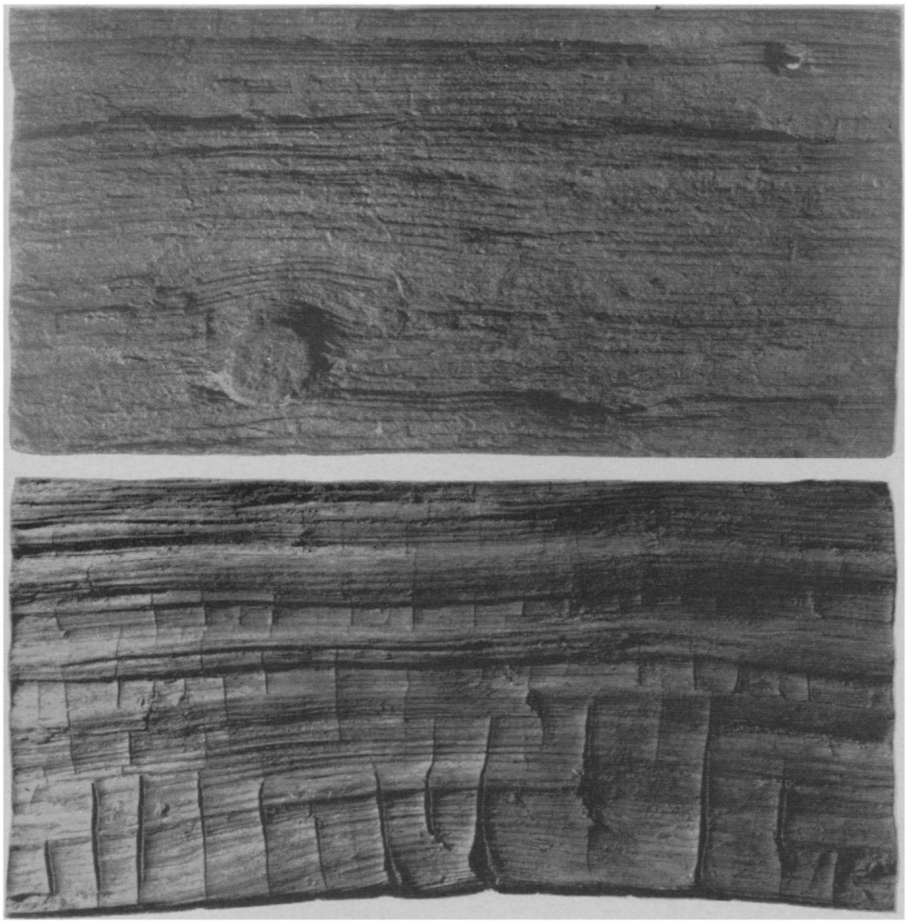

Fig. 1 Treated (top) and untreated (bottom) sections of a waterlogged white pine board (200 to 300 years old) raised from Lake George. The treated section was soaked for 1 week in 50-percent polyethylene glycol, then air-dried. The untreated section was air-dried.

checking was markedly reduced by treatment, regardless of the duration (4 hours to 7 days). The soaking period that will give the desired reduction in shrinkage and checking of the specimen depends on the size of the wood pieces and on the extent of wood decay.

The effect of polyethylene glycol treatment on face checking is clearly shown in Fig. 1. The top part shows a section of a white pine board that was soaked for 1 week in 50 percent polyethylene glycol and then air dried. No noticeable checking occurred during drying. The picture at the bottom shows the severe checking of an adjacent section that was air-dried from the waterlogged condition without treatment.

This study was limited to treating wood with polyethylene glycol having a molecular weight of 1000. Wood treated with polyethylene glycol-1000 becomes damp under high moisture conditions (above 80 percent relative humidity) and tends to "bleed" or "sweat" at 90 percent relative humidity (*3*). Polyethylene glycol of a molecular weight greater than 1000 may have a slight advantage for treatment of wood because it is somewhat less hygroscopic than that we used. For wood decayed to the extent that it is difficult to handle without crumbling, polyethylene glycol of a higher molecular weight may also have the advantage of imparting greater rigidity to the wood. The reduced solubility of polyethylene glycol with a higher molecular weight can easily be overcome by a moderate increase in temperature.

Processing of the actual bateaux was started in the field in the summer of 1961. The bateaux were kept under wet sawdust during the winter of 1960–61. A wooden tank big enough to contain the largest section of a bateau was constructed and lined with a sheet of polyethylene. Polyethylene glycol-1000 in a 50-percent aqueous solution was used for treatment. Half sections and planks were soaked for 3 days and then removed for drying. In over 3 months' drying time a minimum of hair-like surface cracks developed. The wood remained slightly damp to the touch, but has become firmer and is less susceptible to damage than it was when it was removed from the water. No shrinking or change of shape is apparent.

The treatment thus proved to be very valuable. Before treatment, these bateaux had to be handled with utmost care and constantly supported throughout their length and breadth. Slight pressure caused compression and subsequent collapse of cells. After treatment, however, it is now possible to handle these craft and reconstruct their lines.

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15 December 1961

Acquisition and Extinction of the Classically Conditioned Eyelid Response in the Albino Rabbit

Abstract. Comparisons of the performance curve of a classical conditioning group with the curves of control groups provided unequivocal evidence that elicitation of eyelid responses to the conditioned stimulus was acquired by associations formed between the conditioned stimulus and the unconditioned stimulus.

The eyelid reflex elicited by stimulation of the cornea is a prompt, stable response which does not appear to show qualitative variations in different mammals (*1*). Nevertheless, the literature on eyelid conditioning contains few references to infrahuman species (*2*) and none on the rabbit. Yet the albino rabbit, because of its docility, large eyelid, and low spontaneous blink rate appears to be particularly suited for classical studies of eyelid conditioning.

The conditioning apparatus we employed has been described in detail (*3*), but it was modified for the present study to accommodate rabbits. In the experimental sessions the rabbit was restrained within a Plexiglas box 9 inches long, 4 inches wide, and 8 inches high. Gross head movements were reduced by placing the rabbit's head through an adjustable stock comprising the front of the box and by placing restraining straps above the snout and across the head. Positioned 9 inches in front of the rabbit was a 6-inch speaker and a rod supporting an air jet and spring-return potentiometer. A silk thread was attached to a rod mechanically coupled at 90 degrees to the shaft of the potentiometer; and a Velcro tab connected to the other end of the silk thread was attached to the rabbit's right upper eyelid by meshing with a permanently set Velcro countertab glued to the upper lid. The signal from the potentiometer, generated by movement of the eyelid, was amplified and then recorded by an inkwriting penmotor. Electronic timers controlled the duration of the conditioned stimulus (600 msec) and unconditioned stimulus (100 msec), and the interval between these stimuli (500 msec). The conditioned stimulus (CS) was an 800-cy/sec tone of 72 db SPL, and the unconditioned stimulus (UCS) was an 80-mm puff of compressed nitrogen delivered to the dorsal region of the right cornea. To insure continual exposure of the cornea, the rabbit's right lower eyelid was taped open.

Forty albino rabbits, 85 to 90 days of age, were assigned to one of four groups for 8 days of acquisition training and 3 days of experimental extinction. In acquisition, one control group received the CS alone (group CS-A), another received the UCS alone (group UCS-A), and a third control group (group R) received random presentations of the CS alone (CS-R) and the UCS alone (UCS-R). The fourth group (group CS-UCS) was the classical conditioning group and received paired presentations of the CS and UCS at a CS-UCS interval of 500 msec. Groups CS-UCS, CS-A, and UCS-A consisted of 12, 10, and 10 rabbits, respectively, and received 82 acquisition trials per day at randomized intertrial intervals of 15, 20, and 25 seconds (mean 20 seconds). Group R consisted of eight rabbits and received 82 CS alone and 82 UCS alone trials. The random presentation of CS alone and UCS alone trials was restricted within two trial blocks, and the intertrial intervals were randomized at 5, 10, and 15 seconds (mean 10 seconds). In extinction, all groups received 82 CS alone trials per day at randomized intertrial intervals of 15, 20, and 25 seconds (average 20 seconds).

In acquisition all eyelid closures of at least 1-mm deflection from the baseline were recorded from 0 to 525 msec after initiation of the trial. In extinction the interval was extended to 600 msec. Figure 1 presents the results of plotting percentage of responses for group CS-UCS in acquisition and extinction. Multiple *t*-test comparisons of mean percentage of responses among the control groups revealed no significant differences in acquisition or extinction; and their performance curves are presented collectively in Fig. 1 by hash lines indicating the upper boundary of percentage of responses. The percentage of acquisition responses among the control conditions did not increase over days, and never exceeded a 4.5 percent level of responding exhibited by the UCS-R condition on day 3. In contrast, group CS-UCS demonstrated a steady increase in percentage of conditioned responses and attained a level of 71 percent on day 8. Although the function is S-shaped, there is little evidence that asymptotic performance had been attained. A *t*-test comparison of mean percentage conditioned responses of group CS-UCS on day 1 and day 8 was highly significant ($P < .001$); and an analysis of trend revealed a significant linear ($P < .01$) and cubic component ($P < .05$). The significant linear trend indicates that the percentage of conditioned responses increased over days, and the significant cubic trend indicates that the S-shaped function was reliable. In extinction, the mean percentage of conditioned responses in group CS-UCS went from 36 percent on block 1 to 9 percent on block 6; whereas, among the control groups, the mean percentage of responses never exceeded 0.5 percent on any block of trials.

The major purpose of our study was to investigate the possibility of classically conditioning the eyelid response in the rabbit. The performance curves in Fig. 1 indicate that the course of acquisition and extinction of responses in group CS-UCS cannot be attributed to changes in spontaneous blink frequency resulting from UCS presentations (group UCS-A), pseudoconditioning or sensitization (condition CS-R of group R), or alpha (reflex) responses elicited to the CS (group CS-A). Consequently, unequivocal evidence has been provided to indicate that elicitation of eye-

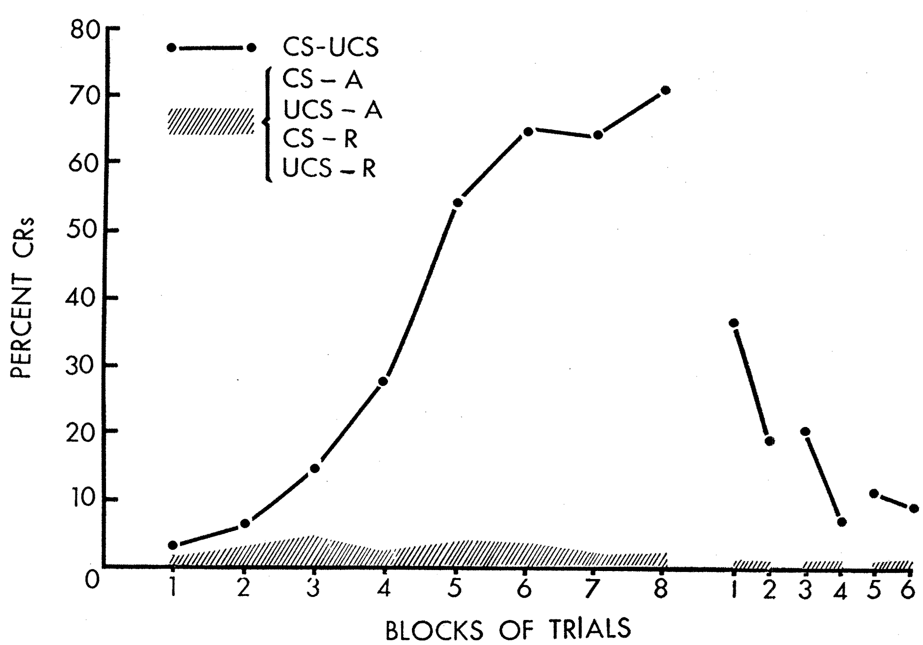

Fig. 1. Mean percentage of responses plotted in 82 trial blocks during acquisition and 41 trial blocks during extinction.

lid responses to the CS by group CS-UCS had been acquired by associations formed between the CS and UCS (*4*).

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24 November 1961

Countercurrent Streaming in Liquid Surfaces and Its Relevance to Protoplasmic Movements

Abstract. Movements of surface films counter to the interior stream are brought about by film pressure generated by surface tension gradients. In a similar process, the formation of new interfaces during protoplasmic syntheses could sustain gradients of interfacial tension with resulting protoplasmic movements.

Biologists are familiar with movements of contiguous protoplasmic constituents in opposite directions (*1*). Some simple but fascinating hydrodynamic systems that produce similar effects and may have a general bearing on protoplasmic movements are presented in this report.

If a propulsive mechanism is assumed at some region along the longitudinal axis of a closed, fluid-filled system, a flow pattern like that depicted in Fig. 1(*a*) follows from the continuity equation. Similar flow patterns, "fountain streaming," have been observed in amebas (*2*). Such patterns of flow can also occur in essentially open systems. The surface forces that are responsible can produce an amazing diversity of phenomena but have received little recent notice in connection with biological problems.

Working models are produced by allowing a stream of water from a nozzle to flow down an inclined plane into a vessel. As long as the stream flows without obstruction and runs off the bottom edge of the plane, the flow remains essentially unidirectional (Fig. 1, *b*). However, when fluid accumulates in a pool at the edge, or when the stream emerges directly into the water in the vessel, separation of flow and backflow of the peripheral surfaces occurs. A countercurrent circulation with sharp boundaries of flow separation is initiated (Fig. 1, *c*). Peripheral surface film is transferred centrally by convergence at the upper boundaries of the vortices. Central surface film either reenters the peripheral streams at the region of emergence over the static body of water, or returns after traveling out over the water. A large portion of the surface can become involved in the circulation.

These surface movements are readily visualized with powdered charcoal. Particles at the surface are seen to flow in opposite directions along adjacent paths, as indicated in rough schematic outline in Fig. 1 (*c, d, e, f, g*). If an outer loop (or a network) is created at the periphery, surface film travels out into the loop and rejoins the main circulation upstream (Fig. 1, *f*). But the loop stream itself travels in the opposite direction and joins the mainstream downstream. When particulate matter moving downstream in the interior is viewed through the countermoving surface film, also carrying particulate matter, particles moving in opposite directions seem to be threading their way between one another. The same impression is gained on microscopic examination of countermoving particulate matter in protoplasm, where depth of focus permits simultaneous viewing of particles both at and between interfaces.

If a stream is confined between two plates, the vortical circulations are limited to the menisci but are greatly accentuated. Even at relatively high flow rates, countermoving peripheral surface film travels from distant regions to the nozzle. Surface particles transfer to the interior at points where the meniscal film is broken. Sometimes they become trapped between the counterflowing surface films, where they spin like tops.

These effects occur over a wide range of flow rates and also take place on horizontal surfaces. A leisurely countercurrent streaming has been set up in a narrow, almost horizontal, stream 15 inches long; convergence of peripheral surface film into the mainstream tends to occur in regions where an appreciable velocity gradient is created by narrowing of the stream, or obstructions cause the peripheral flow to deviate centrally.

These phenomena do not depend on the presence of particulate matter or gas-liquid interfaces. Vortical surface circulations occur to some degree even in double glass-distilled water, on the surface of which camphor will "dance" actively; bits of dust reveal the existence of the circulations. Patterns of movement in water are influenced by rate of flow, extent of the wetted area, obstructions (Fig. 1, *f*), and other factors. The lower the surface tension and slower the flow, the greater the distance over which countercurrent streaming occurs.

It seems clear that the forces responsible for counter movement of surface film in these systems are transmitted longitudinally within the film. Since this cannot take place in the surface of pure water (*3*), the phenomenon

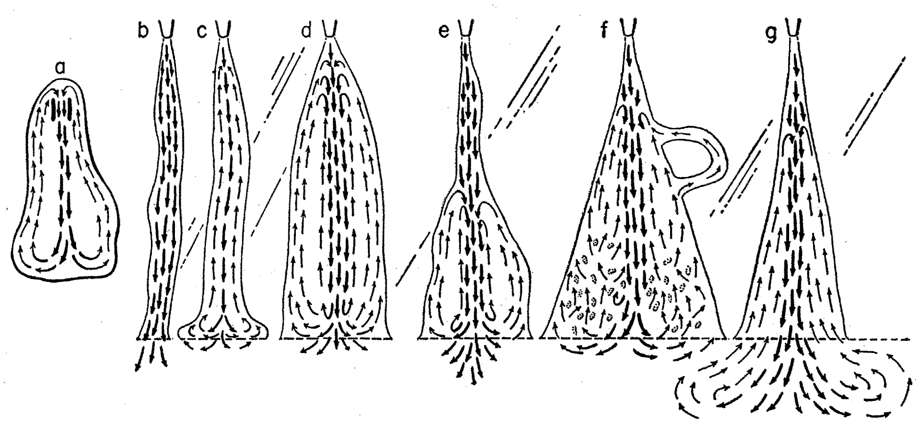

Fig. 1. Models of countercurrent streaming. In *b, c, d, e, f,* and *g* the dashed base line represents the edge of the inclined plane and (in *c, d, e, f,* and *g*) the water level in the vessel. The pattern of *e* occurs either at a greater flow rate or smaller surface tension gradient than that of *d*. A speck of detergent, by lowering the surface tension and increasing the surface tension gradient, converts the circulation of *e* to that of *d*.