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Inferences Based on Nondiagnostic Information

C. MICHAEL TROUTMAN AND JAMES SHANTEAU

Kansas State University

Nondiagnostic samples of evidence were presented sequentially in an inference task. These were samples which logically should not have influenced inference responses, e.g., by Bayes theorem. Experiment I, however, demonstrated that three different types of nondiagnostic samples (neutral, irrelevant, and null) consistently resulted in less extreme inference judgments. Experiment II indicated that the size of this "nondiagnostic effect" depended on serial location and was less with aggregate than sequential samples. Moreover, the effect was shown not to be a response artifact due to a central regression tendency. Several theoretical accounts were considered, such as representativeness and expectancy. But, the most plausible was that inference judgments are based on an averaging combination rule. Finally, some practical implications of this nondiagnosticity finding were discussed.

Suppose you have planned an experiment that you are fairly certain will confirm a particular hypothesis. Then you read two relevant studies by equally well-respected colleagues and one study supports your hypothesis while the other disconfirms it. Would this information make you change your belief about the hypothesis?

If the two studies are equally well done, they cancel each other out so that the total value of the information is "nondiagnostic." That is, the information is very much like no information at all. It follows from a formal analysis (e.g., Bayesian analysis) that nondiagnostic information should not influence your belief.

It cannot be assumed, however, that peoples' beliefs or judgments about uncertain events conform to principles of logic. Pitz, Downing, and Reinhold (1967) and Shanteau (1970, 1972, 1975), among others, have demonstrated the illogic of judgments under uncertainty. Therefore, there is no reason to expect that logic will necessarily hold when the information bearing upon an uncertain event is nondiagnostic.

The present research sought to determine if information that was plainly nondiagnostic would in fact influence inference judgments. To minimize any ambiguity about diagnostic and nondiagnostic information,

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Requests for reprints should be sent to Dr. Michael Troutman, Department of Psychology, Clemson University, Hardin Hall, Clemson, South Carolina 29631.

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a simple "book bags-and-poker-chips" task (Edwards, 1968) was employed. Two boxes contained different numbers of red, white, and blue beads which were, respectively, 70/30/50 and 30/70/50.[1] Subjects were shown successive samples of beads and, after each sample, inferred the probability that the predominantly white box had been sampled.

The composition of the boxes made it possible to investigate three different types of nondiagnostic samples. Since the boxes were complementary, an equal number of red and white beads favored neither box; such a sample was *neutral*. Because each box had an equal number of blue beads, a sample of just blue beads was *irrelevant* for distinguishing between the boxes. A third type of nondiagnostic sample was a *null* sample, which simply contained no beads at all. None of these samples should have logically influenced subjects' beliefs about the boxes.

Although neutral samples have been reported to affect inference judgments (Shanteau, 1975), irrelevant and null samples have not yet been investigated. The purpose of the first experiment was to explore the effects of these different types of nondiagnostic samples. A second experiment is included to explore these effects further.

EXPERIMENT I

Method

Apparatus. Inference judgments were made by sliding a marker along an unmarked 20-cm scale with the left and right ends defined by probabilities of 0 and 1, respectively. The experimenter recorded the responses from a 0 to 100 rule on the rear of the scale.

Procedure. The procedure was similar to Shanteau (1972, 1975) and is only summarized here. The subject was shown two boxes which contained 70/30/50 and 30/70/50 red/white/blue beads, respectively. The boxes were then concealed and one of the two was chosen by a coin toss. Several random samples were drawn with replacement from the chosen box; after each sample, the subject used the accumulated evidence to estimate the probability that the 30/70/50 box was being sampled. After each response, the marker was returned to the center of the scale.

For practice, the subject initially drew a sequence of samples, without looking, from each box. All samples were displayed in a small cup so that the beads were not ordered in any particular way, but rather scattered about. An empty cup was displayed on null samples. After these practice sequences, the experimenter drew the remaining sequences from a specially partitioned box which, unknown to the subject, allowed the experimenter to draw beads of any color.

[1] The bicentennial nature of this task has not escaped the authors' notice. However, patriotic fervor is not likely to have influenced the results.

Twelve different sequences were presented. Six of these were shown twice and are listed in Table 1. The sequences not listed served as fillers to provide a proportionally balanced and representative sample of beads over the experiment; additional samples were also added to the ends of the experimental sequences to increase the believability of the samples. When asked, none of the subjects indicated that the samples were unnatural or suspected that the sequences were manipulated.

Subjects. Twenty-four subjects from introductory psychology courses served for 1 hr of class credit.

Results

The mean responses and 95% confidence intervals are listed in Table 1. In the Neutral sequence, for example, the first sample of two white beads, WW, produced a mean response of 68.6 ± 2.5. The next sample of a white and a red bead, WR, was neutral and the response became less extreme (63.4 ± 1.4). The mean change produced by this nondiagnostic sample was −5.2 ± 2.0; since the confidence interval (2.0) is less than the change score (5.2), the change is significant at the .05 level.[2] The third sample was neutral and the response was again less extreme, although the change (−1.0 ± 1.0) was considerably smaller than before.

Irrelevant and Null sequences were constructed by replacing the second and third positions of the Neutral sequence with either irrelevant samples of two blue beads (BB) or null samples (∅). For the Irrelevant sequence, both BB samples produced changes (−5.1 ± 1.5 and −1.1 ± 0.9) that were quite similar in magnitude to the changes found with neutral samples. Similarly, the ∅ samples in the Null sequence also produced changes, although the change for the first null samples (−3.0 ± 1.9) was less than either the first neutral or the irrelevant sample.

In addition, the final sample in all three sequences was neutral. In all cases, less extreme responses were observed for this sample.

Three control sequences were also used. Each control sequence began with two draws of one of the three types of nondiagnostic samples. As can be seen in Table 1, the initial nondiagnostic samples consistently led to responses very near 50%. This indicates that the various types of samples by themselves were indeed nondiagnostic. This is vital since it shows that subjects did apparently understand the nondiagnostic nature of the samples.

While the above findings were based on group results, the same general

[2] The reported confidence intervals permit statistical comparisons that are equivalent to a *t* test. If the interval extremes do not overlap, then the results are significantly different (see Winer, 1971). Thus, the reader can determine the significance of almost any value or pair of values in the table.

TABLE 1

MEAN INFERENCE RESPONSES, CHANGE IN RESPONSES, AND 95% CONFIDENCE INTERVALS FOR EXPERIMENT I

Sequence	Sample	Mean response	Mean change[a]	Sequence	Sample	Mean response	Mean change
Neutral	WW[b]	68.6 ± 2.5		Neutral control	WR	49.3 ± .7	
	WR	63.4 ± 1.4	−5.2 ± 2.0		WR	49.4 ± .8	−.1 ± .6
	WR	62.4 ± 1.5	−1.0 ± 1.0		RR	32.7 ± 3.3	
	WB	69.4 ± 1.7					
	WR	66.5 ± 1.8	−2.9 ± 1.4				
Irrelevant	WW	69.0 ± 2.5		Irrelevant control	BB	49.7 ± .9	
	BB	63.9 ± 2.3	−5.1 ± 1.5		BB	49.5 ± .8	.2 ± .5
	BB	62.8 ± 2.1	−1.1 ± .9		RR	32.4 ± 3.8	
	WB	70.0 ± 2.5					
	WR	67.0 ± 2.4	−3.0 ± 1.5				
Null	WW	69.9 ± 2.9		Null control	ϕ	49.9 ± .9	
	ϕ	69.9 ± 2.7	−3.0 ± 1.9		ϕ	49.8 ± .9	.1 ± .5
	ϕ	65.8 ± 2.8	−1.1 ± 1.0		RR	31.9 ± 3.9	
	WB	71.1 ± 3.0					
	WR	68.6 ± 2.6	−2.5 ± 1.3				

[a] A negative change score indicates a shift toward 50%.

[b] Indicates that the sample consisted of two white beads.

pattern of results was also found in analyses of single subjects. For instance, after the first sample (WR) of the Neutral sequence, 21 out of 24 subjects gave less extreme responses. Similar results were found for the other nondiagnostic samples.

Discussion

The results show that nondiagnostic samples in fact had some information value when presented following a diagnostic sample. Both neutral and irrelevant samples, and to a lesser extent null samples, were treated as diagnostic. On the other hand, the control sequences indicated that subjects were well aware of the value of a nondiagnostic sample when it was sampled first in the sequence. This makes it difficult to attribute the results to subjects misunderstanding or misperceiving the nondiagnostic samples.

Could the presence of blue beads in each box have made the task ambiguous and thus contributed to these findings? To check this, the results for a sequence from Shanteau (1975) are shown in Table 2. This sequence is almost identical to the present Neutral sequence, except that the boxes contained no blue beads. As can be seen, the mean responses and mean changes in Table 2 are strikingly similar to the results for the Neutral and Irrelevant sequences in Table 1. Thus, the blue beads did not seem to have influenced the inference responses.

While these results demonstrate a "nondiagnosticity effect," several important questions need to be explored further. Therefore, a second experiment was conducted.

EXPERIMENT II

The purposes of Experiment II were threefold. First, there is a question of whether or not the nondiagnosticity effect could have been an artifact due to a tendency for responses to regress toward the mean of the scale. Regression effects are well documented in various judgment tasks (e.g., Helson, 1964, pp. 97–102), including tasks similar to the present one (cf.

TABLE 2
RESULTS FROM SHANTEAU (1975)[a]

Sample	Mean response	Mean change
WW	69.3 ± 2.2	
WR	64.0 ± 2.3	−5.3 ± 2.0
WR	60.6 ± 2.6	−3.4 ± 1.4
W	69.5 ± 3.2	
WR	65.7 ± 3.5	−3.8 ± 1.8

[a] Taken from the B sequence of Experiment II (p. 86).

Lee, 1971, pp. 61–62, 254–255). According to a regression interpretation, nondiagnosticity effects might arise because subjects underestimate their previous response when in fact trying to duplicate it. Therefore, Experiment II included several sequences to check for regression effects. In one sequence, subjects were simply asked to repeat their previous response; in another, subjects were shown several consecutive null samples. In both cases, a regression interpretation implies recurring shifts toward 50%.

Second, Experiment I showed that nondiagnostic samples affected inference responses when *previous* samples were diagnostic. However, it remains to be seen whether or not nondiagnostic samples influence responses to *subsequent* diagnostic samples. This question was addressed by varying the order in which diagnostic and nondiagnostic samples were presented. In three different sequences, the key diagnostic sample was presented (a) at the beginning of the sequence, (b) after one nondiagnostic sample, and (c) after two nondiagnostic samples.

The final purpose of Experiment II was to compare the effects of nondiagnostic samples in sequential and aggregate (combined) presentation. For example, the sequence WW and WR was compared with the aggregate sample WWWR. If the aggregate sample is perceived as partly diagnostic (WW) and partly nondiagnostic (WR), then aggregate and sequential presentation should result in equivalent responses. However, if the aggregate sample is viewed as a unit, then the nondiagnostic component should have less impact.

Method

Apparatus. Responses were made by placing a stylus on an unmarked 70-cm bar defined as in Experiment I. Placement of the stylus on the bar produced a display on a digital meter (Uhlarik, 1972) visible only to the experimenter. The meter was linearly calibrated with the responses to read from 0 to 100.

Procedure. The basic procedure of Experiment I was repeated. However, the boxes contained no blue beads and the response procedure was slightly modified because of a different apparatus. After making a response, the subject moved the stylus completely away from the bar. This meant that the previous response could not be artificially "remembered."

Subjects. Sixteen subjects from introductory psychology classes received 1 hr of class credit for serving. Six prior subjects were run, but were excluded because of experimenter error.

Results

Table 3 lists the various sequences along with the mean responses and confidence intervals. The first sequence to note is the Neutral sequence, which is comparable to the Neutral sequence in Table 1 (and Table 2).

TABLE 3
RESULTS FOR EXPERIMENT II

Sequence	Sample	Mean response	Mean change	Sequence	Sample	Mean response	Mean change
Neutral	WW	74.0 ± 4.1		Order-1	WR	53.3 ± 2.4	
	WR	72.0 ± 3.8	−2.0 ± 2.1		WW	70.9 ± 4.3	
	WR	71.7 ± 3.9	− .3 ± 1.3		WR	68.7 ± 4.2	−2.2 ± 1.8
	W	77.3 ± 4.2			W	75.4 ± 4.8	
	WR	73.6 ± 4.5	−3.7 ± 1.5		WR	73.2 ± 4.9	−2.2 ± 1.8
Repeat	WW	75.4 ± 4.6		Order-2	WR	51.5 ± .9	
	Rep	75.7 ± 4.3	.3 ± .9		WR	51.7 ± 1.0	.2 ± .8
	Rep	76.0 ± 4.3	.3 ± .4		WW	67.8 ± 3.9	
	W	80.7 ± 4.4			W	73.8 ± 4.8	
	WR	76.6 ± 4.2	−4.1 ± 2.9		WR	70.8 ± 4.8	−3.0 ± 1.6
Null	WW	75.3 ± 4.4		Combination-1	WWWR	76.8 ± 4.0	
	ϕ	73.9 ± 4.0	−1.4 ± 2.6		WR	73.6 ± 3.6	−3.2 ± 1.8
	ϕ	73.3 ± 4.2	− .6 ± 1.4		W	79.2 ± 4.4	
	ϕ	73.4 ± 4.3	.1 ± .8		WR	76.6 ± 4.2	−2.6 ± 1.7
	ϕ	73.4 ± 4.3	.0 ± .7	Combination-2	WWWWRR	74.8 ± 3.4	
	W	80.0 ± 3.8			W	79.3 ± 4.0	
	WR	77.9 ± 4.1	−2.1 ± 1.7		WR	77.3 ± 4.2	−+2.0 ± 1.9

Although the mean responses were 5 to 10% more extreme than in Experiment I, the neutral samples produced results in the same direction. In a similar task, Shanteau (1975) found that three different response scales led to different degrees of extremeness. In all cases, however, the same pattern of results emerged. Here as well, the same basic nondiagnosticity effect was replicated despite differences in extremeness.

Regression artifact. The Repeat and Null sequences can be examined to see if a response–regression explanation could account for the present findings. In the Repeat sequence, there were two consecutive instructions to repeat (Rep) the previous response. As can be seen, essentially no change was observed for either response (0.3 ± 0.9 and 0.3 ± 0.4). Therefore, in contradiction to the regression explanation, subjects could very nearly repeat their previous response if they wanted to.

For the Null sequence, there were four consecutive null samples. The first two samples tended to produce less extreme responses (−1.4 ± 2.6 and −0.6 ± 1.4). After the second null sample, however, the responses stabilized at 73.4 ± 4.3 with hardly any shift seen by the fourth null (0.0 ± 0.7). This also seems to contradict the regression explanation, because there was no tendency toward continued shifts following the second null sample. On the whole, the findings with Repeat and Null sequences argue that the nondiagnosticity effect is apparently not due to a regression artifact.

Order variations. The second major purpose of Experiment II was to determine if initial nondiagnostic samples influenced responses to subsequent diagnostic samples. For this purpose, the first three samples of the basic Neutral sequence were reordered so that the key diagnostic sample in the Neutral, Order-1, and Order-2 sequences was presented after 0, 1, and 2 nondiagnostic samples, respectively.

The mean responses to the key (first) diagnostic sample in these sequences were 74.0 ± 4.1, 70.9 ± 4.3, and 67.8 ± 3.9. Thus, the responses became systematically less extreme as the number of preceding nondiagnostic samples increased. This indicates that nondiagnostic samples have some impact on later diagnostic samples.

Sequential and aggregate presentation. The last question to consider is whether or not nondiagnostic samples have a similar effect when presented in combination with other diagnostic samples. To examine this, the first sample of Combination-1 (WWWR) combined the first (WW) and second (WR) samples of the basic Neutral sequence, while the first sample of Combination-2 (WWWWRR) combined the first three samples in the Neutral sequence.

The results in Table 3 reveal that, for equivalent information, aggregate presentation led to more extreme responses than sequential presentation. For example, the response to WWWR in Combination-1 (76.8 ± 4.0) was

more extreme than the response after the first two samples in either the Neutral (72.0 ± 3.8) or the Order-1 (70.9 ± 4.3) sequences; in each case, the total information presented was equivalent. Likewise, the WWWWRR response in Combination-2 was more extreme than the various responses to the same information presented sequentially. These findings indicate that larger samples were perceived as a unit rather than as partly diagnostic and partly nondiagnostic (also see Leon & Anderson, 1974).

Finally, some mention should be made of the greater variability for responses in Experiment II than in Experiment I. This most likely reflects differences in the response scales. To control for variability, all analyses reported here were repeated with the data normalized so that each subject had the same response range. The results with normalized data, however, essentially duplicated the findings reported above. While these differences in variability are vexing, they did not prevent a consistent pattern of results with nondiagnostic samples from emerging.

GENERAL DISCUSSION

Nondiagnostic samples resulted in less extreme responses in both experiments with great consistency. The nondiagnosticity effect was observed for different types of samples, different serial orders, and different response procedures. While the changes did not always reach significance, they were always in the same direction. Furthermore, the effect is apparently not due to regression toward the mean of the scale. In short, nondiagnostic samples seem to have influenced performance as if the samples were in fact diagnostic.

Related Research

The effects of nondiagnostic information on inference judgments are largely unexplored because most past research has quite naturally focused on diagnostic information. However, there are several previous studies that are relevant. Probably the most closely related is the analysis of neutral samples reported by Shanteau (1975). The results are strikingly similar to the present Neutral sequence, as can be seen in Table 2. Essentially the same pattern of results was obtained in three experiments, although, as in the present study, changes in the response procedure produced shifts in the extremity of the responses. Thus, it is worth emphasizing that the same nondiagnosticity pattern has now been observed in five experiments. Of course, the present study expands this conclusion by including different types of nondiagnostic samples in various orders and combinations.

In a related study, Lichtenstein, Earle, and Slovic (1975) had subjects make inferential predictions based on two numerical cues presented se-

quentially. When the second cue was less diagnostic than the first, a substantial number of revised predictions became less extreme. That is, the responses decreased when in fact they should have increased. Although Lichtenstein *et al.* did not employ information that was precisely nondiagnostic, their results, nevertheless, bear a remarkable likeness to the present results.

There are other lines of research in which nondiagnostic information has been employed. One such area is multiple cue probability learning with irrelevant cue dimensions. In one study, Castellan (1973) reported that the irrelevant information retarded performance presumably because subjects were not capable of ignoring that information. Similarly, our subjects were not able to ignore nondiagnostic information and, thereby, did not perform as expected.

Another relevant area concerns resistance to persuasive communications. Youngblood and Himmelfarb (1972) found that a neutral message received prior to a positive (or negative) message resulted in less extreme attitude judgments than did exposure to only the positive (or negative) message. This finding also parallels the present results: Prior nondiagnostic samples produce less extreme responses to subsequent diagnostic samples.

In all, the results from the present and related studies seem to point toward one consistent finding: Nondiagnostic information has a clear effect on human judgment. The key question, of course, is why does nondiagnostic information have this effect?

Theoretical Explanations

Representativeness. Several possible explanations for the nondiagnosticity effect seem to be worth considering. One is that the subjects employed what Kahneman and Tversky (1973) call the representativeness heuristic to evaluate the samples. According to this heuristic, the subjective probability of an event is judged by how similar its distinguishing features are to the inferred parent population. Say it is believed that the predominantly white box is being sampled. Then a nondiagnostic sample would be unrepresentative of that box, i.e., its subjective likelihood of being drawn is relatively small. When it is drawn, the subject's belief then becomes less certain.

However, since representativeness is judged by the sample's distinguishing features, this explanation seems to be applicable only to neutral samples. There are no distinguishing features in an irrelevant sample which would make it unrepresentative. Thus, the representativeness explanation would seem to have limited value for explaining the present results.

Expectancy. Another related explanation entails an expectancy

hypothesis. After a diagnostic sample, subjects may develop expectations about the composition of subsequent samples, e.g., in regard to sample proportion. A nondiagnostic sample, however, fails to confirm the current expectation, and, thus, the subject may become less certain about which box is being sampled.

This explanation can be questioned, however, because the present results show that if the first sample is nondiagnostic, it also influences responses to subsequent diagnostic samples. It is difficult to see how an initial nondiagnostic sample would produce an expectancy different from that held prior to the first draw. Moreover, subjects have been found to actually expect an occasional disconfirming event and still remain firm in their belief when it is drawn (Pitz *et al.,* 1967). These findings make the expectancy hypothesis (and the representativeness explanation) questionable.

Averaging. A third explanation is that nondiagnostic samples produce less extreme responses because sample evidence is combined with the previous response by an averaging rule (Shanteau, 1970, 1972, 1975). If, say, the previous response is 70% and a nondiagnostic sample has a value of 50%, then the revised response will be an average, i.e., between 50 and 70%. The averaging of evidence with prior responses can account for nearly all of the present results. For instance, if prior responses are averaged with subsequent information, then the averaging rule can describe the influence of initial nondiagnostic samples. In addition, averaging models have been able to provide a good quantitative account of inference judgments involving more typical diagnostic information (Leon & Anderson, 1974; Shanteau, 1970, 1972).

The averaging model has also been supported in other decision-making tasks. For instance, Troutman and Shanteau (1976) obtained evidence that consumers average information about product attributes. Similarly, Norman and Louviere (1974) found support for averaging in mode of transportation decisions. Other examples of averaging can be found in Anderson (1971). In all, averaging would appear to be a rather common mechanism for making decisions of many types.

Bayesian models. The present evidence of nondiagnosticity effects seems to be sufficient to raise a question (vis-à-vis Pitz, 1975) concerning Bayesian formulations of inference processes: Can any descriptive model of inference judgment based on Bayes theorem account for nondiagnosticity effects? This seems unlikely, since Bayes theorem predicts that nondiagnostic samples should have no effect, i.e., a likelihood ratio of 1. Take, for instance, Wallsten's (1972) conjoint measurement formulation of a Bayesian model. Although very flexible, this model predicts that nondiagnostic information should have no influence. To account for nondiagnosticity effects, one of the model's cornerstorne assumptions would

have to be abandoned. There does not appear to be any simple way of doing this while at the same time preserving the Bayesian features of the model.

Nondiagnosticity effects can thus be added to the previous deviations found from normative Bayesian theory. For instance, specific deviations have been noted by Pitz *et al.* (1967) and Shanteau (1970) among others; an analysis of a number of these limitations can be found in Shanteau (1972), with more recent discussions in Kahneman and Tversky (1973) and Slovic, Fischoff, and Lichtenstein (1977). While it has become fashionable to criticize Bayesian models (Slovic *et al.*, 1977), it is still useful to specify the nature of the deviations. This is particularly important if there is a desire to correct for these deviations, e.g., in applied settings.

Implications

While the generality of nondiagnosticity effects certainly needs to be examined further, it is still worth considering some possible implications. Two important questions need to be addressed. First, to what extent is nondiagnostic information encountered outside the lab, and, second, what are the practical consequences? On the first count, one need only to recall the number of times that a contemplated choice alternative, e.g., motion picture, restaurant, etc., may have been praised by one friend while scorned by another. While certainly factors such as reliability must be taken into account, there are likely to be many such instances which involve the processing of nondiagnostic or uninformative information. Thus, encounters with nondiagnosticity may be more common than previously realized.

As to the second question, there may be numerous practical consequences associated with nondiagnostic information. In the perception of political candidates, for example, neutral information may "water down" the impression formed. This may be one reason why candidates tend to follow the maxim of "only show your best" (Anderson, 1971). In a different vein, decision making often involves the accumulation of evidence until uncertainty is reduced to a tolerable level. Nondiagnostic information may then have the effect of delaying decisions (cf. Levine, 1973). While further conjectures are possible, these examples should suffice to show the potential consequences of nondiagnostic information. The elaboration of these effects must, of course, await further investigation.

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