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Semantics of Uncertainty:

Some Psychophysical Correlates

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Semantics of Uncertainty: Some Psychophysical Correlates

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ABSTRACT

The making of decisions under conditions of uncertainty is a ubiquitous aspect of the individual's information processing behavior. Consequently, a considerable portion of his communicative activity is occupied with attempts to express the nature of his decision processes. Since the accuracy of such communication is of some social importance, the present study sought to discover the kinds of errors that may occur in communications about uncertain decisions.

Experimental subjects were shown statements expressing different degrees of "chance" for the occurrence of a certain event, and also statements expressing different degrees of "confidence" in predicting the occurrence or nonoccurrence of that event. In response to each statement subjects adjusted a device that indicated graphically the probability of occurrence of the event that they thought the statement expressed.

Results suggest that statements directly expressing the subjective probability of occurrence of an event are seldom misunderstood. Also, it appears that statements expressing high confidence in predicting the occurrence or nonoccurrence of an event are rarely misunderstood. However, statements expressing low confidence in predicting either occurrence or nonoccurrence of an event are frequently misunderstood in any one of three ways. Some of the possible implications of these findings for social communication and for decision making are discussed.

PROBLEM

Terms that refer to subjective probability and subjective confidence play important but not necessarily reliable roles in language communication. A conversation about a decision may require a communicator to make a prediction regarding mutually exclusive future events that have very similarly perceived odds of occurrence, and to indicate his degree of confidence in the prediction. For example, "Do you really think I'd find this article interesting?" "Are you certain he will arrive on the eight o'clock plane?" Although such predictions tend to be two-valued, either "yes" or "no," the subjective probabilities felt for the alternative events can have any of many values. Presumably, the expressed degree of confidence in making the prediction is a function of these subjective probability values.

From a technical view, a two-alternative situation constrains the probabilities for alternative events to a reciprocal relation, with the degree of confidence in predicting future outcomes being a direct function of the difference in probabilities. Conversely, knowing which prediction has been made and the exact degree of confidence expressed in it should enable one to know the perceived probabilities for the alternative events. One way, then, to view a prediction plus the degree of confidence expressed in it is as a value on a two-component verbal scale of subjective probability, the two components being direction and magnitude. But in everyday language communication it is not clear to what extent a prediction and an expression of degree of confidence in it will accurately communicate the subjective probabilities on which the prediction is based.

The characteristics of two-component verbal scales have been studied in relation to attitude scaling. Willis (1961) found that two-component scales are easy to respond to. Peabody (1962) found that in four sets of Likert attitude scales the composite scores reflected primarily the direction of responses, and only to a minor extent their extremeness. (These studies used psychological scaling techniques rather than the psychophysical procedures employed in the present study.) With respect to scaling subjective probability, Edwards (1962) has pointed out the nonadditivity of values of subjective probability that are inferred from measures of utility. Siegel and Goldstein (1959) have underscored the problem of subjective versus objective "rationality" in the construction of models of subjective probability and utility. Yet none of these studies approaches the problem of scaling subjective probability from the point of view of the variable effects of different verbal forms that refer to subjective probability. The present study sought an indication of the general kinds of errors that may occur in common verbal communications regarding uncertain decisions, one aim being to provide a basis for more detailed investigations of specific error-remedying techniques for especially error-sensitive contexts.

The study reported here originated as a methodological side-investigation that was prompted by another research problem. In the original problem, the research procedure required judges to report their subjective probabilities for certain events. In the method of reporting, judges gave their responses on two different scales of numerical magnitude. However, in using these scales the judges often remarked that numerical values were not natural to them, or that they didn't experience subjective probability in numerical terms. Probing further, we found that a judge's numerically reported subjective probability often did not seem to fit his verbal conceptualizations about it. We therefore decided to construct some verbal scales of subjective probability, and to study them.

METHOD

Two scales were constructed. One, called the "chance" scale, is a single-component scale of magnitude. The other, the "confidence" scale, is a two-component scale of direction and magnitude. The nine statements comprising the single-component chance scale are listed under the chance scale heading in the Appendix. The scale is organized around an event called "hitting white," which is described later. Notice that the magnitude of subjective probability varies from statement number one, which says that the chance of hitting white is "almost minimum," to statement nine, which says that the chance is "almost maximum." The nine phrases of magnitude used in these statements were selected through informal preliminary testing; other phrase combinations would probably have worked just as well for our purposes.

The other verbal scale, the "confidence" scale, contains nineteen statements that are listed under the confidence-scale heading in the Appendix. The same phrases of magnitude employed in the chance scale are also employed in the confidence scale. The confidence scale breaks the reported subjective probability into the two components: one component states whether occurrence or nonoccurrence of the "hitting white" event is more likely, and the other component states the degree of confidence in making a prediction. Figure 1 helps to clarify the relation between the prediction and confidence components of this scale.

The vertical axis shows degree of confidence in making a prediction, varying from almost maximum on the top to almost minimum on the bottom. The horizontal axis shows probability of the event called "hitting white." Notice that the lowest point of confidence in prediction is associated with the point-five probability of hitting white. Also, notice that above the .5 line the chances of hitting white are greater, and that below this line the chances of missing white are greater. Items one and two in the confidence scale would be high on the left-hand slope of the curve, items eighteen and nineteen would be high on the right-hand slope, and item ten would be at the lowest point of the curve. Now let us study a comparison of the responses made to the chance scale and responses made to the confidence scale. Responses were made on an adjustable device, which consisted of two eight-inch circular cardboard discs, one colored red and the other colored white, mounted on an axle. The axle projected from a gray background shield to which it was attached. The red disc was fixed to the axle, while the white disc was free to rotate. The two discs were each cut along a radius and interleaved in the manner of color-mixing wheels. There was a handle on the rim of the white disc, so that with a light touch of the hand the percentage of the surface of the white disc showing could be varied from zero to one hundred. The percentage of white disc showing was, of course, the same as the percentage of the red disc masked off by the white disc. An aperture in the back of the gray shield allowed the experimenter to read the percentage of the white disc showing.

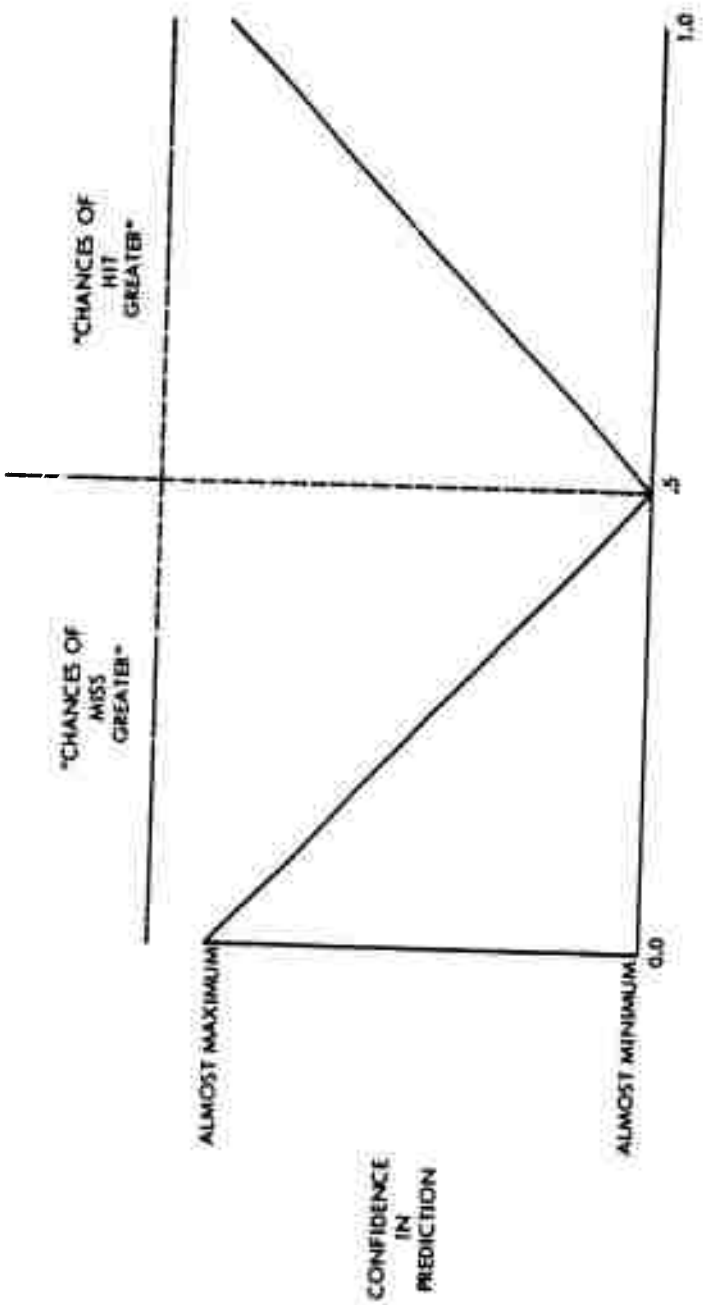


Figure 1. Relation Between Confidence Level and Hit Probability

The judges for this experiment consisted of college sophomores, juniors, and seniors who were not majors in mathematics. Each judge was seated in front of the device so that he could manipulate it comfortably, and was read the following instructions: "This is a study to find out what certain statements mean to different people. There are no right or wrong answers in this task, and you should give the meaning that seems right for you. Notice that on this device the circle can be adjusted so that there is any amount of white showing--from no white, to half-white, to all-white. Now, imagine that the circle is the bottom of a wide-mouthed bucket into which you can toss pebbles. Every pebble would bounce around in the bucket, and might come to rest anywhere on the bottom. By setting the bottom of the bucket to all white the pebbles would always hit white. By setting the bottom of the bucket to half white and half red, the pebbles would hit white half the time, and miss white half the time. Let's agree to call it a hit if the pebble lands on white, and a miss if the pebble lands on red. We are not actually going to play the pebble tossing game, but please keep it in mind the way I've described it.

"What we are going to do is this: I'll show you a series of cards with statements on them. The statements are about pebbles hitting and missing white. Study each statement for as long as you like, and when you feel ready, adjust the amount of white on the circle so that it matches the meaning of the statement. When you are satisfied with the adjustment you have made, tell me, and I will take a reading and then show you the next statement."

Each statement was presented on a three-by-five card. For the chance scale administration, before presentation began, the instructions to the judge were: "In this deck of cards, each statement is a single sentence. Each sentence tells you how much chance there is of hitting white. The circle can always be adjusted so that it matches the meaning of the sentence."

For confidence scale administration, the instructions were: "In this deck of cards each statement is made up of two sentences. The first sentence tells whether the chance of hitting or of missing white is greater. The second sentence tells how much confidence there is in the prediction made in the first sentence. The circle can always be adjusted so that it matches the meanings of both sentences at the same time."

For both scales the two end statements and the middle statement, i. e., the three anchoring statements, were administered first, followed by the remainder of the statements in random order. The order of the anchoring statements was reversed for odd- and even-numbered subjects. This order of presentation provided anchoring stimuli to minimize the response variance produced by semantic adaptation process studied by Krantz and Campbell (1961). Judges averaged about twenty seconds per response to the chance scale statements, and about forty seconds per response to the confidence scale statements.

In the first experimental run, half the judges received the chance scale first, followed immediately by the confidence scale; the other half received the scales in reverse order. Order of presentation showed no apparent effect on responses to the chance scale, but did show an effect significant beyond the .01 level for responses on the confidence scale. For the remainder of the experimental runs, the confidence scale was always given first. This provided results for both scales that were unbiased by order effects.

RESULTS

First, let's look at the results from the chance scale (Figure 2). Each statement number appears directly over the median of its response distribution. The two points where each distribution curve intersects the horizontal axis represent the tenth and ninetieth percentiles for that distribution. Notice that below the figure the statement numbers are repeated and that the number of confused responses for each statement is indicated directly below the statement number. A confused response is defined as one in which the judge sets the percentage of white to the wrong side of the fifty-percent value. With an N of fifty judges, there was only one confused response in the entire distribution, and that was to statement number six. In this case the judge set the percentage of white to something less than fifty percent.

Now, let's look at the results from the confidence scale (Figure 3). The first thing to notice is that the response distributions of statements seven, eight, and nine, and of statements twelve, thirteen, fourteen, and fifteen are skewed to the left. For statements twelve, thirteen, fourteen, and fifteen this skewness indicates some confused responses. Notice that the row indicating frequencies of confused responses shows a concentration of confused responses for these statements. In fact, the same fifty judges who between them made only one confused response to the chance scale have made forty-nine confused responses to the confidence scale. Half the judges made one or more confused responses. Remember also that the confusion frequencies do not reflect many other responses that were distorted in the same direction but did not occur on the wrong side of the fifty-percent line. Of the confused responses, about eighty-eight percent were to items seven through fourteen, excluding item ten, which is the midpoint anchor. This eighty-eight percent of confused responses thus occurred in the low-confidence portion of the scale. Only twelve percent of the confused responses occurred in the high-confidence end regions of the scale.

The skewness of these distributions also suggests that there is a major directional factor involved in the confused responses, as seen more clearly in Figure 4. This shows the face of the response device approximately as it appeared to the judges. The white area of the circles corresponds to the white disc, the finely shaded area corresponds to the red disc, and the coarsely checkered area depicts the range of the response settings. Of the eighty-eight percent of confused responses made to low-confidence statements, approximately fifty-five percent showed the pattern of confusion illustrated in the upper two circles. In the upper left-hand circle, the coarse checkering shows what the range of response settings should have been for statements eleven, twelve, thirteen, and fourteen; that is, for items that state that the chances of hitting white are greater than the chances of missing white, and that the degree of confidence with which

CHANCE SCALE N = 50

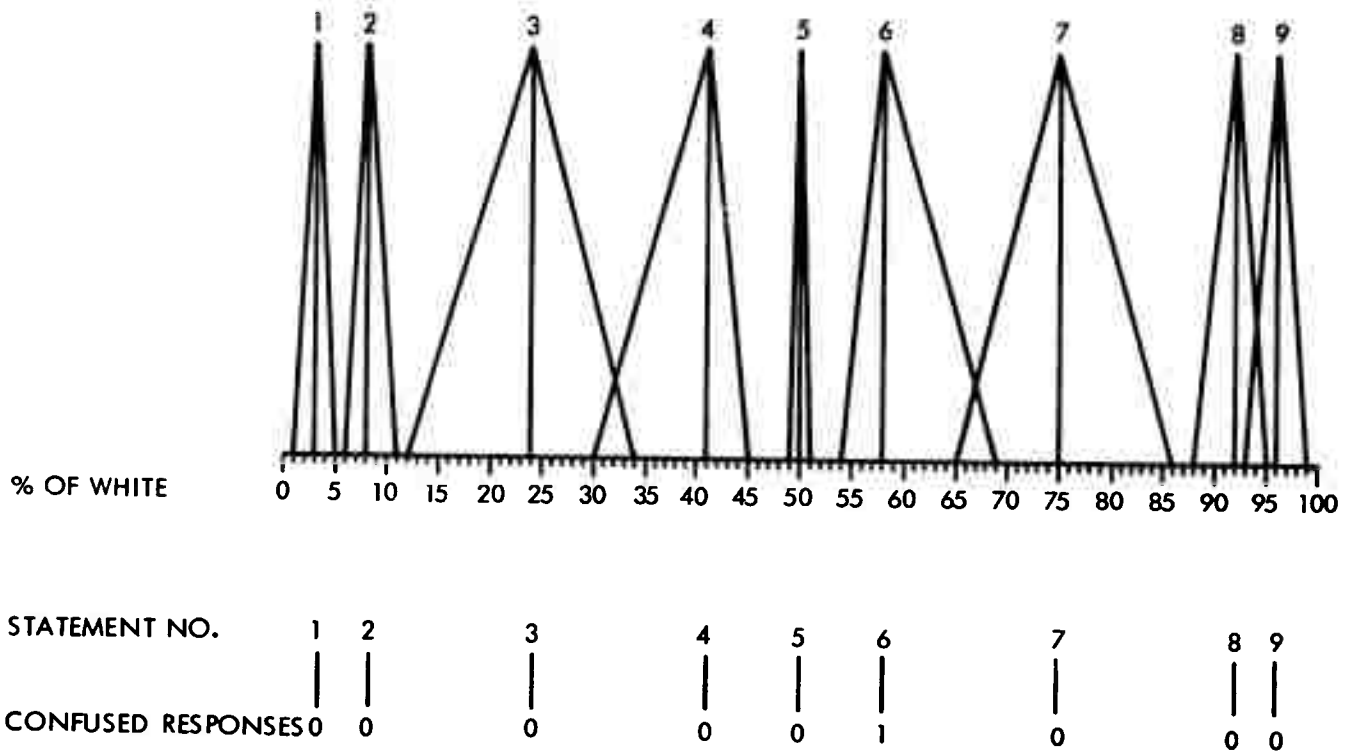


Figure 2. Chance Scale Response Distribution

CONFIDENCE SCALE N = 50

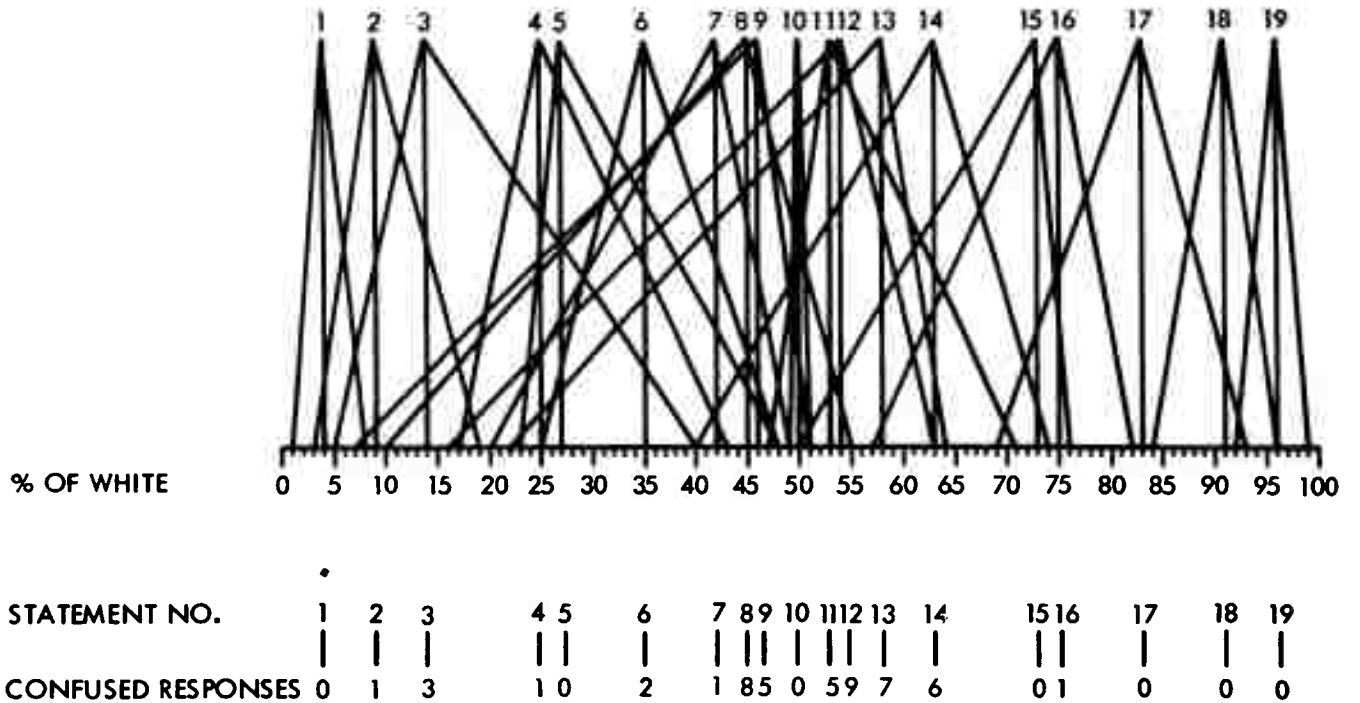
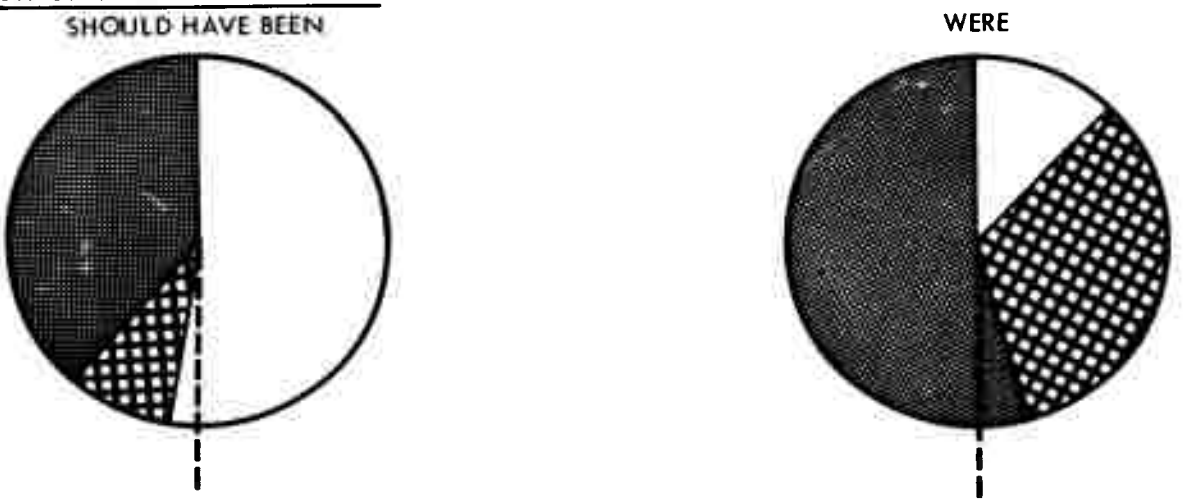


Figure 3. Confidence Scale Response Distribution

APPRX. 55% OF CONFUSED RESPONSES:



APPRX. 33% OF CONFUSED RESPONSES:

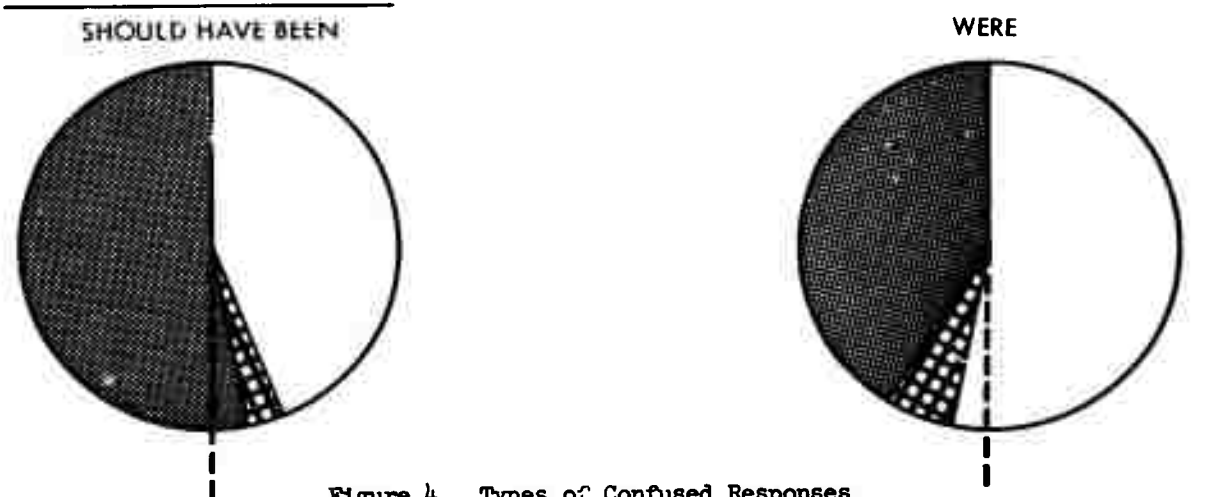


Figure 4. Types of Confused Responses

a hit can be predicted over a miss is almost minimum, quite small, small, or somewhat below medium. In the upper right-hand circle, the checkered area shows the actual range of the confused responses to these statements. This pattern accounts for fifty-five percent of the total of confused responses. It appears that these responses were confusing low confidence with low probability. This interpretation is supported by the answers given to probe questions that were asked after the judges had completed the judgment portion of the task. The bottom two circles show the pattern for another thirty-three percent of the confused responses. In the lower left-hand circle, the checkered area indicates the range of response settings that should have been made to statements seven, eight, and nine. These are low-confidence statements indicating that the chances of missing white are greater than the chances of hitting white. In the lower right-hand circle, the checkered area shows the range of confused responses actually obtained. These responses do not appear to confuse low confidence with low probability. Rather, they appear to take the low-confidence prediction of a miss as a cue to predict the reverse--that is, a low-confidence prediction of a hit.

After considering these results, we thought it possible that the confusions actually might not be linked to low-confidence statements, but, rather might be caused by artifacts in the confidence scale. In the confidence scale statements in the Appendix notice statements six, seven, eight, nine, eleven, twelve, thirteen and fourteen. In these statements, "chances" are characterized as greater, while "confidence" is characterized as low. We thought it was possible that the apparent contradiction between the words "greater" and "low" might create part of the confusion that the judges showed. To check this possibility, we changed the word "greater" to "less" in each of the statements, and switched the positions of the words "hitting" and "missing," so that statement meanings would remain constant but statements would be expressed in reverse. These revised items are shown as Section IV, "confidence scale reversed," in the Appendix. Notice that for statements six, seven, eight, and nine, and eleven, twelve, thirteen, and fourteen, the word "less" now occurs with the phrases "almost minimum," "quite small," "moderately small," and "somewhat below medium." Thus the hypothesized contradiction factor is moved from the central statements of the scale to the more extreme end statements. Also, notice that in the "confidence scale" statements, the most likely event is mentioned first in the sentence, while in the "confidence scale reversed" statements, the least likely event is mentioned first. In all other respects, the confidence scale and the reversed confidence scale are identical.

We presented the reversed confidence scale to a separate sample of judges. We presented the reversed confidence scale first, and, as an additional point of information, we also reversed the chance scale and presented it immediately after the reversed confidence scale. The results from the reversed chance scale were indistinguishable from those of the original

chance scale. However, the reversed confidence scale results looked quite different from the regular confidence scale results (see Figure 5). There are two main results to notice. First, the degree of dispersion of the response distributions is markedly increased, indicating an increased level of confusion. The frequencies of confused responses given below the figure show that the number of confusions has more than doubled. It appears that mentioning the least likely event first in the sentence may make the statements much more difficult to understand. Second, the hypothesized contradiction factor is not borne out by these results. That is, the eight central low-confidence statements still account for more than seventy percent of the confused responses.

CONFIDENCE SCALE REVERSED N = 50

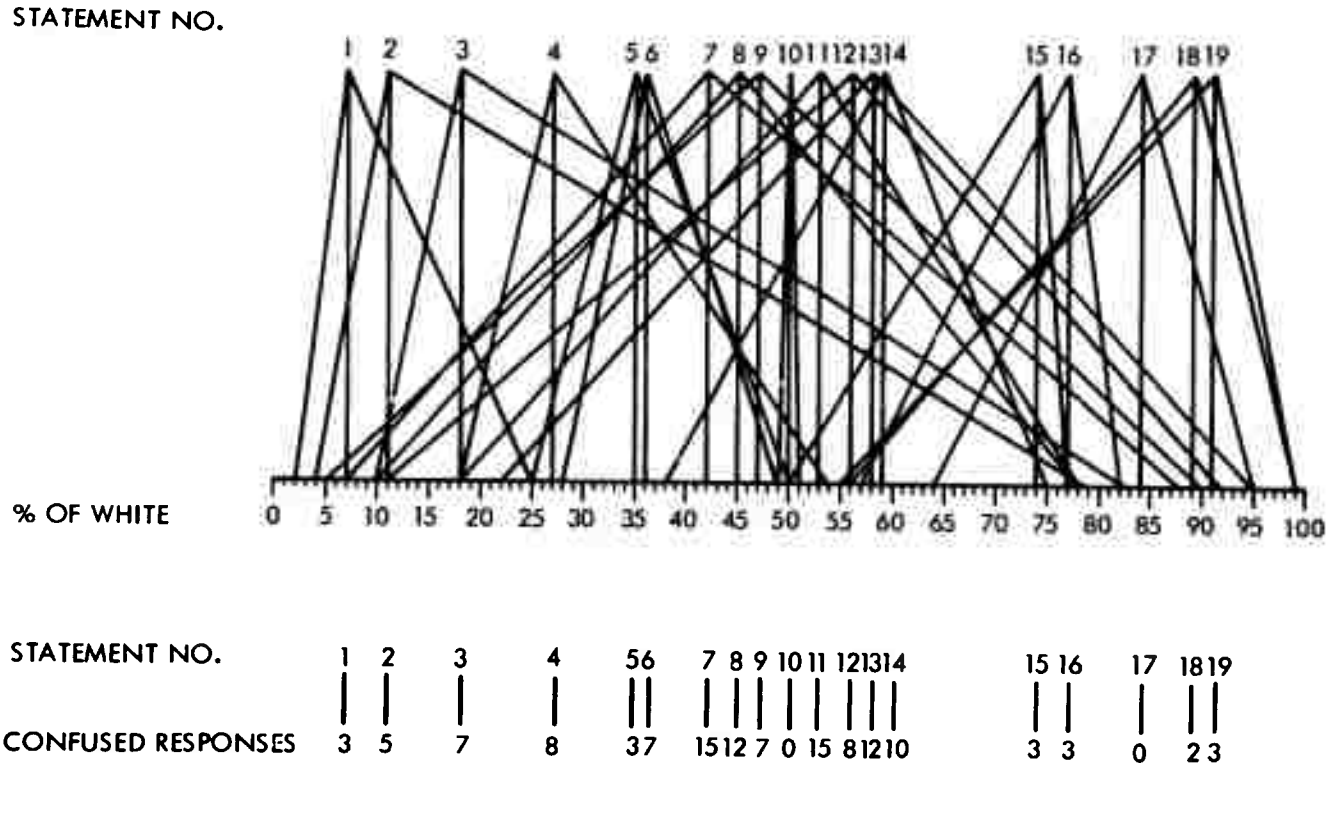


Figure 5. Confidence Scale Reversed Response Distribution

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CONCLUSIONS

We may conclude with several brief points. The confusions we found are not attributable to a few individuals. Half of the judges made one or more confused responses on the confidence scale, although they made none on the chance scale. The frequency of less severely distorted responses was even greater. Second, our experimental situation caused the judges to be especially deliberate and consciously analytical. This suggests that the frequency of such confusions may be considerably higher in the less structured, more rapidly moving situations of everyday life.

Third, a commonly occurring way of reporting subjective probability in ordinary conversations is very similar to the confidence scale format. That is, people often simply state an alternative outcome that they perceive as the most likely to occur (for example, that someone will or will not arrive on a certain airplane), and they may add that they are pretty sure or not very sure of their opinion. The results of the present study suggest the possibility of considerable error in the low-confidence versions of such communications.

Finally, while it is purely speculative at this point, it seems possible that people who show identifiable confusions such as these at the verbal-conceptual level may show predictable biases in their risk-taking behavior. For example, someone who interprets a low-confidence prediction of occurrence as a high-confidence prediction of nonoccurrence might be a markedly conservative risk-taker with respect to that event and, perhaps, a conservative risk-taker toward uncertain events in general. On the other hand, someone who interprets a low-confidence prediction of nonoccurrence as a low-confidence prediction of occurrence might be a slightly optimistic risk-taker. Such relationships might be especially noticeable in the kinds of situations in which a person must depend on verbally presented information from others as to the event probabilities involved. The increased confusions on the reversed confidence scale indicate that confidence statements referring to less likely outcomes were more easily misunderstood. This suggests the hypothesis that, in judgments about situations with uncertain outcomes, the most common focus of the judgmental processes may be the outcome perceived as the most probable.

Differences in language usages in the area of subjective probability may reflect differences in cognitive modes of information processing. Studies presented by Bruner (1964) indicate that a child's acquisition of language mediation "tools" can alter his information-processing practices. Spurts of performance change appeared at more or less common points of transition in the course of growth for a given type of information processing. The related language usages employed by the individual before such a spurt are often markedly different from those employed after it. Such developmental transitions points are way-stations for some persons and termini for others. They may also be the sites of frequent misunderstandings in verbal communication.

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SUMMARY

Subjects were shown statements expressing different degrees of subjective probability for the occurrence of an event, and different degrees of confidence in predicting the occurrence and nonoccurrence of the event. In response to the statements, they adjusted a variable device that depicted probability graphically. Psychophysical distributions were obtained for the terms "chance" and "confidence," each term being varied systematically in accompaniment with the same nine terms of magnitude. Considered from the point of view of communication, statements that directly expressed subjective probability were rarely misunderstood. The subjective probabilities underlying statements of high confidence in predictions were also rarely misunderstood. The subjective probabilities underlying statements of low confidence in predictions were misinterpreted in either of two ways. Somewhat-greater-than-even perceived odds for occurrence were misinterpreted as small odds for occurrence, while somewhat-less-than-even perceived odds for occurrence were misinterpreted either as small odds for occurrence, or as somewhat-greater-than-even odds for occurrence.

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APPENDIX

Scale Statements

I. Chance Scale

The chances of hitting white are _____.

1. Almost minimum	4. Somewhat below medium	7. Moderately large
2. Quite small	5. Medium	8. Quite large
3. Moderately small	6. Somewhat above medium	9. Almost maximum

II. Chance Scale Reversed

The chances of missing white are _____.

1. Almost maximum	4. Somewhat above medium	7. Moderately small
2. Quite large	5. Medium	8. Quite small
3. Moderately large	6. Somewhat below medium	9. Almost minimum

III. Confidence Scale

The chances of missing white are greater than the chances of hitting white, and the degree of confidence with which a miss can be predicted over a hit is _____.

1. Almost maximum	4. Somewhat above medium	7. Moderately small
2. Quite large	5. Medium	8. Quite small
3. Moderately large	6. Somewhat below medium	9. Almost minimum

10. The chances of hitting white and of missing white are even, and the degree of confidence in predicting a hit or a miss is the same.

The chances of hitting white are greater than the chances of missing white, and the degree of confidence with which a hit can be predicted over a miss is _____.

11. Almost minimum	14. Somewhat below medium	17. Moderately large
12. Quite small	15. Medium	18. Quite large
13. Moderately small	16. Somewhat above medium	19. Almost maximum

IV. Confidence Scale Reversed

The chances of hitting white are less than the chances of missing white, and the degree of confidence with which a miss can be predicted over a hit is _____.

1. Almost maximum	4. Somewhat above medium	7. Moderately small
2. Quite large	5. Medium	8. Quite small
3. Moderately large	6. Somewhat below medium	9. Almost minimum

10. The chances of hitting white and of missing white are even, and the degree of confidence in predicting a hit or a miss is the same.

The chances of missing white are less than the chances of hitting white, and the degree of confidence with which a hit can be predicted over a miss is _____.

11. Almost minimum
12. Quite small
13. Moderately small
14. Somewhat below medium
15. Medium
16. Somewhat above medium
17. Moderately large
18. Quite large
19. Almost maximum

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The making of decisions under conditions of uncertainty is a ubiquitous aspect of the individual's information processing behavior. Consequently, a considerable portion of his communicative activity is occupied with attempts to express the nature of his decision processes. Since the accuracy of such communication is of some social importance, the present study sought to discover the kinds of errors that may occur in communications about uncertain decisions. Experimental subjects were shown statements expressing different degrees of "change" for the occurrence of a certain event, and also statements expressing different degress of "confidence" in predicting the occurrence or nonoccurrence of that event. In response to each statement subjects adjusted a device that indicated graphically the probability of occurrence of the event that they thought the statement expressed. Results suggest that statements directly expressing the subjective probability of occurrence of an event are seldom misunderstood. Also, it appears that statements expressing high confidence in predicting the occurrence or nonoccurrence of an event are rarely understood. However, statements expressing low confidence in predicting either occurrence or nonoccurrence of an event are frequently misunderstood in any one of three ways. Some of the possible implications of these findings for social communication and for decision making are discussed. (author)