tion of erythropoiesis as evidenced in the bone marrow, blood, and spleen. Table 1 shows resumption of erythropoiesis at 14 days after infection. Uptake of Fe^{59} by the blood of HP mice infected with the virus was comparable to that observed in HP mice receiving erythropoietin. The erythropoiesis in the spleen was approximately three times greater in the HP mice receiving the virus than in HP mice receiving erythropoietin. The polycythemic virus has a strong affinity for the spleen; removal of the spleen prevents the polycythemic response (*4*). In HP mice receiving the polycythemic virus, depression of erythropoiesis in the bone marrow occurs during the 2nd week. This occurs routinely as the spleen increases in size.

The histological examinations of the spleens in HP mice to which erythropoietin had been administered and in those which had received polycythemic virus were similar in showing marked erythropoiesis. Early erythroid cells and mature red blood cells were evident in the area of the red pulp.

Friend virus, like Rauscher virus, did not initiate erythropoiesis in a HP state. Histological examination of the hemopoietic organs, particularly the spleen, confirmed the inability of these viruses to reestablish erythropoiesis. Mice not in a hypertransfused-polycythemic state, which received the polycythemic, Friend, or Rauscher virus at the same time as the hypertransfused-polycythemic mice, showed signs of the disease usually induced by these viruses. Therefore, the inability of the Friend or Rauscher virus to initiate erythropoiesis in HP state is not attributable to a decreased virus titer at the time of inoculation. Possibly, the HP state does not make available a cell type (or types) that permits replication of the Friend or Rauscher virus.

Like immunological techniques, the HP state has borne out the similarity of the Rauscher and Friend viruses (*3, 10*). It is significant that, although all three viruses stimulate erythropoiesis in a normal state, only the polycythemic virus can initiate erythropoiesis in a HP state; the exact mechanism by which this is accomplished is not known. Perhaps the polycythemic virus influences erythropoietin-producing cells to release erythropoietin, causing differentiation of stem cells (*11*) into erythroid cells. Another possibility is that the polycythemic virus induces erythroid stimulation independently of erythropoietin. If this is so, then presumably the polycythemic virus in itself, like erythropoietin, is capable of enzyme induction (*11*) in stem cells, causing them to differentiate into early erythroid cells.

Attempts to isolate erythropoietin from concentrated plasma and urine from infected normal and HP mice at various stages after viral infection have not been successful. Thus far, it has also been impossible to determine whether the polycythemia induced by the polycythmic virus is erythropoietin-dependent or independent by use of an antierythropoietin (*12*).

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27 February 1967

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Attention Shift and Errorless Reversal Learning by the California Sea Lion

Abstract. *Repeated combinations of a previously well-learned size cue preference with the previously negative form cue followed by gradual reduction of the size cue resulted in nearly errorless performance by two sea lions on a series of nine form-discrimination reversals. Systematic insertion of probe trials, during which the size cue was not present, revealed that attention was primarily focused on the size dimension during early stages of training, when size differences were large, and then was gradually shifted to the form dimension as a function of the increasing difficulty of the size discrimination.*

As an outgrowth of research on animal learning, a powerful technique has been developed that facilitates getting an animal to attend to the relevant stimulus dimension of a discrimination task. The relevant dimension is introduced in such a way as to minimize or eliminate errors. The technique relies on establishing a simple discrimination between stimuli within a single dimension, superimposing a new relevant dimension on the previous one, and then gradually eliminating the original dimension until it is no longer present (*1*). Recent work has extended the use of this progressive training procedure to a series of discrimination reversals performed virtually without error by the California sea lion (see *2*).

The critical elements of training were the repeated combining of a previously well-learned size cue preference with the previously negative form cue, followed by the progressive reduction of the size cue. Figure 1 shows a prototype of the progressive training procedure used in a series of reversal tasks. The figure shows that the first form reversal may begin by having the negative form (circle) and the positive size (small) constitute the positive or reinforced compound stimulus and by having the positive form (triangle) and the negative size (large) constitute the negative or nonreinforced compound stimulus. During succeeding training stages the area of the circle is gradually increased and the area of the triangle is gradually decreased until size is eliminated as a cue and only the circle and triangle serve as discriminative stimuli. Training on the next form reversal proceeds in a similar manner except that the small triangle becomes the positive compound stimulus and the large circle becomes the negative compound stimulus.

Within the present context, the most important feature of these experiments was the errorless performance throughout training. The lack of error occurred despite the fact that each new reversal series first began by combining positive size with previously negative form (positive compound stimulus) and negative size with previously positive form (negative compound stimulus), and finally reached a terminal training stage wherein the size cue had been completely eliminated. This must mean that during the initial stages of each reversal training series the sea lion was primarily attending to the size cue and that, at the end of the training series, form became the primary controlling stimulus dimension.

There are several questions to be asked about this process of shifting attention from one cue to another. When does the animal abandon the size cue and shift attention to the form cue? Is this done suddenly or gradually? If the shift in attention is sudden, does it occur early in training, that is, when both cues are readily available, or does it occur when the size cue is completely eliminated? Inducing a subject to shift from one set of perceptual properties to another is not only of considerable theoretical interest (*3*), but it is also of interest from the standpoint of educating young children, either normal or retarded (*4*). Progressive training on a serial reversal task is particularly well-suited for the study of perceptual shifts, since the animal is repeatedly forced to shift from one dimension to another.

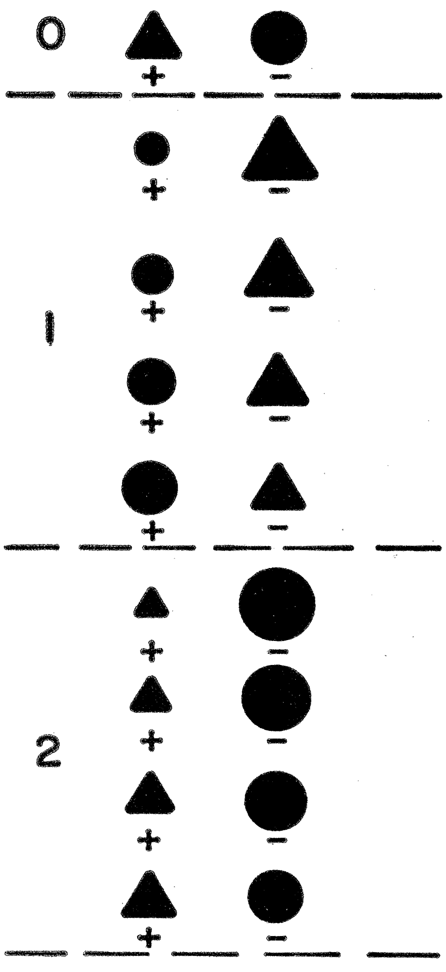

Fig. 1. Prototype of progressive dimensional-change training for obtaining errorless learning on two form reversals. Pluses refer to the positive or reinforced stimulus and minuses refer to the negative or nonreinforced stimulus. Note that at the beginning of each form-reversal training series both size and form cues are correlated with reinforcement and that at the end of the series the size cue is eliminated.

In an experiment with two sea lions (*Zalophus californianus*) information regarding the questions posed above was obtained by systematically inserting "probe" trials throughout the course of progressive training for each of nine form reversals. Each probe trial was a presentation of an equal-sized triangle and circle. Responses to either form were reinforced. Determining the frequency with which the previously negative form was chosen on a probe trial (see Fig. 1) gave an estimate of the degree to which attention had shifted from the size cue to the form cue.

The sea lions used in this experiment were 4- and 5-year-old males, Sam and Growler. Testing was done under water in an oval redwood tank (*5*). Sam had previously been trained on a pattern discrimination task (*6*) and both animals had been trained on a size discrimination task (*7*). Just before the present experiment, Growler had received progressive training on a series of seven form reversals. During the experiment the animals were signaled to approach the stimulus display as it was lowered into the water. The response was striking one of two targets, presented simultaneously, in order to obtain either a piece of herring or a whole smelt. Position of the targets was randomly determined and the targets were withdrawn immediately after a response.

The targets were black triangles and circles cut from 20-gauge steel. Obtaining a series of form reversals by means of progressive training has been described (*2*). The general outline of this procedure is shown in Fig. 1, and the specific sequence of training stages, target size, and number of trials per training stage for each reversal are shown in Table 1. With one exception each form reversal was accomplished in 1 day. Each day began with ten trials of the same form discrimination which had ended testing on the previous day. During stages 1 through 16 for each of the nine reversals, the positive compound stimulus consisted of the previously negative form (a triangle on the odd reversals) and the positive size (small), and the negative size and previously positive form constituted the negative compound stimulus. A single probe trial was inserted throughout stages 1 through 16 after every ten training trials. Since there were 220 training trials (in which cues of size and form were available) there were a total of 22 probe trials during the course of each reversal.

The sea lions performed with few or no errors throughout stages 1 through 17 for each of the nine form reversals (*8*). The error scores for Sam and Growler were 4, 0, 0, 0, 0, 0, 2, 2, 0 and 2, 3, 1, 1, 0, 3, 0, 0, 0, respectively. The results of the probe trials for both sea lions are shown in Fig. 2. Each data point represents 18 probes consisting of two probes for each of the nine reversals. The ordinate plots the total number of times that each sea lion responded to the previously negative form, showing the degree to which the animals had shifted from their last previous form preference. Since there were either few or no errors on the reversal problems, this curve must therefore reflect a shift in attention from the size dimension to the form dimension. Probe-trial choices revealed that during the first 40 training trials there was a significant preference by

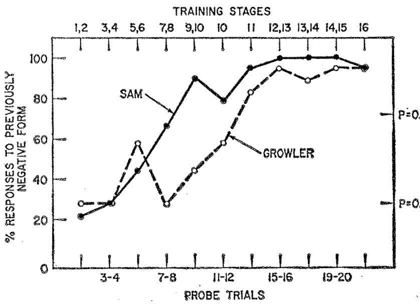

Fig. 2. Results of probe trials from two sea lions during the course of performing nine form reversals virtually without errors. The curve shows a shift in preference from the previously positive or preferred form to the previously negative or nonpreferred form as a function of progressive training stages.

Table 1. Description of training for nine form reversals.

Training stages	Area of positive form (cm^2)	Area of negative form (cm^2)	Size-difference ratio larger : smaller	Trials (No.)
1	41.80	280.49	6.70:1	10
2	42.72	224.76	5.26:1	10
3	42.72	180.19	4.21:1	10
4	52.94	180.19	3.40:1	10
5	52.94	173.69	3.28:1	10
6	66.87	173.69	2.59:1	10
7	66.87	156.04	2.33:1	10
8	78.02	156.04	2.00:1	10
9	78.02	136.53	1.74:1	10
10	85.50	136.53	1.59:1	30
11	85.50	121.67	1.42:1	20
12	95.67	121.67	1.27:1	20
13	95.67	114.24	1.19:1	20
14	101.24	114.24	1.12:1	10
15	101.24	110.53	1.09:1	10
16	104.95	110.53	1.05:1	10
17	107.74	107.74	1.00:1	30

both animals ($P < .01$, binomial) for the previously positive form. Thus, during the early training stages, when the size differences were large, attention was focused on this dimension and the animals learned little about changing their form preference. This interpretation is consistent with evidence indicating that animals frequently solve a problem on the basis of one relevant cue while learning little about a second relevant cue (*9*).

Probe-trial choices during the next 40 to 80 training trials, when size differences had been reduced considerably, demonstrated no significant preference for either of the two forms. The curves in Fig. 2, however, show a steady increase in responses to the previously negative form. This means that as the size discrimination became progressively more difficult, the animals, on any given trial, attended to both size and form cues with attention gradually shifting more and more to the form cue. It is likely that during this phase of progressive training the sea lions learned to change their form preference. Finally, when the size difference ratio had decreased to 1.27 : 1, a value considerably above *Zalophus*' threshold (*7*), the preference for the previously negative form approached a probability value of 1.00. This preference persisted even when the size cue was no longer available.

The present results support the notion (*2*) that, during repeated errorless reversals of a form discrimination, attention is primarily focused on the original dimension (size) during the early stages of each training series and then is gradually shifted to the superimposed second dimension (form) as a function of the increasing difficulty of the original discrimination.

Such an interpretation is consistent with Mackintosh's (*3*) recent position on the issue of attention in animal discrimination learning, which he describes as a "modified noncontinuity theory." This position states that although animals do not attend to all cues equally, they may attend to more than one cue on any given trial, depending on such factors as the difficulty of the original discrimination, the abruptness with which a second dimension is introduced, and the degree to which the original discrimination is learned. The first two variables are positively related to shifts of attention; the relationship of the third variable, however, is negative. Since both sea lions had extensive size discrimination training, the present results indicate that difficulty of the original discrimination is a more potent fatcor in attention shift than is degree of original training.

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Maternal Behavior in the Domestic Cock under the Influence of Alcohol

Abstract. *When normal male domestic chickens were given a single dose of grain alcohol and then exposed to newly hatched chicks, they assumed maternal behavior. The same behavior can be elicited by the administration of prolactin, but the results of these experiments suggest that maternal behavior in the cock is not exclusively dependent on hormonal mechanisms.*

Maternal behavior can be induced in domestic cocks by repeated injections of prolactin (*1*). This finding is in agreement with the general observation in a variety of species that the development of maternal behavior is associated with secretion of prolactin (*2*). However, we induced maternal behavior in cocks by administering a single dose of grain alcohol and then exposing them to newly hatched chicks. Maternal behavior is not part of the normal behavior cycle of male domestic chickens and our procedure for inducing it precludes the operation of hormonal mechanisms (*3*).

In a pilot study we exposed individually seven mature, sexually active cocks