Notes and Comment

A catastrophe model for the effects of a response set on a discrimination task

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Zeeman (1976) has used catastrophe theory, a mathematical method for dealing with abrupt and discontinuous changes (Thom, 1970), to construct a number of graphic models that can be used in the behavioral sciences. The simplest model, the cusp catastrophe, consists of a behavioral surface whose height varies along a bipolar dimension as a function of changes in two stimulus dimensions. The behavioral surface in this model is distinguished by a fold or overlap that is cusp shaped.

The fold or overlap in the surface of a cusp catastrophe is used to represent a variety of abrupt and discontinuous changes in behavior. The fold in the surface indicates, first, that there should be sudden changes from one end of the response dimension to the other end of the response dimension, and second, that these changes should exhibit a property called hysteresis. Hysteresis means that the change from one end of the response dimension to the other occurs at one point when moving in one direction but at another point when moving in the opposite direction. Because of the nature of hysteresis, some stimuli are expected to be associated with both ends of the response dimension, a property called bimodality. Two additional properties of behavior, inaccessibility and divergence, are also associated with the fold or overlap in the surface. Inaccessibility means that responses are not available in the space between the overlapping planes. Divergence means that a jump to either the upper or lower plane in the surface is to be expected when moving toward the point of the cusp. Thus, the fold in the surface of a cusp catastrophe indicates that five distinctive behaviors should be observed: sudden changes, hysteresis, bimodality, inaccessibility, and divergence.

The purpose of the present experiment was to determine if the manipulation of a response set, perseveration, would affect the judgments on a discrimination task so that the judgments would correspond to the features that distinguish a cusp catastrophe.

Method

Perseveration, that is, the tendency for the initial judgment to persist or recur when it is no longer appropriate, was established during a brightness discrimination task. The probability that perseveration would occur was varied by using easy and difficult discrimination tasks. The occurrence of perseveration at each dif-

ficulty level was determined by comparing a condition in which all the trials were administered in an ascending order with a condition in which all trials were administered in a descending order.

The use of easy and difficult discrimination tasks was based on the assumption that response sets, such as perseveration, are more likely to occur in an ambiguous situation than in a situation in which the alternatives are clearly different (Mischel, 1968). In the easy discrimination task, a relatively weak standard was paired with variables whose increments were likely to be greater than the difference threshold. The increments used in the difficult discrimination task were the same as those used in the easy one, but because the strength of the standard was increased, the increments in the variables were now likely to be less than the difference threshold. These manipulations were based, of course, on Weber's law (Underwood, 1966).

The decision to use conditions with only ascending or only descending trials was based on two factors: first, because it is a well-known fact that errors of habituation, or perseveration, are common when ascending and descending orders are used (Underwood, 1966); and second, because the difference between the point of subjective equality (PSE) for the ascending and descending conditions provides a convenient way to measure the occurrence of perseveration.

Apparatus. Two 7.5-W lights, each housed in a 4×4×4 in. box with a 1.25-in. circular opening, served as the discriminanda. The brightness of each light was controlled with an adjustable voltage transformer. The output of the transformers was expressed in terms of the percentage of a maximum of 120 V. The easy task used a standard of 26% and was paired with nine variable stimuli that ranged from 16% to 34% in increments of 2%. The difficult task used a standard of 92% and was paired with nine variable stimuli that ranged from 84% to 100% in increments of 2%. In order to have a single set of labels for the construction of Figure 1, the variable stimuli in both conditions were represented by deviations from the value of the standard. For instance, the 16% variable in the easy task was represented by -8%, while the 100% variable in the difficult condition was represented by +8%. The onset and duration, 1 sec, of both the standard and variable lights were controlled with a Hunter timer. The light on the subject's left always served as the standard.

Procedure. Students were instructed that two lights would be presented and that their task was to indicate which was the brighter by saying left or right. Each student was then administered a single series of trials on both the easy and difficult discrimination tasks. Half of the students were given trials for both tasks in an ascending order. For instance, one of the two standards was first paired with the weakest (-8%) variable, on the second trial the standard was paired with the next strongest (-6%) variable, and so on, until all the trials in the series had been given. The remaining half of the students were administered trials for both the easy and difficult tasks in a descending order. That is, on the first trial one of the standards was paired with the strongest (+8%) variable, on the second trial the standard was paired with the next weakest (+6%) variable, and so on, until all the trials in the series had been given. The sequence of easy and difficult discrimination tasks was counterbalanced over students.

Subjects. A total of 40 introductory psychology students participated in the present experiment.

Results and Discussion

Figure 1 shows a behavioral surface whose height varies with the proportion of students that judged the variable to be brighter than the standard as a function

Figure 1. The proportion of students in the ascending and descending conditions that judged the variable to be brighter than the standard as a function of both the strength of the standard, either 26% or 92%, and the strength of the variable stimuli. The variable stimuli are represented by deviations from the value of the standard and range from -8% to $+8\%$.

of both the strength of the standard, either 26% or 92%, and the strength of the variable stimuli, represented by deviations that ranged from -8% to $+8\%$. The back edge of the surface is fitted to the judgments made during the easy, 26%, discrimination task by students in the ascending and descending conditions. The front edge of the surface is fitted to the judgments made by both groups of students during the difficult, 92%, discrimination task. The behavioral surface in Figure 1 is characterized by a cusp-shaped fold or overlap similar to those presented by Zeeman (1976).

Inspection of Figure 1 indicates, first of all, that perseveration affected the students' judgments in the expected manner. That is, during the easy discrimination task, the differences between the ascending and descending conditions were so small that a single function could be fitted to both sets of data. The results of a t test indicated that the difference between the mean PSE, $+3.9\%$, for the students in the ascending condition and the mean PSE, $+3.7\%$, for the students in the descending condition was not significant ($t = .15$, $df = 38$, $p < .50$). During the difficult discrimination task, however, the initial judgments were repeated long after they were appropriate and a discontinuous function was required to fit the data from the ascending and descending conditions. The results of a t test indicated that the mean PSE, $+3.7\%$, for the students in the ascending condition was significantly higher than the mean PSE, -1.9% , for the students in the descending condition ($t = 3.00$, $df = 38$, $p < .01$).

Further inspection of Figure 1 indicates that the behavior surface fitted to the judgments made by the students conforms to the characteristics that distinguish a cusp catastrophe. That is, the front edge of the behavior surface in Figure 1 corresponds to sudden changes, hysteresis, and bimodality, while the fold or overlap in the surface represents inaccessibility and divergence.

Examination of the front edge of the behavior surface shows that the proportion of students judging the variable to be brighter than the standard increased suddenly in the ascending condition when the variable was increased from the $+4\%$ to the $+6\%$ value. The front edge also shows that the proportion of students judging the variable to be brighter decreased suddenly in the descending condition, but not until the variable was reduced from the $+2\%$ to the 0% value. These observations provide evidence for hysteresis because they indicate that a sudden change in the level of judgments occurred at one point when moving in one direction and at a different point when moving in the opposite direction. These same observations also provide evidence for bimodality because they indicate that two different levels of the students' were associated with some of the variable stimuli, those with values between 0% and $+6\%$. The empty space between the fold or overlapping planes in the surface illustrates inaccessibility. Because responses are not available in the empty space, divergence—or jumping to either the upper plane, where the probability of judging the variable brighter is high, or the lower plane, where the probability of judging the variable brighter is low—would be likely to occur when moving from the point of overlap to the front edge of the surface.

The behavior surface presented in Figure 1 indicates, then, that not only did perseveration affect the students' judgments in the expected manner, but also, and more importantly for the purpose of the present study, that the judgments were affected so that they corresponded with the behavioral features of a cusp catastrophe. An implication of the present experiment is, therefore, that catastrophe theory can be used as a model to describe and perhaps to predict behavior in perceptual and psychophysical situations.

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