cultures was established by inoculating tenfold dilutions into ten mice per group and found to be 1×10^3 LD_{50} per milliliter (lethal dose effective for 50 percent of the animals) of medium for both cultures.

Proteolytic biochemical activity of the cultures, first noted in cooked meat medium, was further tested on iron milk, gelatin, and coagulated egg albumin media. All four media were digested by the organisms, thus indicating the presence of proteolytic enzymes.

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Color: A Motion-Contingent Aftereffect

Abstract. *After human observers alternately view green stripes moving up and red stripes moving down for periods of ½ to 4 hours, they see a pink aftereffect when white stripes move up and a green aftereffect when white stripes move down. Longer exposures produce aftereffects which are visible 20 hours after stimulation. Thus, experience which pairs simple attributes (color and motion) of visual stimulation can result in a lasting modification of perception.*

McCullough (*1*) described negative color aftereffects, dependent on the orientation of lines in the test field, which were obtained by presenting a horizontal grating of one color alternately with a vertical grating of another color. These color aftereffects are orientation specific and persist for 1 hour after brief adaptation exposure periods.

The experiments reported here pair stimulus attributes of color and motion to produce color aftereffects which are motion contingent. An observer alternately views green stripes moving up and red stripes moving down on a black ground. When the stripes are later illuminated by tungsten (white) light, he perceives a color aftereffect which is direction specific; white stripes appear pink when they move up and green when they move down. These color aftereffects may persist for 20 hours (*2*).

Seven male and nine female university students who had no experience with visual aftereffects were paid observers. All had uncorrected normal vision without anomalies of color perception when tested with OSA pseudoisochromatic plates. While fixating the center of a moving grid with his head positioned in a chin rest, each observer viewed red stripes moving in one direction and green stripes moving in the opposite direction. A grid of 3-mm stripes was seen moving up or down at 2 degrees visual angle per second. A black mask restricted the grid area to 6.3 by 7.6 degrees visual angle at viewing distance of 83 cm. Magenta and yellow-green filters (*3*) provided the colors paired with ascending and descending motion. When these filters were placed in a projector behind the grid, the observer saw transilluminated colored stripes moving on a black field in the dark test room. Integrated visible transmission values were 35.6 percent for the magenta filter, 49.4 percent for the yellow-green filter, and the luminance of the grid in white light was 232 mlam. A timing circuit alternated color filters and reversed the direction of the motor powering the grid every 5 seconds. Each exposure period of alternating stimulation continued for 24 to 33 minutes.

Table 1. Color paired with motion: minutes of exposure required to produce color aftereffects which were direction-specific and visible immediately and 20 hours after stimulation. R, red; G, green; arrows indicate direction of motion.

Exposure condition		Time (min)	
		Immediate test	Delayed test*
R↑	G↓	198	192
R↑	G↓	132	501
R↑	G↓	231	384
R↑	G↓	120	48
G↑	R↓	33	288
G↑	R↓	33	312
G↑	R↓	216	216
G↑	R↓	120	216
		mean=135	mean=270

*$N = 8$ in both immediate and delayed groups.

Eight of the 16 observers were tested immediately after each exposure period. They judged the appearance of the moving stripes seen in white light from the projector bulb (3200°K). After repeated periods of exposure on successive days (one period per day), all observers reported that they clearly saw a negative color aftereffect specific to each direction of motion. They reported no colors when the grid remained in a stationary position. Data in Table 1 show that an immediate test produced reliable reports of color aftereffects that were direction specific when observers had experienced a mean of 135 minutes (2.3 hours) of paired stimulation.

To determine whether a persistent change had been produced, eight of the observers were not tested until 20 to 27 hours after each exposure period. (These observers did not judge the appearance of moving stripes immediately after exposure since a decision made at that time might have influenced their delayed reports.) At this delayed test interval [after a mean of 270 minutes (4.5 hours) of exposure to paired stimulation (Table 1)], observers saw color aftereffects which were direction specific. They did not see lasting colors after shorter exposure periods; perception of persisting color aftereffects required about twice as much experience as perception of similar aftereffects seen immediately after stimulation.

Test instructions simply requested a description of the moving stripes and did not mention the possibility of a color aftereffect. However, observers may have expected to see a color difference. A naive observer might easily think that he should report the color that was originally paired with a particular direction. Instead, all observers reported negative color aftereffects, and it seems unlikely that they could have known which color should be associated with a particular direction of motion. Another explanation is that paired exposure in these experiments associated perception of different colors with distinctive patterns of eye movements elicited by ascending and descending motion. Color adaptation, and the resulting complementary aftereffect,

would be contingent upon such eye movements. But this interpretation relies on Kohler's (*4*) report of color conditioning that was gaze contingent, and recent attempts (*5*) have failed to replicate his original observations.

In electrophysiological research (*6*) neurons in the visual system of the monkey that respond to moving contours have been described. These motion detectors have preferred directions. Psychophysical experiments (*1*) suggest that similar cells exist in the human visual system. In the present experiments, different populations of motion detectors would respond to ascending and descending motion. It is possible that the motion-detector cells show color adaptation to the wavelengths paired with their preferred direction. After adaptation the cells would remain more sensitive to other wavelengths, and in white test light, these adapted cells would signal a color complementary to the adapting color. This neurophysiological process could underlie observers' reports of negative color aftereffects specific to a particular direction of motion.

In these experiments cumulative, spaced stimulation was used to produce lasting color aftereffects. Such experimental conditions typically result in habituation, the conditioned inhibition of sensory responses (*8*). Persisting color aftereffects which are motion contingent may be the result of this conditioning process (*9*).

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9. Recent unpublished observations by C. McCollough, Oberlin College, and C. Stromeyer, Harvard University, confirm the existence of color aftereffects which are motion-contingent and similar to those reported here.
10. Supported by a Canadian National Research Council grant to D. C. Donderi.

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Hypothalamic Motivational Systems: Fixed or Plastic Neural Circuits?

Abstract. *Eating and drinking were elicited by electrical stimulation through the same electrode in the hypothalamus of a satiated rat. Intensity thresholds for eliciting eating and drinking were different, and both thresholds decreased with repeated testing. These findings suggest an alternative to the hypothesis that the neural organization of hypothalamic drive systems is modified by experience.*

In the rat, eating and drinking are mediated by the same general "feeding area" of the lateral hypothalamus. Lesions in this area usually produce both aphagia and adypsia (*1*), and both eating and drinking can be elicited by electrical stimulation in the area (*2*). On the other hand, the relative independence of the neural mechanisms of eating and drinking is shown by the fact that chemical stimulation through a given cannula in the feeding area produces either eating or drinking, depending on the nature of the chemical agent used (whether it is adrenergic or cholinergic) (*3, 4*). Thus, it appears that eating and drinking involve neural drive systems that are interwoven anatomically, but whose functional independence is preserved by chemical coding. While such a view is widely accepted, it has been recently challenged by Valenstein, Cox, and Kakolewski (*5*). They question the existence of fixed and stable neural drive systems, and suggest that the function of hypothalamic drive structures can be modified by experience. I now present data which show that the findings of Valenstein *et al.* do not require such an interpretation.

The proposal of Valenstein *et al.* (*5*) is based on their finding that electrical stimulation of a particular site that initially elicits only one response (for example, eating) can come to elicit a different response (for example, drinking) as a function of experience. In their study, animals with electrodes in the lateral hypothalamic area were electrically stimulated in a cage where food, water, and wooden wedges were available. The intensity of the stimulation was gradually raised until it reliably elicited eating, drinking, or gnawing. Stimulation intensity was fixed at this level, and then the objects appropriate to the observed response were removed (for example, if the response displayed by the animal was eating, food was removed from the cage). Stimulation was then continued on an overnight schedule with only the other two materials present (that is, water or wooden wedges). After several nights of such stimulation, a second stimulation-bound response, appropriate to one of the remaining objects, emerged. When the animal was restimulated in a situation with all three stimulus objects once again present, this second response (gnawing or drinking) was found to be about as likely to occur as the original response (eating). Valenstein *et al.* seem to interpret this finding as evidence that the hypothalamic drive systems are plastic in that the drive-specificity of particular cell populations can be altered by learning.

An alternate hypothesis is that, in experiments involving electrical stimulation of lateral hypothalamic sites, fixed and stable independent drive systems are simultaneously activated, and that stimulation experience merely changes the thresholds of the different systems without altering the functional organization of any. My study was designed to test this hypothesis.

Monopolar electrodes were implanted in the lateral hypothalamus of 23 adult albino rats of the Wistar strain (*6*). The electrodes were stainless steel wires (0.010 inch in diameter) insulated with lacquer and cut off square at the tip. Electrode connectors were imbedded in dental cement anchored to four stainless steel screws in the skull. A skull screw over the olfactory bulb served as an indifferent electrode.

One week after surgery, subjects were screened in preliminary testing for stimulation-bound behavior. Each rat was placed in a box with free access to food and water, and its electrodes were connected with flexible wire leads to an electrical stimulator. The rat was stimulated with 60 hz sine-wave pulses 20 seconds long with a 20-second interval between stimulation periods. Intensity of the stimulation was 5 μa on the first stimulation and was increased slowly until stimulation-bound eating or drinking or an aversive response was observed, or until an intensity of 100 μa was reached. Eight subjects showed stimulation-bound eating or drinking; only these subjects were used in further testing.

Next, intensity thresholds were determined. Each subject was placed in a box