now contains 21 rather than 64 words: ''Account for Whole Grains and

Oilseeds stored on December 1, on the total acres operated, regardless of ownership or intended use.''

Anecdotal evidence from interviewers suggests that these questionnaire changes have improved data collection, but there is a need for more formal evaluations. A major limitation of the present studies was an inability, because of lack of independent check data and confidentiality issues, to verify whether respondents were answering accurately or truthfully. We were therefore unable to specify the relation, if any, between cognitive strategy and the magnitude and direction of survey errors. In future research, one might ask respondents to answer both the original and the revised versions of the questions, either immediately or in a reinterview, and note whether respondents answer differently. Alternatively, one might experiment by asking half of the sample the original question and half the revised question.

In conclusion, we believe this to be the first study of how respondents answer quantitative factual questions in an establishment survey. Our results led to major changes in how NASS asks inventory questions, but clearly more research is needed before developing general rules about how to improve reporting of quantitative information in establishment surveys.

6. References

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