postoperatively. Hence, the observed effects of somatotropin are not the result of synergism with pituitary hormones that might remain in the blood for a short time after hypophysectomy.

Our observations indicate that somatotropin can synergize with appropriate ovarian or adrenocortical steroids, or both, to induce ductal development, lobulo-alveolar development, and lactogenesis in the mammary glands of triply operated C3H/He CRGL female mice. Unlike the rat (*1*), our C3H mouse is responsive to the mammogenic and lactogenic actions of somatotropin even in the absence of appreciable amounts of mammotropin (*6*).

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Intrasubject Conditioning as a Function of the Intensity of the Unconditioned Stimulus

Abstract. Subjects conditioned concurrently to two different conditioned stimuli, light and tone, exhibited a significantly higher level of conditioning to the stimulus paired with a strong unconditioned stimulus than to the stimulus paired with a weak one. The findings suggest that habit strength in aversive conditioning varies with the intensity of the unconditioned stimulus.

In a number of experiments (*1*) concerned with the problem of whether habit strength (*H*) is a function of the intensity of the unconditioned stimulus (UCS), the conditioning performances of two different groups of subjects (*S*'s), equated for level of drive (*D*) but differing with respect to reinforcement conditions, were compared. The finding of a higher level of performance on the part of *S*'s that received a strong UCS on trials producing conditioning (that is, habit growth) as compared with *S*'s who were given a weak UCS on such trials was interpreted to mean that habit strength (*H*) varies with the level of intensity (noxiousness) of the UCS.

In the present experiment (*2*) we attempted to obtain further evidence on this problem by comparing the conditioning performances of a single group of *S*'s under two different reinforcement intensities. All *S*'s were conditioned concurrently to two different conditioned stimuli (CS's) (light and tone). Half of the *S*'s had the light paired with a strong UCS and the tone paired with a weak UCS. In the case of the other half of the *S*'s these relations were reversed, the tone being paired with the strong UCS and the light with the weak UCS. Our primary interest lay in a comparison of the level of conditioning performance to the CS paired with the strong UCS with that to the CS paired with the weak UCS. On the basis of the findings of the previous experiments and the interpretation offered by them, namely, that a greater amount of *H* is established to a CS paired with a strong UCS than to one paired with a weak UCS, it may be predicted that a higher level of conditioning performance will be made to the CS paired with the stronger UCS.

Twenty-four men and 24 women from an introductory course in psychology served as *S*'s in this experiment. Nine other *S*'s were eliminated, including three who met the criterion defining a voluntary responder (*3*), two who gave conditioned responses (CR's) to initial test trial presentations of the CS, and four who adapted to the air puff. An *S* was considered to have adapted to the puff if the mean amplitude of the unconditioned responses (UCR's) made on the last 10 trials involving the weak puff was less than 50 percent of that on the first 10 weak puff trials.

The apparatus was the same as that used in earlier studies (*1*) except for the addition of a 1000-cycle tone CS produced by a loudspeaker driven by a Hewlett-Packard oscillator.

Instructions and preliminary trials were similar to those of the previous studies. A variable (15, 20, 25 sec) intertrial interval was used, as well as a ready signal which preceded the onset of the CS by 2, 3, or 4 seconds.

Each *S* received 100 conditioning trials, 50 of which involved a tone CS and 50 a light CS. The two CS's were given in a prearranged sequence within which neither of the CS's occurred more than twice in succession. For half of the *S*'s the tone was always paired with a strong (2 lb/in.^{2}) puff and the light with a weak (0.33 lb/in.^{2}) puff, while the other half received the reverse pairing, a 0.33 lb/in.^{2} puff with the light and a 2 lb/in.^{2} puff with the tone. The CS-UCS interval was 500 msec, with the duration of the CS 550 msec and the duration of the UCS 50 msec. At the end of the experiment all *S*'s were questioned regarding their understanding of the purpose of the experiment and cautioned not to discuss the experiment with other members of the class.

Table 1. Summary of analysis of variance of frequency of CR's for trials 1 to 20 and 61 to 80.

Source	*df*	*MS*	*F*	*P*
Between *S*'s	47			
A B (b)	1			
Error (b)	46	14.94		
Within *S*'s	144			
CS (A)	1	40.33	11.86	.005
Puff (B)	1	44.08	12.96	.001
Trials (C)	1	752.08	191.37	.001
A C	1	3.01	1.11	> .200
B C	1	18.76	6.90	.025
A B (b) C	1	1.34	< 1.00	
Error W	138	3.35		
Error_1 W	46	3.40		
Error_2 W	46	3.93		
Error_3 W	46	2.72		
Total	191			

Acquisition curves in terms of the number of anticipatory CR's given to the CS paired with the strong UCS and to the CS paired with the weak UCS are shown in Fig. 1. As may be observed, the curve for the strong puff is consistently above the curve for the weak puff, with the difference gradually increasing during the course of conditioning. A summary of an analysis of variance, involving three within-subjects factors and one between-subjects interaction (*4*, p. 279, Type VII), based upon the first and last blocks of ten conditioning trials is presented in Table 1. As may be seen from the lower portion of this table, the differential effect of the UCS variable was highly significant, the obtained *F* providing a *P* value of .001. Also of interest is the fact that the interaction between the UCS variable and blocks of conditioning trials was significant ($P = .025$), thus indicating that the diver-

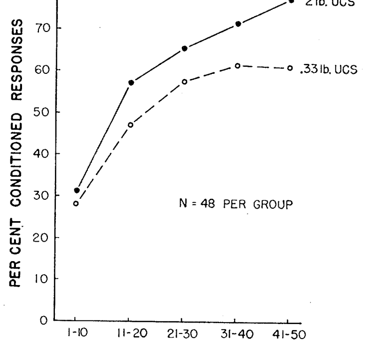

Fig. 1. Percentage of CR's in blocks of ten trials made to CS paired with 2-lb UCS and 0.33-lb UCS.

gence of the conditioning curves was not a chance one.

Further examination of Table 1 reveals that the CS variable—that is, whether tone or light—also significantly affected the level of conditioning performance. Indeed, this variable gave a slightly larger value of F than did the UCS variable. It will be observed, however, that the interaction term between CS and trial blocks was not significant. This implies that the acquisition curves for the tone and light did not diverge. Presumably the different performance in the case of the two CS's reflects Hull's stimulus dynamism variable, V.

The results of this experiment add still further evidence supporting the interpretation that habit strength (H) is a function of the intensity of the UCS. In the previous experiments (*1*) the performance of two independent groups of *S*'s whose drive level (D) was equated by employing two different puff intensities equally often was compared. It was found in every instance that the group which had the CS paired with the strong UCS exhibited a higher level of conditioning performance than did the group which had the CS paired with the weak UCS. The present experiment involves a comparison of the levels of conditioning to two different CS's, light and tone, established concurrently in the same group of *S*'s. Controlling for any possible effects of the two CS's per se, the analysis of the data of this experiment clearly shows that a higher level of response was given when the CS was paired with the strong UCS than in the case in which the CS was paired with the weak UCS. Since the two conditionings were within the same S, the level of D must have been the same and thus equal for the two CR's. This performance difference reflects, then, a greater development of H in the case of the conditioned reflex established with the stronger UCS.

As the number of conditioning trials in our several experiments concerned with this problem was not sufficient to reach the performance asymptote, one cannot infer for certain whether it is the maximum to which H grows that is related to intensity of the UCS, or whether it is the parameter determining the rate of approach of H to its asymptote. Examination of the curves from the several experiments, including Fig. 1 of the present study, suggests that it is the asymptote of H which is affected and not the rate-of-approach parameter.

In concluding, we should like to call attention once again to the fact that, while the findings of these studies may be interpreted as supporting the drive-reduction versions of reinforcement theory (*5*), we prefer to confine our interpretation to the more general conception that habit formation in such aversive types of conditioning is some function of the intensity of the UCS. Evidence with regard to the precise nature of the reinforcing mechanism in such learning requires other, presumably physiological, types of experimentation.

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Luminosity Curves of Normal and Dichromatic Observers

The question of the relative heights of the luminosity curves of normal and color-blind observers is an important one for theories of color vision, but one which has received very little investigation. If color blindness is due to the absence or inactivation of one or more of the normal retinal receptor-types, a color-blind observer should demonstrate a loss of luminosity in the spectral region to which the missing receptors would normally respond. If the missing receptors were replaced by receptors of a different type, it might be expected that a corresponding enhancement of luminosity would be demonstrable in the spectral region to which this type of receptor was responsive. Alterations in photopigment content of visual cells, substitutions or alterations in the photochemicals themselves, or abnormal retinal distributions of the receptor-types or their neural connections would similarly be expected to produce corresponding luminosity losses and gains. Thus, comparative studies of the luminosity curves of color-defective observers should provide some of the facts necessary, but not yet available, for evaluation of the various theories of color blindness.

Unfortunately, conventionally determined relative luminosity curves provide no basis for direct interobserver comparison of luminosities, since there is no assurance that the standard light to which each test wavelength is matched appeared equally bright to each observer. Abnormalities in the shapes of such curves could be the result of luminosity losses, or gains, or both.

In an attempt to make the desired interobserver comparisons, Hecht and Hsia in 1946 (*1*) determined the relative energy levels of the foveal thresholds of several protanopes, deuteranopes, and normals, for five colors in a 1-deg test field. Plotting relative threshold sensitivities (reciprocals of relative energy) versus wavelength, and measuring the areas under these "luminosity curves," Hecht and Hsia concluded that protanopes lose 49 percent and deuteranopes lose 39 percent of the luminosity of an equal-energy spectrum. Very recently, Hsia and Graham (*2*) repeated these measurements with other subjects. Though their findings differed markedly from those of the earlier study, they nevertheless concluded that there was basic agreement inasmuch as both investigations showed luminosity losses for deuteranopes as well as for protanopes.

One objection to this procedure lies in the fact that the comparisons of observers were made only at the threshold of vision in the dark-adapted eye but were interpreted in terms of photopic luminosities. The stimuli may have been confined to foveal cones [though a 1-deg test spot probably covers about four times the area of the "rod-free" region of the fovea (*3*)], but even this does not permit the inference that photopic brightnesses are in the same relation to each other as are foveal thresholds, either when different wavelengths are compared for a single observer or when different observers are compared at a single wavelength. To afford a basis for photopic comparisons, the use of a photopic visual function would be preferable to the threshold of cone vision as the criterion of equality of brightness. The criterion employed in the present study was equality of the critical frequency of flicker-fusion (CFF) (*4*).

Nine normals, six deuteranopes, and five protanopes served as subjects. The flicker apparatus presented a 5-deg test field (*5*) in Maxwellian view to the subject, who was positioned by means of a mouthbite containing his dental impression. Fourteen narrow spectral regions were isolated as test lights by means of interference filters combined with gelatin filters. Luminance of the test field was varied by neutral filters and a neutral wedge. For these experiments four frequencies of intermittence of the test light were used: 20, 25, 30, and 40 flashes per second, with a light-dark ratio of 1:1. The subject varied the luminance of the test field until flicker was just eliminated—that is, he set the neutral wedge so that the slightest in-