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Order of Information Affects Clinical Judgment

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ABSTRACT

Family practice physicians read a case vignette describing a patient with a history of lung cancer, a new transient neurological disturbance, and a normal computerized tomographic (CT) scan of the head. They then estimated the probabilities of two diagnoses: transient ischemic attack (TIA) and brain tumor. Probability estimates of TIA were lower if the history of lung cancer was presented at the end of the case rather than at the beginning. This recency effect was found for both more and less experienced physicians and whether subjects were prompted for a single end-of-sequence probability judgment or multiple step-by-step judgments after each piece of information. These results are inconsistent with Hogarth and Einhorn's (1992) belief-adjustment model, which predicts a recency effect for the step-by-step condition but a primacy effect for the end-of-sequence condition.

KEY WORDS recency effect; belief adjustment; clinical judgment

INTRODUCTION

Many professional judgments are based on long sequences of information. For example, before making a diagnostic judgment, a physician first obtains a patient's description of present and previous illnesses, examines the patient, and finally obtains laboratory data, if indicated. A normative model for incorporating many different pieces of information into one diagnostic judgment is Bayesian updating. According to this model, the physician starts with prior probabilities of relevant diagnoses and then updates those probabilities based on patient history, signs and symptoms, and laboratory test results. One prediction of this model is that order of information should not affect the final judgment. Thus, provided patient history does not affect which tests are ordered, the physician's diagnosis should be the same whether patient history is obtained before or after test results are obtained.

Contrary to this normative prescription, results from a variety of judgment studies show that information order often *does* have an effect. Some research has shown that information early in the sequence is more influential, a primacy effect (e.g. Curley *et al.*, 1988), while other research has shown more influence of information presented late, a recency effect (e.g. Tubbs *et al.*, 1993).

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Hogarth and Einhorn's (1992) belief adjustment model is a descriptive model that predicts whether primacy or recency effects will occur. The model incorporates five task characteristics: (1) the length of the sequence, (2) the complexity of each piece of information, (3) whether the task is to estimate a value or evaluate a hypothesis, (4) whether all the pieces of evidence support the same hypothesis, and (5) whether judgments are given only at the end of the sequence, or step-by-step after each piece of information.

The present study serves to test the belief adjustment model in the applied context of medical diagnoses. The clinical case used in this experiment was a hypothesis evaluation task with a short sequence of mixed evidence, i.e. evidence supporting more than one hypothesis. For short sequences of mixed evidence, the belief adjustment model predicts that for simple information, an end-of-sequence response mode will lead to a primacy effect, whereas a step-by-step response mode will lead to a recency effect. For end-of-sequence judgments, the initial piece of information acts as an anchor that is adjusted once in light of all the remaining evidence. The initial anchor is given more weight than the remaining evidence, leading to insufficient adjustment and a primacy effect. For step-by-step judgments, the initial anchor is adjusted after each piece of evidence, and this adjustment contrasts the new evidence with the previous belief. A strong piece of negative evidence will decrease belief in a hypothesis much more if the preceding belief was high (because of a previous piece of positive evidence) than if the belief was already low. Thus, positive evidence followed by negative evidence will lead to a lower belief than negative evidence followed by positive evidence, a recency effect.

A number of estimation studies have shown a primacy effect for end-of-sequence judgments but a recency effect for step-by-step judgments, consistent with the belief-adjustment model. Levin (1976) asked subjects to compute an average of a series of numbers and found that outlying numbers had a larger effect near the end of the series for sequential judgments, but a larger effect at the beginning of the sequence if only one end-of-sequence judgment was given. Stewart (1965) asked subjects to rate the likability of people described by a series of 4, 6, or 8 adjectives. Dreben, Fiske, and Hastie (1979) also gathered likability ratings of people described by 8 pieces of information, where each piece of information was a two-sentence description. Both studies reported a recency effect for step-by-step and a primacy effect for end-of-sequence judgments. Although an effect of response mode on judgments of simple sequences has been well documented for estimation tasks, it has not been explored in hypothesis evaluation.

According to the belief-adjustment model, more complex information will encourage decision makers to make step-by-step judgments even when only an end-of-sequence judgment is requested. Thus, short sequences of complex information will lead to a recency effect regardless of response mode. For example, Hogarth and Einhorn (1992, Experiment 3) found a recency effect for both response modes when they asked subjects to evaluate a hypothesis about whether working in a chemical factory caused cancer in a particular worker. Subjects read two short paragraphs presenting evidence (one positive and one negative with respect to the hypothesis) and made judgment after each paragraph (step-by-step) or only at the end (end-of-sequence).

Very few studies have examined order effects in medical judgments. One exception is a study by Curley *et al.* (1988). Medical and nursing students were presented with 28 slides, each with a specified clinical sign and disease. At the end of the sequence, subjects estimated the strength of the relationship between sign and disease. As the belief-adjustment model predicts for long sequences of information, trials presented early in the sequence were more influential. The model predicts that for long sequences, as information accumulates, people become more firmly committed to their beliefs and less sensitive to new evidence. Pain and Sharpley (1989) also found a primacy effect in a clinical setting.

An extension of the work by Curley *et al.* could address the question of whether the belief adjustment model accurately predicts order effects in other medical scenarios. Another question raised by their results is whether order effects are related to level of clinical experience. The medical and nursing students used as subjects were relatively inexperienced. Would health care providers with more advanced training to be able to avoid the effect of information order? There is reason to suspect this might be true, because in other domains, experience has been shown to be related to order effects. Adelman, Tolcott, and Bresnick (1993) examined judgments made by Army air defense operators and found that enlisted personnel were more influenced by information order than were officers.

The present study addresses these questions and also extends previous work (Bergus *et al.*, 1995). In that inquiry we presented clinicians with a case vignette of a patient who had a history of small cell lung cancer, a new transient neurological disturbance, and a normal computerized tomographic (CT) scan of the head. (This case was first used by Balla, Iansek, and Elstein, 1985.) Clinical judgments about the probabilities of a diagnosis of transient ischemic attack (TIA) or pre-existing disease (brain metastasis from lung cancer) showed a recency effect. If the history of lung cancer was presented at the end of the case rather than at the beginning, the judged probability of TIA was considerably lower (i.e. more consistent with the history of cancer).

One explanation of this recency effect is that step-by-step judgments were requested. The belief-adjustment model (Hogarth and Einhorn, 1992) predicts that in tasks with mixed evidence, hypothesis evaluation will tend to show a recency effect if step-by-step judgments are made after each piece of information in a short series. In contrast, the model predicts that for simple information, a single end-of-sequence judgment will tend to result in a primacy effect. In the present study, we varied both the order of information and whether physicians gave one end-of-sequence judgment or multiple step-by-step judgments to test the belief-adjustment model in an applied context. In addition, because this study involved practising physicians with varying years of experience, we were able to ask whether order effects were related to clinical experience.

In this study, family practice physicians read a clinical case of a patient who had a history of lung cancer, now in remission. The patient now reports transient neurological symptoms (weakness of the right arm and leg). The case also reports that a computerized tomographic (CT) scan of the head was negative. The text was a slight modification of that used by Balla *et al.* (1985) and Bergus *et al.* (1995). Because this case presents a small amount of information relative to an actual patient chart, and because the information is familiar to practising physicians, we categorize this case as simple material. In the General Discussion we reconsider this classification.

We asked subjects to consider two possible diagnoses. One is that the new symptoms are the result of pre-existing disease. The patient's lung cancer may have metastasized to the brain, causing a brain tumor that could result in neurologic symptoms. A second possible diagnosis is that the symptoms are the result of a new disorder, namely transient ischemic attack (TIA). (A third unlikely possibility, a primary brain tumor unrelated to the history of lung cancer, was grouped with metastatic cancer for this judgment task.) The patient's symptoms are prototypical of TIA but also consistent with the brain tumor hypothesis. The history of lung cancer points towards the brain tumor diagnosis. The fact that the head CT scan did not detect a tumor, however, points toward the diagnosis of TIA.

Half the subjects learned about the history of lung cancer at the beginning of the case. These subjects were presented with a piece of negative evidence, relative to the diagnosis of TIA, before a piece of positive evidence (the normal CT scan). The remaining subjects learned about the cancer history at the end of the case. These subjects were presented with positive evidence before the negative evidence. This design allowed us to determine if order of presentation affected final diagnostic judgments.

METHODS

Subjects

A paper-and-pencil questionnaire was mailed to 300 family practice physicians practising in Iowa. Responses were obtained from 182 physicians (61% response rate), with a mean age of 48.2 (range 32 to 80). Questionnaires were coded so that demographic information about each respondent could be accessed from databases at the University of Iowa. Demographic information included age, year the physician completed his or her medical degree, and whether the physician was board certified in family practice.

Procedure

Each subjects received one of four versions of a paper-and-pencil questionnaire. The four versions were the result of two information order conditions (lung cancer history presented first or last) crossed with two response mode conditions (single end-of-sequence or multiple step-by-step judgments).

Subjects in the cancer history first (CHF) condition were given the following clinical case:

> Six months ago, a previously healthy 50-year-old man developed a cough with chest pain and shortness of breath. He had a 30 pack-year smoking history. Physical examination at that time showed a normal blood pressure and pulse, a respiratory rate of 24 breaths per minute, and localized wheezing over the right hemithorax. A chest X-ray showed a right central lung mass, enlargement of the right hilum and prominent mediastinal nodes. Bronchoscopy and biopsy revealed small cell carcinoma of the lung. He was treated with combination chemotherapy and achieved a complete clinical remission.
>
> He now comes to you complaining that he experienced the sudden onset of transient weakness of his right arm and right leg earlier in the day. The episode lasted about one hour. When you examine him you find he has a normal blood pressure, a regular pulse, and a normal neurological exam. The rest of his physical exam is also normal

Subjects in the cancer history last (CHL) condition were given the following clinical case:

> A 50-year-old man (not previously your patient) comes to you complaining that he experienced the sudden onset of transient weakness of his right arm and right leg earlier in the day. The episode lasted about one hour. He has a 30 pack-year smoking history. When you examine him you find he has a normal blood pressure, a regular pulse, and a normal neurological exam. The rest of his physical exam is also normal.

All subjects then read the following:

> After hearing his story and completing your exam, you consider two diseases in your differential: transient ischemic episode (TIA) and brain tumor, primary or metastatic.

Subjects in the step-by-step condition were then asked to estimate the probability that the patient had each of these two diagnoses and were told that the two probabilities should add to 100%.

All subjects then read 'You immediately send the patient for a head CT scan *with* contrast. The head CT scan is normal.' Next, subjects in the step-by-step condition were asked to estimate the probability that the patient has each of the two diagnoses, given the patient's history (if known), the physical exam, and normal head CT scan. They were also asked to estimate the probability of normal CT scan given a brain tumor (false negative rate, FNR) and given TIA (true negative rate, TNR).

Subjects in the CHL condition then read:

> Later in the week you see the patient again in follow up. You now find out that in the past this man was healthy, but six months ago he developed a cough with chest pain and shortness of breath. Physical examination at the time showed a normal blood pressure and pulse, a respiratory rate of 24 breaths per minute, and localized wheezing over the right hemithorax. A chest X-ray showed a right central lung mass, enlargement of the right hilum and prominent mediastinal nodes. Bronchoscopy

and biopsy revealed small cell carcinoma of the lung. He was treated with combination chemotherapy and achieved a complete clinical remission.

Finally, all subjects were asked to estimate the probabilities that the patient had TIA or a brain tumor, based on all the information they had been given. This was the only judgment made by the end-of-sequence subjects, but was the third time these probabilities were estimated by the step-by-step subjects. Subjects in the CHF step-by-step condition gave their second and third rating separated only by the task of estimating CT accuracy. This was done to equate the number of ratings made by the CHF and CHL step-by-step groups. Exhibit 1 illustrates the order of information and judgments requested for each of the four groups.

Exhibit 1. Experimental design

	Cancer history first		Cancer history last	
	SbS	EoS	SbS	EoS
Cancer history	x	x		
Current symptoms	x	x	x	x
judge p(TIA)	x		x	
Test results	x	x	x	x
judge p(TIA/CT−)	x		x	
judge TNR and FNR	x		x	
Cancer history			x	x
judge final p(TIA/CT−)	x	x	x	x

Note:
Entries in the left-hand column in roman type are pieces of information presented in the clinical case. (Cancer history refers to the patient's history of lung cancer. Current symptoms refers to the patient's complaint of transient neurological symptoms. Test results refers to the negative CT scan with contrast.) Entries in italic are judgments requested of subjects. p(TIA) is the prior probability of TIA given only symptoms (and cancer history for subjects in the Cancer History First condition). p(TIA/CT−) is the probability of TIA given the negative CT scan. TNR and FNR are the true negative and false negative rates of a CT scan with contrast. Final p(TIA/CT−) is the probability of TIA given all information in the case, including cancer history. The remaining columns show the order of information and judgments for each of the four conditions. SbS refers to the step-by-step response mode, and EoS refer to the end-of-sequence response mode.

RESULTS

The primary question of interest was whether the final diagnostic judgments for the CHF groups differed from those for the CHL groups and whether any order effect varied with response mode (end-of-sequence or step-by-step). A second question was whether clinical experience affected order effects.

To answer these questions, we analyzed subjects' estimates of the probability of TIA. Because the estimated probability of brain tumor was the complement of judged p(TIA), only judged p(TIA) was analyzed.[1] These judgments were converted to natural logarithm (ln) odds (ln(p(TIA)))/(1 − p(TIA)). This transformation normalizes the data and also has the property that ln posterior odds should

[1] Three subjects gave judgments that did not sum to 100%. One subject gave judgments of 66% and 33%, which sum to 99%. A second subject gave judgments of 80% and 10%, noting that she or he needed a third category. A third subject gave estimates of 100% and 2%. For these three subjects, their estimated p(TIA) were used for analysis, without correcting them to sum to 100. Twelve subjects gave estimates that were not precise numbers (e.g. >95%); these were coded as missing values.

normatively be the sum of ln prior odds and ln likelihood ratio.[2] We also examined estimated true and false negative rates of the CT scan with contrast.[3] For analysis, these judgments were converted to a ln likelihood ratio (ln(TNR/FNR)). Because of the number of statistical comparisons made, α was set at 0.01.

Exhibit 2 shows means (and standard deviations) of each judgment for each of the four conditions. The first column shows the number of physicians giving a judgment. The next column shows the mean (and standard deviation) of the judgment expressed as ln odds (or ln likelihood ratio). The following column of each exhibit shows the probability corresponding to each ln odds (for row C, this column shows the likelihood ratio corresponding to the ln likelihood ratio shown in the previous column).

Exhibit 2. Judged Probabilities of TIA

	Cancer history first			Cancer history last		
	n	ln odds	prob	*n*	ln odds	prob
Step-by-step judgments						
A. Prior p(TIA)	42	0.11 (1.84)	52.8%	45	2.12 (1.34)	89.8%
B. p(TIA/CT −)	41	1.96 (1.85)	87.6%	45	3.79 (1.62)	97.8%
C. Likelihood ratio	38	1.73 (2.20)	5.6[a]	40	2.78 (1.33)	16.4[a]
D. Calculated p(TIA/CT −)	38	1.89 (3.08)	86.9%	39	4.72 (2.03)	99.1%
E. Final p(TIA/CT −)	41	1.75 (2.03)	85.2%	46	−0.38 (2.25)	40.6%
End-of-sequence judgment						
F. Final p(TIA/CT −)	49	1.47 (2.43)	81.3%	42	−0.12 (2.11)	47.0%

Notes:
Row A shows the prior estimate of p(TIA). Row B shows the estimate of p(TIA) after learning of the CT − result. Row C shows the ln ratio between the estimated TNR and FNR for the CT scan. Row D shows the posterior estimate expected given each subject's prior probability and LR estimates. Rows E and F show the final estimates of p(TIA). The calculated posterior log odds in Row D are not quite the sum of the odds in row A and the log likelihood ratio in row C because of steps taken to accommodate estimates of 0% and 100% (cutting off log odds at 7 and −7, and not allowing false negative estimates to go below 0.5%).
[a]This value is a likelihood ratio (ratio between TNR and FNR), not a probability.

Order effects

We first examined the final judgments of p(TIA) (shown in rows E and F) given by each group to see if order of information presentation affected diagnosis. The final judgments for the Cancer History Last condition are lower than for the Cancer History First condition. The ln odds of final p(TIA) estimates were used as the dependent variable in an ANOVA containing the between-subjects independent variables of information order (cancer history first or last), response mode condition (step-by-step or end-of-sequence), and the interaction. Only the effect of information order was significant ($F(1,174) = 31.21$, $p < 0.0001$), indicating that subjects who learned about the history of lung cancer at the end gave lower judgments of the probability of TIA. Normatively, the information about the history of lung cancer should lower the probability of the TIA hypothesis. Thus, the lower estimates in the CHL condition indicate that the lung cancer history had more influence when presented late — a

[2] A few subjects gave estimates of p(TIA) of 100%. Converting to odds would then involve dividing by zero. The largest estimate that was not 100% was 99.9%, so we converted the 100%s to a number slightly higher than this maximum. Specifically, estimates of 100% were treated as 99.91%, resulting in a ln odds of 7. Likewise, if a subject estimates p(TIA) to be 0%, that was converted to a ln odds of −7.

[3] Two subjects in the CHF group estimated the false negative rate to be 0%, resulting in an infinite likelihood ratio. We treated these estimates as 0.5% and calculated the likelihood ratio accordingly.

recency effect. This recency effect did not differ in magnitude for the two response mode conditions, as evidenced by a lack of interaction ($F < 1$).

Step-by-step judgments

To explore the order effect further, we examined the step-by-step judgments for subjects in that response mode condition. An examination of each of the step-by-step probability estimates indicates how the physicians used the information presented in the case. Exhibit 3 shows how judgments for the two information order groups changed across the three step-by-step judgments. We used ln odds of p(TIA) estimates as the dependent variable in an ANOVA, information order as a between-subjects independent variable, and time of judgment as a repeated measure. There was no main effect of information order ($F(1,83) = 2.57$, $p > 0.11$), but there was an effect of time of judgment ($F(2,166) = 75.63$, $p < 0.0001$) and an interaction ($F(2,166) = 77.70$, $p < 0.0001$). This interaction indicates that on the first two judgments of p(TIA), the CHF group, who already knew about the history of lung cancer, gave lower judgments. At the third judgment, when the CHL group had learned of the lung cancer history, this group gave a lower judgment. For the CHF group, the second and third judgments were not different from one another ($t(40) = 1.25$, $p > 0.2$) but were both higher than the first judgment ($ts(40) > 6.5$, $ps < 0.001$). For the CHL group, the second judgment (after the CT scan)

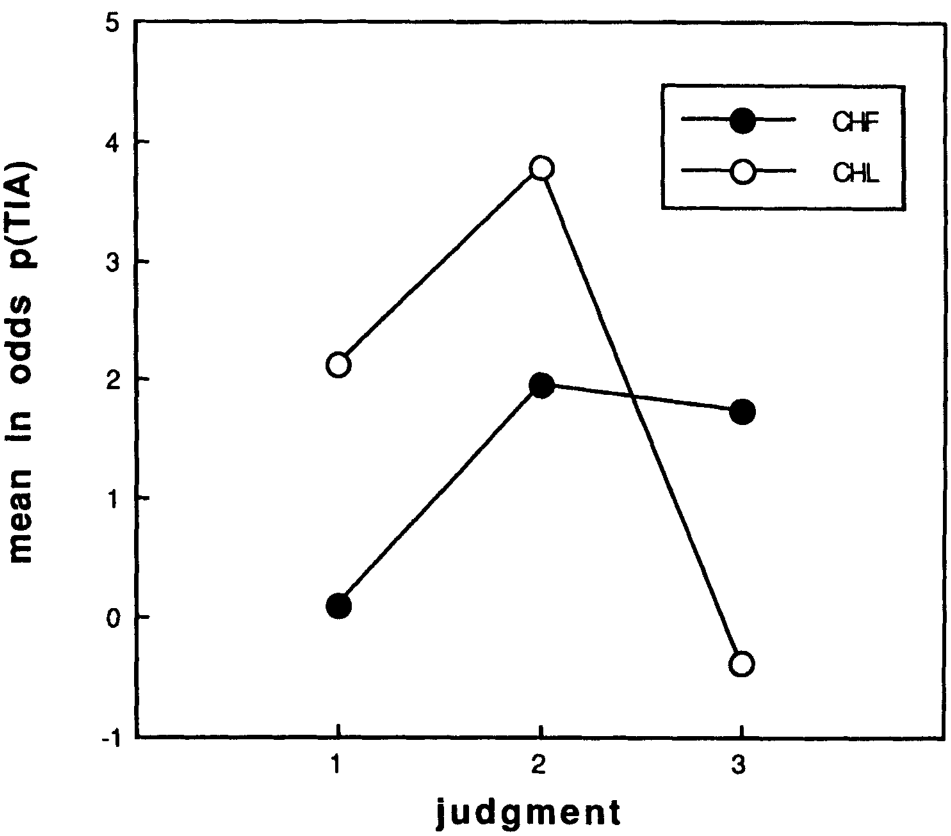

Exhibit 3. Estimates of the likelihood of TIA (expressed as mean ln odds) for the two step-by-step groups. Judgments 1 to 3 correspond to Rows A, B, and E of Exhibit 2. Filled circles represent the Cancer History First group and open circles the Cancer History Last group

was higher than the first ($t(43) = 7.89$, $p < 0.001$), and the third (after learning the cancer history) was smaller than both the first and second ($ts(43) > 8.1$, $ps < 0.001$).

Prior and posterior probabilities

Row A of Exhibit 2 indicates that the CHF group gave lower prior estimates of p(TIA) than did the CHL group ($t(83) = 5.66$, $p < 0.0001$), as is normatively appropriate given that only group CHF knew of the cancer history at this point and that the cancer history normatively should lower the probability of TIA. Similarly, estimates of the likelihood of TIA after finding out about the normal CT scan (p(TIA/CT−), see row B) were larger for the CHF group ($t(83) = 4.78$, $p < 0.0001$). Thus, judgments were appropriately affected by whether subjects knew about the history of lung cancer.

Likelihood ratios

Row C of Exhibit 2 shows estimates of the likelihood ratio of the CT scan. The ln likelihood ratios were marginally larger for the CHL group than for the CHF group ($t(76) = 2.56$, $p < 0.02$). To interpret this group difference, estimates of true and false negative rates were examined separately. Whereas the groups did not differ in estimated true negative rates (estimated probability of a normal CT scan given TIA, means 87% for CHF, 94% for CHL, $t(82) = 1.85$, $p > 0.06$), the CHF group (mean 29%) gave higher estimates of the false negative rate (estimated probability of normal CT scan given brain tumor) than did the CHL group (mean 12%, $t(77) = 3.74$, $p < 0.001$). This difference in FNRs would lead to the observed difference in LRs. We explain this difference by proposing that subjects in the CHF group, who knew about the cancer history, thought it was more likely that the patient had a brain tumor and consequently explained the negative CT scan by reasoning that the CT scan had a high false negative rate.

Bayesian updating

Normatively, ln posterior odds should be the sum of ln prior odds and ln likelihood ratio. If subjects followed Bayesian updating, then those who gave higher prior and likelihood ratio estimates should also give higher posterior estimates. To see if this was the case, we used ln prior odds (row A) and ln likelihood ratios (row C) as independent variables in a regression, with ln posterior odds (row B) as the dependent variable. Both ln likelihood ratio ($F(1,73) = 29.02$, $p < 0.0001$, slope $= 0.41$, partial $r = 0.38$) and ln prior odds ($F(1,73) = 69.68$, $p < 0.0001$, slope $= 0.65$, partial $r = 0.58$) were significantly related to ln posterior odds.

As another way of assessing Bayesian updating, we used each subject's estimate of p(TIA) and likelihood ratio to calculate what his or her estimate of p(TIA|CT−) should be. We then compared that calculated posterior estimate (row D) with the actual posterior estimates. Type of estimate (actual or calculated) was used as a repeated measure in an ANOVA with information order as a between-subjects factor and ln posterior odds as the dependent measure. There was no main effect of information order ($F < 1$), but there was a main effect of estimate type ($F(1,75) = 151$, $p < 0.0001$) and an interaction between information order and estimate type ($F(1,75) = 128$, $p < 0.0001$), indicating that the CHF groups gave actual estimates about the same as their calculated posteriors ($t < 1$), but the CHL group gave actual estimates lower than their calculated posteriors ($t(38) = 4.29$, $p < 0.001$, see Exhibit 2, rows B and D). Although the difference between actual and calculated ln odds for group CHL is notable (3.79 versus 4.72), the difference between actual and calculated probabilities is slight (97.8% versus 99.1%). A t-test using mean probabilities instead of mean ln odds showed no difference between actual and calculated probabilities ($t(37) = 1.10$, $p > 0.2$). Thus, this result may not indicate that the CHF group followed Bayesian updating more closely than the CHL group, but rather that subjects in general fail to make distinctions between very high probabilities in the manner prescribed by Bayes' theorem. These two analyses indicate that subjects update their subjective prior probabilities in light of new evidence as prescribed by Bayes' theorem.

Thus, subjects were quite accurate in updating their beliefs in light of the CT test. They were also influenced in the appropriate direction by information about the history of lung cancer. However, the recency effect found in the final judgments indicates that the information about cancer history was much more influential when it was presented at the end of the case.

Experience

The final question of interest was whether the effect of presentation order would decrease with clinical experience. One measure of experience was the time elapsed since receiving the MD degree. The median time since the degree was 18 years (range 4 to 53). We divided the physicians into an upper and lower group based on years since their degree. We also examined whether or not the physicians were board certified in family practice, as 66% of our respondents were. We did not examine age of the respondents because it correlated 0.97 with time since the degree. Certification, however, was not correlated with years since degree.

We then asked whether probability estimates differed between more and less experienced physicians. We used final estimates of p(TIA) (transformed to ln odds) as the dependent variable in an ANOVA containing the factors of information order (CHF or CHL), level of experience (high or low) and certification. Final estimates of p(TIA) were marginally lower for the more experienced group of physicians ($F(1,170) = 5.94$, $p < 0.02$). The mean ln odds for the more experienced group was 0.30 (corresponding to a probability of 57%), whereas the mean ln odds for the less experienced group was 1.03 (74%). There was a negative Spearman correlation between years of experience (a continuous measure) and estimated p(TIA) ($r = -0.20$, $p < 0.01$). The more experienced group gave lower estimates, suggesting that, relative to less experienced physicians, they were more influenced by the history of lung cancer, whether it was presented early or late. There was no effect of board certification on final probability estimates ($F < 1$).

Neither certification nor experience (dichotomous or continuous measure) interacted with information order ($Fs(1,170) < 1.8$, $ps > 0.18$), indicating that the size of the recency effect did not vary with experience. Thus, more experienced physicians do not appear to be less susceptible to the recency effect.

GENERAL DISCUSSION

We examined order effects in clinical judgments made by family practice physicians. These judgments revealed that clinicians were influenced by the order of information. The patient's history of lung cancer was more influential when presented last rather than first. Clinical experience did not reduce this recency effect. In contrast to this non-normative order effect, other aspects of subjects' judgments were quite Bayesian. They were influenced by the history of lung cancer in the right direction. In addition, their posterior probability judgments were based on their prior probabilities and their estimates of the diagnostic value of the CT scan. In contrast to other research that shows that decision makers neglect prior probabilities or base rates (e.g. Dawes *et al.*, 1993), this experiment shows that physicians attend to their own estimated priors.

Recency effect

The recency effect found here replicates and extends the results found by Bergus *et al.* (1995). As discussed in the Introduction, the recency effect found in our previous study could be related to the step-by-step judgments given by subjects. In the present study, we compared groups who gave multiple step-by-step judgments to groups giving one end-of-sequence judgment. We did not demonstrate the belief-adjustment model's prediction that for simple information, the order effect is moderated by whether step-by-step or end-of-sequence judgments are made. Instead, we found a recency effect in both response mode conditions.

One explanation for this result is that subjects in the end-of-sequence condition were making unrecorded step-by-step judgments. Hogarth and Einhorn (1992) predict that this will happen if the evidence presented is complex. Although the clinical scenario presented to subjects was simple compared to a real clinical situation, it was nonetheless complex compared to stimuli used in other judgment tasks (e.g. Levin, 1976).

Hogarth and Einhorn (1992) distinguish complex information from simple based on the amount of information to be processed for each piece of evidence and the lack of familiarity with the task. A summary of a medical case may contain a lot of information, similar to the short paragraphs used by Hogarth and Einhorn (1992), but much less information than an actual patient chart. In addition, the information should be very familiar to physician decision makers. Despite this familiarity, it may be that any clinical vignette is complex enough to result in a recency effect regardless of response mode.

Even if our clinical scenario represents complex information, however, physicians with more experience might be more familiar with TIA and metastatic disease, making the vignette simpler. Thus, more experienced physicians could be expected to show less of a recency effect (or even a primacy effect), especially in the end-of-sequence condition. However, unlike research in other domains (Adelman *et al.*, 1993), we did not find a relationship between order effects and experience. One possible explanation for this result is that the clinical problem used in this study is sufficiently unfamiliar to family practice physicians that the case comprises complex information even for the most experienced subjects. A question for future research is whether physicians with special expertise in TIA or metastatic cancer (e.g. neurologists and oncologists) would be less affected by information order in this case.

Prescriptive applications

Although information order can be easily manipulated in written clinical cases, it is less easily changed in real clinical practice. For example, patient history is usually obtained before a clinical exam is performed or laboratory tests results are obtained. Our results suggest that information that is usually gathered first, such as patient history, will be underweighted relative to information collected later, such as laboratory tests. This psychological process may be the basis for the observation of many academic physicians that patient history is often very diagnostic yet neglected (Bordage, 1995).

The recency effect demonstrated in the present experiment deviates from normative Bayesian updating. Thus, one extension of this finding would be to discover ways to debias the recency effect. Physicians could be taught to re-order information for themselves. For example, if patient history is generally underweighted because it is collected first, a reminder to review a patient's history before making a diagnosis might encourage physicians to give that history more weight. An alternative tactic is not to debias the recency effect but rather to exploit it to correct other biases. Neglected information, such as base rates, could be presented at the end of the case, thus increasing its weight. In either case, the recency effect suggests methods for improving clinical judgment.

AUTHORS' NOTE

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