Table 1. Proportions of subjects ($N = 32$) having a performance level superior to the mean performance level of the reference group on plots of receiver operating characteristic curves.

Grade	Experimental group	
	Auditory	Visual
	Superior to mean performance level of grade 1	
1	0.41	0.34
3	.59	.78
5	.81	.97
Adult	1.00	1.00
	Superior to mean performance level of own grade	
1	0.41	0.34
3	.38	.31
5	.38	.38
Adult	.25	.38

consistent with our finding that a fifth reader and average adult texts have approximately equal redundancy (*10*). The better beginning and slower growth of auditory skill in the recognition task is consistent with our finding that simple sequential constraints of phonemes are essentially equal for first, third, or fifth graders, and for adults (*11*). There is, of course, some further differentiation from first graders to adults when the distribution of phonemic words is considered.

A useful fruit for the educator might come from an exploration of a given child's preformance index for visual and auditory material. Not only could his auditory and visual performance be related to each other, they could be related to group norms obtained in a standardized recognition-memory experiment, and to other independent indices of ability such as mental ability subtest scores, school grades, or even actual reading performance. The advantage of the recognition task is its minimal demands on auditory or visual perception, making it useful over a wide range of ages. The advantage of the ROC plot lies in the freedom of the detectability index from perturbation by criterion, motivation, implicit (but unspecified) reward and cost schemes, and other variables extraneous to the test situation.

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30 January 1967; 20 March 1967

Discrimination Learning and Inhibition

Terrace's conclusions in his recent report (*1*) are not supported by the evidence he presents and opposite conclusions seem to follow. He argues that when a subject learns to discriminate between two stimuli (S+ and S−) without errors, the negative stimulus (S−) does not acquire an inhibitory function. He supports this conclusion by showing that there is no generalization gradient around S−, or in other words, that this gradient has zero slope. However, to evaluate this argument we must take into account the absolute values of the points of which the gradient is composed. These are all zero or very close to zero. The animals did not respond in the presence of any stimulus similar to the original S− when they learned without errors. Since they did not respond, and the animal cannot make scores of less than zero, we cannot infer that inhibition around S− is greater than that away from S−. The score at S− cannot be lower than zero when this experimental design is used, and therefore the lack of slope may only reflect this design. We cannot discriminate between an increase or no increase of inhibition at S− with Terrace's data. Can we interpret the zero scores, as Terrace does, as indicating that there is no inhibition when the subject learns to discriminate without errors? (He states: " . . . it is nonetheless clear that S− controls the tendency not to respond, that is, functions as an inhibitory stimulus, only after a subject has learned to discriminate with errors.") This question can be answered by looking at the scores of the group which learned S− with errors. Their rates of responding are much greater than zero when the stimuli presented moves away from S−. When the subjects learn to discriminate without errors, however, these rates of responding stay at zero or very close to it when the stimuli move away from S−. Therefore, rates of responding to stimuli away from S− are lower when the subjects learn to discriminate without errors than when they learn to discriminate with errors. Since the amount of responding is used as a measure of inhibition, one must infer that there is greater inhibition due to S−, when the subjects learn to discriminate without errors, as the stimulus moves away from S−; but this conclusion is the opposite of that made by Terrace. Far from supporting the evidence that Terrace quotes in favor of the idea that S−, when learned without errors, does not have an inhibitory function, the facts presented in the report cast strong doubt on Terrace's previous interpretations of such data.

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6 March 1967

When, given the same set of data, two scientists reach opposite conclusions, it is likely that each used different decision rules. In this case, the data in question are generalization gradients of wavelength that were obtained after a subject was trained to discriminate between a white vertical line on a black background (S+) and a homogeneous circular patch of monochromatic (either 550 or 580 nm) light (S−). The gradients of those subjects who learned the discrimination without errors were flat, with all of the data points having zero or near zero values. The gradients of the subjects who learned the discrimination with errors were U-shaped with minima (of zero or near zero value) located at S—. At issue is the question of how these gradients can be used to measure inhibition. Deutsch (but not this author) states that "the amount of responding is used as a measure of inhibition," and concludes that "there is greater inhibition due to S— when the subjects learn to discriminate without errors," because in the case of errorless learning the "rates of responding stay at zero or very close to it."

The validity of Deutsch's decision rule and conclusions can be questioned on at least two grounds. (i) A low rate of responding can be explained in terms of lack of excitation. Thus, given no additional information, the concept of inhibition is superfluous. (ii) A flat generalization gradient cannot be used as evidence of inhibition for the same reason that it cannot be used as evidence of excitation. The second point follows from the definition of an inhibitory stimulus, first formulated by Jenkins (*1*), which states that an inhibitory stimulus is a stimulus which controls the tendency not to respond. To determine whether or not a stimulus controls the tendency not to respond, one varies the stimulus along a stimulus continuum and observes to what extent the tendency not to respond has been affected. Thus, the rationale for determining whether or not a stimulus controls the tendency not to respond (inhibition) is identical to the rationale for determining whether or not a stimulus controls responding (excitation). In both cases one examines the relationship between the frequency of occurrence of a conditioned response and the value of the stimulus. Since, in the present experiment, S+ and S— were selected from different continua, they could be varied independently of one another and it was possible to obtain both excitatory and inhibitory gradients from each subject. A flat generalization gradient that is obtained along the S+ continuum (at either a zero or greater than zero level) usually signifies that there was no stimulus control with respect to the continuum under study. Applying the same logic to a test for generalization along the S— continuum, it seems erroneous to use a flat generalization as evidence of inhibition. I would instead suggest that the flat gradients that were obtained from the errorless group reflect a uniform lack of excitation and that stimuli from the S— continuum should be considered neutral in the sense that they have neither inhibitory nor excitatory properties.

Deutsch also argues that "Since . . . the animal cannot make scores of less than zero, we cannot infer that inhibition around S— is greater than that away from S+." He then concludes: "We cannot discriminate between an increase or no increase of inhibition at S— with Terrace's data." However, Deutsch did in fact conclude that "there is a greater inhibition due to S— when the subjects learn to discriminate without errors as the stimulus moves away from S—." It is nevertheless interesting to explore the significance of the fact that scores of less than zero were not possible. Deutsch's interest in negative scores apparently stems from the Spence-Hull model of discrimination learning which algebraically combines positive quantities of excitation with negative quantities of inhibition at each stimulus value to determine the net strength of the responses. However, in applying this model to experimental data, one must transform the data to produce negative quantities. Responses either occur or do not occur, and the only way one could obtain scores of less than zero would be to subtract an appropriate amount from each response frequency. Gradients of the type obtained in the present experiment would be transformed by assigning zero to the highest value of each gradient and assigning minus signs to all points below the highest point. The amount of inhibition at a given point would be determined by the difference between that point and the highest point. Thus flat gradients would result in zero inhibition and the amount of inhibition represented by gradients of greater than zero slope would be the sum of the differences between the highest point and the remaining points.

What would be gained if one obtained an elevated base line? (By definition, however, this is impossible since once the level of responding along the S— continuum is raised we could no longer have subjects who learned the discrimination without errors.) Suppose that this hypothetical experiment yielded the same type of results as those obtained in the present experiment, that is, flat gradients from those subjects who learned without errors and U-shaped gradients from those subjects who learned the discrimination with errors. If in interpreting these results Deutsch applied the decision rule he used in his letter, he would again have to conclude that there was more inhibition in the case of the errorless group. But whether or not a stimulus has an inhibitory function is determined by whether the tendency not to respond decreases as we move away from S—, and that a flat gradient signifies the absence of inhibitory stimulus control. Thus the design which Deutsch might suggest would result in the same problem of interpretation that arose from his criticism of my conclusion. We are still left with the question of why, given that both groups had an equal opportunity to produce gradients of greater than zero slope, such gradients were obtained only from the group that learned with errors. I have chosen to interpret these findings as indicating that S— functions as an inhibitory stimulus only when a discrimination is learned with errors. This conclusion follows readily from the definition of an inhibitory stimulus as a stimulus which controls the tendency not to respond.

The evidence that Deutsch feels is inconsistent with the data obtained in the present experiment includes the findings that emotional responses in the presence of S— and a peak shift away from S— are only observed after a discrimination is learned with errors. It remains to be demonstrated that these observations are in any way compatible with Deutsch's contention that there is more inhibition associated with S— after a discrimination is learned without errors than after a discrimination is learned with errors.

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