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JUDGED LETHALITY

DECISION RESEARCH

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by

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SUMMARY

Overview

Four methods were used to elicit judgments of relative frequency. Although formally equivalent, these methods elicited estimates that differed as much as a hundredfold. Subsequent investigations revealed that careful attention must be paid to how people store and process information before one can ask them what they know or try to teach them more.

Background

Decision-making processes typically involve the extensive interchange of information. Those involved state their opinions, ask others for their assessments, and attend to incoming data. Often, there are a number of formally equivalent ways to express any given piece of information. Formal equivalence is not, however, a guarantee of psychological equivalence. If different modes of expression lead to different answers, the result can be miscommunication or ineffective exploitation of existing knowledge. The present experiments studied the effect of mode of expression on the elicitation of information regarding the risks of various potentially lethal events such as automobile accidents and heart attacks.

Approach

In two experiments, estimates of lethality were elicited in four ways: (1) direct estimates of death rate per 100,000 afflicted, (2) estimates of the number of survivors for each individual who succumbs, (3) estimates of the number of people

who died given the number afflicted, and (4) estimates of the number of survivors given the number of casualties. In the second experiment, participants were told the correct answers after making their estimates; one hour later, following a series of extraneous tasks, they were unexpectedly asked to remember the correct answers. Both they and a third group of individuals were asked to judge the "naturalness" of the different modes of expression.

Findings and Implications

Judgments proved to be highly sensitive to mode of expression, sometimes varying by a factor of one hundred for a single lethal event. There were corresponding differences in the accuracy of the estimates, which varied from consistent overestimation to consistent underestimation, depending upon the mode used. Judges showed some proficiency for learning the correct answers, with the best memory accompanying the group that initially showed the worst performance. Thus, the failure to have information available in a particular way need not indicate an inability to utilize that mode of expression. The discussion considers the importance of probing information-processing propensities before designing procedures for the elicitation of information.

TABLES

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JUDGED LETHALITY

One component of the risk one faces from any malady is the probability of being afflicted with it. A second component is the probability of succumbing, should one be afflicted. The latter component, lethality, has proven in recent research to be a critical component of people's attitudes toward the risks they face in life. For these attitudes to lead to appropriate behavior, people's lethality judgments must be reasonably veridical (Fischhoff, Slovic & Lichtenstein, in press; Slovic, Fischhoff & Lichtenstein, 1980).

Table 1 presents some evidence regarding the veridicality and impact of lethality judgments. Lichtenstein, Slovic, Fischhoff, Layman and Combs (1978) had people estimate the annual number of deaths in the U.S. from various causes. The causes whose frequency was most over- or most under-estimated are listed, along with lethality rates based on U.S. DHEW statistics and direct judgments of lethality (on a 21-point scale) from Lichtenstein et al. Although there appears to be no relation between bias in frequency estimation and these rough lethality judgments, the most overestimated causes are statistically somewhat more lethal than the most underestimated ones ($p < .10$; Mann-Whitney test). These lethality judgments also seem to be reasonably veridical, with a rank correlation of .70 between lethality judgments and statistical estimates. Interpretation of this correlation should be qualified by noting that the statistical values vary over several orders of magnitude. The absence of at least some correlation with judgments would reflect an extraordinary degree of ignorance. This correlation could also hide a great disparity between statistical and judged values, a possibility that cannot be examined with this (interval) response mode.

The present study looks at judgments of lethality derived by four, formally equivalent, elicitation modes, responses to which can be translated to a form comparable with lethality statistics. It has two foci. One is the substance of lethality judgments. How accurate are they? Are there any persistent, interpretable biases? In particular, are there mis-judgments related to those identified by Lichtenstein et al. (1978)?

The second focus is the impact of elicitation mode on the lethality rates derived from the responses. Like many other numerical quantities, lethality rates may be elicited in a number of formally equivalent ways. For example, one may ask about the rate of death or about the rate of survival. One may ask for a direct rate estimate (e.g., deaths per 100,000) or for estimates of the numbers of afflicted and dying which can then be converted into the desired rate. One may or may not provide a context regarding the overall number or rate of deaths. Conceivably, these discretionary decisions may affect both how people assess their knowledge and how they translate that knowledge into a response (Fischhoff, Slovic & Lichtenstein, in press). For example, if people have difficulty providing large numerical responses, the smaller the correct answer in the response mode chosen, the more veridical the derived lethality rates will be. Or, a focus on survivors might reduce the salience of death and, thereby, reduce judged lethality (Tversky & Kahneman, 1973).

In addition to shedding some light on the storage and evocation of risk information, the discovery of appreciable response-mode effects could have considerable applied implications. Those interested in how much the public knows about

Table 1

Judgments of Lethality and Bias in Frequency Judgments

Cause of Death	Judged Lethality [a]	Statistical Lethality [b]
Frequency Most Overestimated		
1. All Accidents	7.0	.03
2. Motor Vehicle Accidents	9.0	.025
3. Pregnancy, Childbirth, Abortion	4.6	.01
4. Tornado	6.3	---
5. Flood	6.5	---
6. Botulism	10.3	.5
7. All Cancer	13.2	.372
8. Fire and Flames	10.6	---
9. Venomous Bite or Sting	6.8	---
10. Homicide	18.3	1.0
Frequency Most Underestimated		
1. Smallpox Vaccination	0.7	.000
2. Diabetes	6.5	.008
3. Stomach Cancer	11.9	---
4. Lightning	10.1	---
5. Stroke	11.8	.116
6. Tuberculosis	7.7	.018
7. Asthma	2.1	.0003
8. Emphysema	11.0	.014

[a]Judgments of lethality with 0 = never fatal; 20 = certainly fatal.

[b]Probability (death|affliction). Blank indicates not available.

lethality could derive quite different appraisals of the public's knowledge or ignorance from surveys of knowledge conducted with different methods. Those appraisals could, in turn, affect the credibility afforded public concerns about risk in the management of hazards. Where public education is the order of the day, information should, presumably, be presented in the mode most compatible with the recipients' "natural" representation of such knowledge.

Experiment 1

Method

Stimuli. Twenty causes of death were chosen on the basis of their familiarity to subjects, the availability of statistics on their incidence, and the stability of lethality rates over recent years. These statistics were derived from U.S. public health statistics, many of which were collected in Chemical and Engineering News for December 5, 1977. They appear in the right-hand column of Table 2, and represent 100,000 times the ratio of the number of people who die from a cause each year to the total number who become afflicted with it during the year.

Design. Subjects were asked either to estimate lethality rates directly or to provide numerical estimates that could be readily converted to lethality rates. Both the "rate" and the "number" questions were posed in two ways, one focusing on deaths and the other focusing on survivors.

Instructions. All questionnaires began with the following general information:

> There are rougly 215,000,000 people in the United States. Some 1,900,000 die each year . . . . Of these, about

1,750,000 succumb to diseases; 100,000 die due to accidents, while 50,000 either commit suicide or are murdered.

In this questionnaire, we would like you to estimate the lethality of each of a number of problems.

A parenthetical remark inserted at the ellipses in the first paragraph translated these overall statistics into terms consistent with the response mode each group used (e.g., "about 884 per 100,000 people" for the estimate death rate group described immediately below).

Exemplary questions from each of the four conditions follow:

(a) Estimate death rate: In a normal year, for each 100,000 people who have influenza, how many people do you think die of influenza?__________

(b) Estimate number died: Last year, 80,000,000 people had influenza. How many of them do you think died of it?__________

(c) Estimate survival rate: In a normal year, for each person who dies of influenza, how many do you think have influenza but do not die of it during the year?_________

(d) Estimate number survived: In a normal year, 5,000 people die of influenza. How many people do you think have influenza, but do not die from it during the year?__________

Thus, the death rate and survival rate conditions called for estimates of rates, whereas the number died and number survived conditions called for estimates of numbers of people. The death rate and number died conditions dealt with fatalities, whereas the survival rate and number survived conditions dealt with survivors. Minor wording changes were used with some maladies: for drug abuse, "have" was replaced with "suffer from;" "are injured" was used for automobile accidents; "become" was used for pregnancy.

Subjects. One hundred and fifty-eight individuals took part; 40 in the death rate group, 38 in the number died group, 40 in the survival rate group, and 40 in the number survived group.

Results

Subject culling. One subject in the death rate group and five in the survival rate group responded with percentages rather than with numbers and were eliminated.

Data analysis. In order to facilitate comparisons between groups, responses were translated into death rates per 100,000 individuals afflicted. The death rate group estimated these rates directly. For the number died group, which was given the number afflicted and asked to estimate the number of fatalities, the appropriate ratio was calculated and multiplied by 100,000. The survival rate group's estimates of the number of survivors per fatality were confetted to a death rate by multiplying the reciprocal of [1+ estimated number of survivors] by 100,000. The final group's estimates of the number of survivors were converted to a death rate by dividing the number of dead (given to subjects) by the sum of the number of dead and the estimated number of survivors (and multiplying by 100,000). Individual subjects' converted responses were summarized by geometric, rather than arithmetic, means so as to reduce the influence of occasional outliers. They appear in Table 2, the bottom row of which presents coefficients of concordance for each group. That coefficient represents the mean of the correlations between each pair of subjects' rankings of the maladies by lethality. There was fairly high agreement within the death rate, number died, and number survived groups; rather low agreement within the survival rate group.

Agreement between response modes. Table 2 presents the geometric means of the derived death rates. The four columns differ markedly in the magnitude of the death rates they include. These differences provide an ordering of the response modes by the magnitude of the estimates they produce. Number survived estimates are greater than those for death rate for 75% of the items; death rate estimates are greater than number died estimates for 75% of the items; whereas 75% of the number died estimates are greater than the corresponding survival rate estimates. Since instructions to estimate the number of survivors produced the largest death rates and instructions to estimate the survival rate produced the lowest rates, the substantive focus of the task (survivors or dead) cannot be the sole determinant of the magnitude of estimated death rates. In terms of magnitude, the statistical death rate fell in the middle of the four sets of estimated rates. Thus, whether these individuals tended to over- or underestimate lethality depends upon how the question was asked. Number survived and death rate instructions produce overestimates in 83% and 55% of the cases, respectively, whereas number died and survival rate produced underestimates in 53% and 85% of the cases, respectively.

Despite these discrepancies in absolute estimates, there was general agreement regarding the relative lethality of these 20 maladies. Rank correlations between the entries in Table 2 were all in the range .72 to .83 and were all significant statistically ($p < .001$). There was no tendency for estimates

Table 2

Direct and Converted Lethality Rate Estimates

Based on Geometric Mean Responses

Malady	Death Rate per 100,000 Afflicted				
	Estimate Death Rate [a]	Estimate Number Died	Estimate Survival Rate	Estimate Number Survived	Statistical Death Rate
Dental Problems	10	1	2	1	1
Influenza	393	6	26	511	6
Mumps	44	114	19	4	12
Skin Diseases	63	4	6	641	30
Asthma	155	12	14	599	33
Alcoholism	539	70	13	294	44
Venereal Disease	91	63	8	111	50
Measles	52	187	18	28	75
High Blood Pressure	535	89	17	538	76
Drug Abuse	1,020	1,371	19	95	80
Bronchitis	162	19	43	2,111	85
Pregnancy	67	24	13	787	250
Diabetes	487	101	52	5,666	800
Emphysema	1,153	1,998	70	5,417	1,423
Tuberculosis	552	1,783	188	8,520	1,535
Pneumonia	563	304	77	9,553	1,733
Automobile Accidents	6,195	3,272	31	6,813	2,500
Strokes	11,011	4,648	181	24,758	11,765
Heart Attacks	13,011	3,666	131	27,477	16,250
Cancer	10,889	10,475	160	21,749	37,500
Coefficient of Concordance	.62	.67	.34	.67	

[a]Only these rates were estimated directly. Participants in other groups estimated other quantities, which were converted to lethality rates as described in the text.

with a common focus (death or survival) to be more highly correlated than those without, and a slight tendency for those using the same mode (number or rate) to be more poorly correlated (mean correlation = .75 vs. .81), although the small number of comparison groups makes these trends untrustworthy. Using the geometric means of estimates of the 20 maladies, the highest correlation (.83) was between the death rate and number survived groups, which differed in both focus and mode. Despite the relatively low agreement among subjects within the survival rate group, their aggregate estimates agreed reasonably well with those of the other groups (mean correlation = .80).

Validity of Death Rate Estimates

In a correlational sense, all judgmental estimates were highly related to the statistical estimates, with rank correlations ranging between .82 (survival rate) and .86 (number survived). As Table 2 shows, however, these high correlations obscure substantial differences in the actual estimates and their degree of accuracy. One measure of the absolute accuracy estimates might be called the error ratio, created by dividing the estimated rate by the statistical rate for a particular malady. Table 3 shows the median of these ratios for each group, calculated on the 20 items means appearing in Table 2. As the ordering of the groups by magnitude would lead one to expect, the death rate and numbers survived groups produced the greatest ratios, representing overestimation, whereas the survival rate group produced the smallest ratios, reflecting underestimation. Estimating the number of deaths produced as many cases of overestimation as of underestimation. The absence of any systematic error in this group need not, however, guarantee that its estimates were the most accurate. Perhaps a more telling measure of overall accuracy is derived by ignoring the direction of the error. This "error factor" is equal to the error ratio or its reciprocal, whichever is larger. As Table 3 shows, the number died group was also most accurate in this sense, although it was not greatly superior to the death rate and number survived groups. Survival rate estimates are substantially inferior. The bottom line of Table 3 presents the geometric means of the error factors for each individual estimate. Since they do not allow overestimates and underestimates for a particular malady to cancel one another out, these figures are quite a bit larger than the error factors (in the row above), obtained by first calculating the geometric mean response for each malady. Nonetheless, they show the same pattern. Individual estimates in the death rate, number died, and number survived groups are off by about the same amount (about a factor of 10), whereas survival rate estimates are considerably more inaccurate, being off by a factor of about 30.

Particular causes of death. Table 4 presents causes of death whose death rate was systematically over- or underestimated relative to the median error ratio for the various groups. Thus, for example, the dental problems death rate was overestimated by the estimate death rate group since its error ratio (10) was larger than the median error ratio (1.86). In general, the highest death rates were consistently underestimated and the lowest overestimated. The magnitude of this flattening may be crudely assessed by the slope of the regression line predicting log estimated rate from log statistical rate for the number died group, the group without any overall tendency to over- or underestimate. The slope equals .78 (with $r = .87$). The most marked exceptions to this tendency are the underestimation of death rates from pregnancy and venereal disease and the overestimation of death rates from bronchitis and high

Table 3

Magnitude of Error

Experiment 1

	Estimate Death Rate	Estimate Number Died	Estimate Survival Rate	Estimate Number Survived
Median of Item Error Ratios[a]	1.86	1.08	.18	3.48
Median of Item Error Factors[b]	3.26	2.64	5.63	3.48
Geometric Mean of Error Factors for Individual Estimates	10.9	10.2	33.2	12.5

[a]Error ratio = estimated lethality ÷ statistical lethality

[b]Error factor = larger of (error ratio or its reciprocal)

Table 4

Persistent Biases in Judged Death Rates

Relative to Median Error Ratio in Each Group

Experiment 1

Cause of Death	Rank of Statistical Lethality Rate
Always Underestimated	
Cancer	20
Heart Attack	19
Stroke	18
Pregnancy	12
Underestimated in 3 of 4 Methods	
Pneumonia	16
Diabetes	13
Venereal Disease	7
Overestimated in 3 of 4 Methods	
Bronchitis	11
Drug Abuse	10
Asthma	5
Skin Diseases	4
Mumps	3
Dental Problems	1
Always Overestimated	
High Blood Pressure	9
Alcoholism	6
Influenza	2

Note: Measles (8), tuberculosis (15), auto accidents (17), emphysema (14) were overestimated by two groups and underestimated by two groups. Rank in parentheses.

blood pressure. These might be viewed as cases of misinformation above and beyond any tendency subjects have to underestimate the difference in the lethality rates of the most and least lethal maladies.

Extending this reasoning, one might assume that there is not only a general bias toward over- or underestimation in each group, but also a systematic "primary bias" toward flattening the response scale. Deviations from the regression lines predicting judgmental estimates from statistical estimates could be called "secondary biases," following Lichtenstein et al. (1978). Table 5 shows the direction and rough magnitude of these secondary biases in the four conditions. In this light, some of the most lethal events, in terms of both their statistical lethality rate and total number of people killed (cancer, strokes, heart attacks, emphysema, high blood pressure) were rather accurately judged in this perspective. Skin diseases, venereal disease, and dental problems, which afflict many but kill very few, were overestimated. On the other hand, influenza, which kills many people in terms of absolute numbers, but also afflicts a large portion of the population in any given year, was overestimated. The mixed pattern of secondary biases for the other maladies lends itself to no simple summary. Influenza, skin disease, dental problems, and pregnancy were among the few causes of death to assume the same status in Tables 4 and 5, indicating that any discussion of relative bias in estimates for particular maladies depends upon whether one treats the flattening observed here and elsewhere (Lichtenstein et al., 1978; Slovic, Fischhoff & Lichtenstein, 1979) as a substantive result or a statistical artifact.

Discussion

Four methods were used to obtain estimates of the lethality

Table 5

Direction of Secondary Bias

Experiment 1

Malady	Estimate Death Rate	Estimate Number Died	Estimate Survival Rate	Estimate Number Survived
Dental Problems	-	--	--	--
Influenza	++	+	++	++
Mumps	-	++	++	--
Skin Diseases	--	--	--	+
Asthma	0	--	-	+
Alcoholism	++	0	0	+
Venereal Disease	--	0	--	-
Measles	--	+	0	--
High Blood Pressure	+	0	0	0
Drug Abuse	++	++	0	--
Bronchitis	-	--	++	++
Pregnancy	--	--	--	0
Diabetes	-	--	0	+
Emphysema	0	+	+	0
Tuberculosis	-	+	++	+
Pneumonia	--	--	+	+
Auto Accidents	++	+	--	0
Strokes	++	0	0	0
Heart Attacks	++	0	0	0
Cancer	0	0	0	-

++ Strongly overestimated
+ Somewhat overestimated
0 No appreciable secondary bias
- Somewhat underestimated
-- Strongly underestimated

of 20 maladies. The estimated death rates derived from subjects' responses to the four methods showed similar rank orderings. These were, in turn, similar to the ranking of available statistical estimates. In this sense, subjects exhibited an overall knowledge of lethality rates similar to the knowledge of the frequency of death from various causes exhibited by the subjects in Lichtenstein et al. (1978), who also found similar orderings with different response modes.

Nonetheless, the estimates obtained with the different methods varied greatly in their absolute values, ranging from consistent overestimation of the statistical rate with the number survived group to consistent underestimation with the survival rate group. Thus, the estimated lethality rate for diabetes, for example, assumed values from 7 times too large to 15 times too small, depending upon the response mode chosen. It is possible to identify particular maladies that are consistently over- or underestimated relative to the "overall biases" induced by the different methods. Such "item biases" were also observed by Lichtenstein et al. (1978).

Of course, one need not take the statistical lethality rate as an absolute standard. Public health statistics, like all other statistics, are fallible. Poor sampling and incomplete reporting are two obvious problems; uncertainty about how to attribute causes of death is another. For example, if high blood pressure predisposes someone to heart attacks, or if cancer weakens resistance to tuberculosis, or if alcoholism encourages reckless driving, which cause is to be implicated? Even where a standard attribution has been adopted, it may not be known and utilized by all the physicians who produce these statistics. As a result, some of respondents' estimates may be more or less accurate than suggested in these tables. Such errors would not, however, explain the discrepancies between the rates obtained with different response modes.

How might those discrepancies be explained? One possibility is to look for substantive differences between the tasks. Although all four tasks consider the same elements, two of them present additional information in the course of posing their questions: Number died instructions tell how many people were afflicted; number survived instructions tell how many died. That information was designed to equate the difficulty of their tasks with that of the other tasks. For respondents who knew the lethality rate, its provision would have improved performance. For respondents whose lethality estimates were in error, it might have made matters better or worse by introducing compensating or exaggerating biases. A more interesting possibility is that the information changed how respondents thought about the problem, or even how they defined the maladies. For example, being told that 80 million people were afflicted with influenza may have surprised the number died group and encouraged them to think of it as "common flu," a non-threatening nuisance that merited a low lethality estimate. Other speculative examples are also possible, particularly when one considers the ambiguous nature of affliction with some maladies (e.g., drug abuse, alcoholism). Such explanations would require a substantive theory for each malady, regarding what people know already and what they learn or infer from the question; these explanations might also be quite sensitive to the nature (or knowledge) of the subject population studied, at least more so than explanations involving more fundamental cognitive processes.

Whenever one deals with such "rich" stimuli like the present ones, speculative, item-specific explanations are possible.

Aside from being unparsimonious, unsupported, and unsatisfying, such explanations cannot account for the systematic differences between the lethality estimates of the four groups. Nor can they cope with the consistent, order-of-magnitude differences between the death rate and survival rate groups, which received no additional information. Another, more artifactual, mode of explanation is to look at the size of the responses each group was required to provide, under the hypothesis that people may have difficulty giving very large or very small (fractional) responses (Poulton, 1968). Table 6 presents the correct answer for each condition, the number that, when converted, would produce the statistical lethality rate. The number survived group was required to produce the largest numbers. Inability to do so would mean underestimating the number of survivors and emerge as overestimation of the lethality rate, the result obtained. This particular response-bias explanation (failure to give sufficiently large numbers) does not, however, hold up for the remaining groups. Although each group was required to produce numbers in a similar range, they showed quite different systematic biases. The death rate group produced overestimates; the number survived group gave numbers which were too large and which emerged as unduly small lethality rates, whereas there was no systematic bias in the number died group.[1]

A third explanatory strategy is to ask whether the different tasks did not prime the availability of certain considerations and thereby increase their judged likelihood (Tversky & Kahneman, 1973). All other things being equal, reliance on the availability heuristic should lead to higher estimates with tasks focusing on death than with those focusing on survival. Although the number died and death rate groups did have similar error ratios (indicating the overall level of their

Table 6

Correct Answers

Malady	Estimate Death Rate[a]	Estimate Number Died	Estimate Survival Rate	Estimate Number Survived
Dental Problems	1	40	162,500	6,500,000
Influenza	6	5,000	16,000	80,000,000
Mumps	12	15	8,000	120,000
Skin Disease	30	1,800	3,333	6,000,000
Asthma	33	2,000	3,000	6,000,000
Alcoholism	44	4,000	2,250	9,000,000
Venereal Disease	50	500	2,000	1,000,000
Measles	75	90	1,333	120,000
High Blood Pressure	76	17,500	1,314	23,000,000
Drug Abuse	80	400	1,250	500,000
Bronchitis	85	5,500	1,182	6,500,000
Pregnancy	250	15,000	400	6,000,000
Diabetes	800	36,000	124	4,460,000
Emphysema	1,423	18,500	69	1,280,000
Tuberculosis	1,535	3,300	64	212,000
Pneumonia	1,733	52,000	58	3,000,000
Auto Accident	2,500	50,000	39	1,950,000
Stroke	11,765	200,000	7.5	1,500,000
Heart Attack	16,250	650,000	5	3,350,000
Cancer	37,500	375,000	1.8	675,000

[a]This is also the statistical estimate.

responses), they were bracketed by the two "survivor" groups. The survival rate group had by far the lowest estimates, whereas the number survived group had the highest ratio.

Although inherently unsatisfying, hybrid explanations are also possible. A tentative account of these systematic biases might be that the death rate group overestimated lethality because they were forced to think of deaths, whereas the survival rate group underestimated lethality because of being forced to think of survivors. The same did not happen with the other "survivors" group, because the required responses (the number of survivors) were just too large. The relative success of the number died group might be attributed to its response mode being the most "natural" way to think about these matters.

This last set of arguments assumes, of course, that people do have basically accurate perceptions of lethality; the more compatible a response mode is to the natural way in which those perceptions are organized, the truer the translation of those perceptions into expressed judgments. On the other hand, if one believed that people tend to overestimate or underestimate lethality, comparable cases might be made for the naturalness of the number survived or survival rate perspectives, respectively. With proper assumptions about what people know, a claim could even be made for the naturalness of the survival rate perspective, although in doing so, one would have to contend with the low agreement among those subjects and their poor discrimination between maladies with greatly varying lethality rates. Experiment 2 attempts to study naturalness with two straightforward strategies. One is asking for explicit judgments of naturalness, bearing in mind that such assessments are only as good as the quality of the introspections upon which they rely (Ericsson & Simon, 1980). The second involves looking at people's ability to utilize information presented in each of the modes. In Experiment 2 as in Experiment 1, subjects first made estimates in one of the four modes. They then receive the statistically correct answer (in that mode). After a series of intervening tasks, they are unexpectedly asked to remember that correct answer. Arguably, the best recall and the greatest improvement in knowledge will indicate the most natural representation, that mode most conducive to the integration and preservation of additional knowledge.

Experiment 2

Method

Stimuli. Ten of the twenty maladies used in Experiment 1 were selected for Experiment 2 by eliminating those ten for which public health statistics seemed most unsatisfactory. The remaining ones allowed reasonable confidence in the diagnosis of affliction and the attribution of responsibility for death. They can be found listed in various tables of results below.

Design. Participants' first task was to make estimates following the procedures for one of the four response modes of Experiment 1. Immediately afterward, they were given the statistical answer as the "true value." To encourage them to attend to this value, they were asked to score their own answers as being higher or lower than the true value. Approximately one hour later, after a series of unrelated tasks, respondents were asked to recall the true value they had been given. Finally, they were given statistical lethality estimates for a new malady, infectious hepatitis, phrased in formats consistent with each of the four response modes. Their task was to rank those phrasings according to how "natural" they seemed. A final group received just the one page asking for naturalness rankings without any preceding judgment tasks.

Instructions. The initial estimation task was identical to that of Experiment 1. The subsequent scoring task gave the true value rounded to two significant figures and told subjects:

> For each problem, compare your estimates from Part I with the true value. If your estimate for a particular problem was too high, place a check in the column labeled "my estimate too high." If your estimate was too low, place a check in the column labeled "my estimate too low." If your estimate was exactly correct, leave the space blank.

In the recall task, the following instructions were used to help ensure that respondents gave their recollection of the true value, rather than their own original response.

> In an earlier part of this experiment, you made estimates of the lethality of a number of problems. After you made your estimates, you compared each of them to the true value and indicated for each estimate whether you were above or below the true value.
>
> Listed below are each of the problems you saw before. Now, we would like you to recall as best you can the true values for each of the problems. In the space next to each problem, write your recollection of the true value.
>
> Remember, it is the true value we would like you to do your best to recall, not your estimate. If you feel unable to recall a true value exactly, make a best guess.

The final task was introduced as follows:

> The lethality of infectious hepatitis is phrased below in four different ways. Read each of the four phrasings carefully and decide which expression seems most natural to you. That is, which phrasing describes the lethality of infectious hepatitis in terms that correspond most closely to the way you usually think of the lethality of diseases and accidents?

Subjects. Two hundred and thirty-four individuals took part: 37 in the death rate group, 36 in the number died group, 37 in the survival rate group, 36 in the number survived group, and 87 in the group that only rated naturalness.

Results

Subject culling. Seven subjects used the wrong response mode and were eliminated. No more than two came from any one group.

Initial estimates. Table 7 presents the geometric means of subjects' initial estimates. In general, these estimates resemble the comparable estimates from Experiment 1 (presented in Table 2). Across the four groups, 26 of the 40 present estimates are within a factor of 2 of the comparable Experiment 1 estimates; all 40 are within a factor of 5. Again, the coefficients of concordance reflected considerable agreement among subjects within all but the survival rate group. As would be expected, given this general pattern of similarity, particular maladies that tended to be relatively over- or underestimated in Experiment 1 (as presented in Tables 4 and 5) generally assumed the same status here. Perhaps the only changes of note

Table 7

Initial and Recalled Lethality Rates

Experiment 2

(Geometric Means)

	Death Rate		Number Died		Survival Rate		No. Survived		Statistical Rate
	Init.	Recall	Init.	Recall	Init.	Recall	Init.	Recall	
Influenza	136	4	11	10	140	36	284	370	6
Asthma	59	49	12	35	33	397	858	115	30
Measles	57	57	401	407	67	321	61	37	75
Pregnancy	57	115	25	124	20	299	549	444	250
Diabetes	278	344	436	374	54	579	8435	2236	800
Emphysema	1503	902	1008	751	277	787	8658	4475	1400
Tuberculosis	650	462	4346	4563	310	882	11057	1115	1500
Pneumonia	482	352	392	156	199	854	9279	9580	1700
Strokes	3745	3153	4045	3823	380	3655	19072	22919	12000
Cancer	6110	12106	9211	8433	327	7388	17526	33128	37000
Coefficient of Concordance	.63	.58	.64	.66	.35	.33	.71	.80	
Rank Correlation with Statistical Rate	.64	.87	.73	.64	.56	.78	.78	.78	

from Experiment 1 were that the present death rate group gave somewhat lower estimates, although there was no great change in their accuracy, and the survival rate group gave somewhat higher estimates, thereby moderating their tendency to underestimate in Experiment 1. It is unclear whether this modest improvement reflects greater knowledgeability of the present subjects or some change due to deleting 10 maladies (e.g., helping subjects to concentrate on the remaining ten).

Perhaps the most important substantive result of Experiment 1 to be replicated was that although the ranking of the items was similar in the different groups (intergroup rank correlations between .56 and .77), the absolute value of the lethality rates varied systematically across groups. Again, the groups fell into the following order according to the size of their estimates: number survived, death rate, number died, survival rate (although the difference between the middle two was minimal). In terms of order of magnitude, the statistical rate came after number survived. Thus, one could again find tendencies toward overestimation or underestimation, depending upon the group whose estimates were being examined. Table 8 presents the error ratios and error factors for Experiment 2, along with corresponding results for this subset of 10 items from Experiment 1. Except for the modest changes in the magnitude of the death rate and survival rate group's estimates noted above, the pattern here is quite the same. The number died group's estimates were most accurate, followed by death rate, number survived, and survival rate, a group whose estimates were markedly inferior.

Attention to correct answers. After making their initial estimates, subjects were given the statistical answers. In an effort to encourage them to attend to those answers, they were

Table 8

Contrast Between Original Estimates
and Recall of True Values
Ten Items of Experiment 2

		Death Rate	Number Died	Survival Rate	Number Survived
Median Error Ratio Across Items					
Experiment 1	Initial	.651	.380	.059	4.66
Experiment 2	Initial	.391	.369	.158	5.82
Experiment 2	Recall	.415	.516	.656	2.35
Median Error Factor Across Items					
Experiment 1	Initial	3.24	2.64	19.60	4.66
Experiment 2	Initial	3.04	2.90	10.52	5.82
Experiment 2	Recall	2.25	2.59	2.64	2.41
Percentage of Cases					
Recall = True Value		19.3	15.3	21.3	10.4
Recall = Orig. Estimate		4.1	4.4	3.0	5.2

asked to score their own estimates as being too high or too low. One sign of the attention they paid is the accuracy of that scoring. There were 47 errors in 1480 scoring opportunities (= 3.2%), approximately equally divided between incorrectly marking too high or too low (26 vs. 21). Although almost half of the errors (21) were made in the survival rate group, this reflected primarily two subjects who generally scored themselves incorrectly. Roughly equal proportions of subjects made at least one error in each group (overall percentage = 18.2). These results seem to indicate quite a high level of attention.

Recall estimates. Table 7 presents the results of subjects' efforts to recall the correct answer that they had been given. For the death rate and number died groups, these memories were quite similar to subjects' initial estimates. The respective rank correlations were .77 and .96, and few of the paired estimates were different by as much as a factor of two. Recalled estimates tended to be a bit more accurate than the initial estimates, indicating some learning on subjects' part. As the bottom of Table 8 indicates, these subjects remembered the true value as given about 1/6 of the time. Overall, their memories were closer to the true value than were their initial estimates about 2/3 of the time.

Changes were, however, somewhat greater with the number survived group and much greater with the survival rate group. The rank correlations between initial and recall estimates were .73 (number survived) and .64 (survival rate). More impressive, their error factors were indistinguishable from those of the death rate and number died groups. The survival rate group remembered the largest percentage of the true answers (although this percentage was only nominally greater than that of the death rate group, which showed much less improvement. There was, however, still considerable disagreement among survival rate subjects on the recall task, as reflected in the low coefficient of concordance. One possible explanation is that the group's improvement was due primarily to shifts in the responses of a portion of subjects, whose responses then became discordant with those of subjects who were not responsive to the information provided.

As Table 8 indicates, subjects remembered the true value that they had been told only 16.6% of the time. For individual maladies, the memory rate varied from 0.6% (emphysema) and 1.7% (tuberculosis) to 36.1% (influenza) and 48.3% (pregnancy). These rates were consistent with a serial position effect; the two best-remembered were first and last in the list, respectively; the two worst-remembered were fourth and sixth, respectively. It seems reasonable, however, that personal relevance had some contribution to memorability. For example, cancer had the third best memory rate (22.4%) despite being fifth in the list, sandwiched between emphysema and tuberculosis. The low rate of subjects remembering their own original responses (about 4%) suggests that those numbers were not very well ingrained in subjects' minds. Whatever subjects remembered when they were unable to recall the true value, it was not their previous expression.

Naturalness of phrasing. Table 9 shows preferences for different modes of expressing information about the lethality of infectious hepatitis. Those in the top section represetn subjects who performed only this task. They received one of four different forms, with each mode occupying a different ordinal position on each form. There were no appreciable order effects; hence, the forms are combined for the 87 subjects.

Table 9

Naturalness of Phrasing

	Number of Choices in Each Rank				
Phrasings Judged	Rank 1	Rank 2	Rank 3	Rank 4	Mean Rank
Subjects who received no other tasks					
Death Rate	37	24	12	14	2.03
Number Died	26	43	14	4	1.95
Survival Rate	13	10	33	31	2.94
Number Survived	12	9	28	38	3.06
Subjects who made estimates					
Death Rate	56	38	24	25	2.13
Number Died	44	62	25	12	2.03
Survival Rate	30	24	52	38	2.68
Number Survived	14	20	42	67	3.13
	Mean Rankings of Phrasing Received				
	Death Rate	Number Died	Survival Rate	Number Survived	
Death Rate	1.73	2.03	2.41	2.30	
Number Died	2.22	2.13	1.89	1.88	
Survival Rate	2.70	2.78	2.50	2.79	
Number Survived	3.35	3.06	3.19	2.91	

Clearly, subjects preferred the death phrasings to the survival phrasings and did not consistently distinguish between number and rate phrasing.

The middle and lower portions of the table summarize the rankings of the subjects who had previously completed the estimation and recall tasks. Two orders were used here, that appearing in the table and: survival rate, number survived, death rate, number died. Again, no order effects were found and results are collapsed over the two orders. As the middle section of the table indicates, the popularity of the phrasings was similar here to what it was for the "fresh" subjects in the top section. When mean rankings are examined as a function of the phrasing subjects had faced in their estimation and recall tasks (bottom of table), much the same pattern is seen. However, having used a phrasing in a task did tend to increase its popularity. Overall, mean rankings decreased by an average of 0.24 for subjects who had used a phrasing. These changes were greater in the less popular groups. Thus, although judgments of naturalness seem quite robust, they can be affected somewhat by immediate experience.

Discussion

The initial estimates of Experiment 2 strongly replicated the basic pattern of results from Experiment 1. These four formally equivalent response modes produce systematically varying subjective estimates. Differences of a factor of 25 in the estimated lethality of a given malady were not uncommon. Depending upon the method used, one could find that people tend to systematically overestimate (e.g., number survived) or underestimate (e.g., survival rate) lethality.

Despite this divergence in the absolute accuracy of the estimates derived with the different methods, the relative lethality of the different maladies was seen as quite similar across methods. Rank correlations between the estimates of the different groups were on the order of .75. Moreover, there were fairly consistent tendencies to underestimate or overestimate the lethality of particular maladies, relative to the overall bias of their group.

The similarities of the responses in the two experiments means that the status of the various explanations offered for the results of Experiment 1 remain intact. The disagreement between the survival rate and number survived groups' estimates means that availability explanations are inadequate. The disagreement between the survival rate and death rate groups' estimates, despite their being required to produce numbers with a similar order of magnitude, means that a predisposition not to use large numbers cannot be the single effective element. The lack of any special affinity between the estimates of subjects with "rate" and "number" tasks reduces the likelihood of that aspect being an explanatory factor. As noted in Footnote 1, anchoring and adjustment continues to provide no predictive guide. Thus, we are left with the same unsatisfying (even if true) item-specific or hybrid explanations offered earlier.

The recall and naturalness judgment tasks do, however, cast some additional light. The two "death" perspectives were judged to be more natural ways of considering lethality; moreover, they produced somewhat more accurate assessments in both experiments. Despite being judged less natural and producing poorer estimates, the "survival" groups were equally or more responsive to information presented in their perspective. The accuracy of their recalled estimates was indistinguishable from that of the other groups. Particularly striking was the improvement in the survival rate group. That perspective received poor naturalness rankings and produced poor estimates, yet subjects remembered 20% of the true answers presented in that perspective.

Apparently, perspectives that are not used "naturally" may still be quite usable. As a result, one might use quite different criteria for choosing a method by which to assess people's current store of knowledge and by which to increase that store. On the basis of what we have learned here, one might reasonably ask for direct estimates of lethality to find out what people know, but give them new information in the form of survival rates. Given the weakness of our theoretical understanding of these processes, there may be no alternative to systematic experimentation whenever one must choose between formally equivalent ways of expressing a problem.

An unanswered question at this moment is the extent to which information presented in one mode becomes accessible in another. For example, how much will teaching people survival rates improve their direct estimates of the lethality rate? The critical theoretical question here is whether people have a single coherent mental representation of lethality information. If they do, then anything that people learn becomes, in principle, accessible to whatever mode of questioning is employed. Whenever and however a question is asked, people access that bloc of knowledge, performing the inferences and transformations needed to produce the desired response. It is these inference and transformation processes that lead to discrepant expressions of the same knowledge produced with differing response modes. Thus, for example, the low coefficient of concordance with the survival rate group might mean that that was indeed a less natural perspective, requiring a more cumbersome and unreliable translation process to produce responses.

An alternative assumption is that people have no such coherent core of knowledge. Rather, they know somewhat different things about death rates, survival rates, numbers died, and numbers survived. These four bodies of knowledge are sufficiently linked to produce similar rankings of the lethality of hazards with greatly varying lethality rates. However, they are sufficiently independent to allow for fairly discrepant judgments. In this light, the responses of the four groups tell four different stories, and the disagreement among subjects' responses reflects actual differences in their knowledge, not noise introduced by inference or processing. One might then expect to find the greatest disagreement among subjects associated with the least accuracy, suggesting a form of information that people do not track very well (or regularly); the survival rate perspective would fit this description quite well.

The question of whether people have a single store or multiple stores of information is hard to answer, even when respondents are presented with concentrated doses of well-characterized information about completely novel tasks for which they must create storage schemes (e.g., Estes, 1976; Hintzman, 1977). With naturally occurring information, such as that dealing with lethality, a definitive answer is probably impossible. Yet, some idea of the coherence of people's knowledge on a topic is needed to enable one to understand what they can be expected to learn from the information with which they are presented and whether special instruction is needed to help them to integrate their knowledge and derive logically implied conclusions.

FOOTNOTE

1. Another response-bias explanation, which may be invoked for any numerical estimation tasks is anchoring and adjustment. The judge picks some initially relevant number as a starting point (or anchor) and then adjusts it to accommodate additional information. Although anchoring can be a powerful heuristic (Tversky & Kahneman, 1974), its application in the present tasks is unclear. For example, was the number died group anchored on the total number of deaths, the number of deaths per 100,000 people in the U.S., the number of survivors, the number of deaths from accidents or the violent causes (all of which appeared on their form) or some other number(s) of their own creation? In the absence of an experimental design controlling for various possible anchors, all one may be able to do is to assume that people are using the anchoring heuristic and work backwards to identify the anchor(s) capable of producing the observed results.

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Four methods were used to obtain estimates of the lethality of 20 maladies (i.e., the likelihood of dying from them given that an individual is afflicted). Although the estimates elicited by the different methods showed similar rank orderings, the actual values of these lethality rates varied greatly, from consistent over-estimation of the true rate to consistent underestimation. No method proved initially to be demonstrably more accurate than

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the others. Aside from their practical implications, regarding the most effective way to inform people about such life-and-death issues, these results offer some hints as to the ways that such knowledge is stored and integrated in memory.