"Conditioned" Alpha Desynchronization

Abstract. Results casting doubt on the reported findings of Wells and Wolff on conditioned alpha desynchronization are presented. The experimental findings indicate that these authors were most likely dealing with the phenomenon of adaptation to a complex stimulus. These results are compared to similar phenomena in the conditioning of the galvanic skin response.

In a recent article Wells and Wolff (*1*) speak of the development of conditioned cerebral responses which were "considered to have occurred when the alpha rhythm was obliterated or strikingly depressed following the presentation of the tone and before the appearance of the light." In view of the results obtained by Knott and Henry in 1941 (*2*) and by Wells and Wolff (*3*), we seriously question whether the latter authors demonstrated development of a conditioned cerebral response in their more recent report (*1*).

We replicated the experimental conditions described by Wells and Wolff, the only difference being the presentation of tone through a speaker rather than through earphones. "Conditioning" consisted of the presentation of a tone (500 cy/sec approximately 40 db above level of audibility) for 4 sec, with light stimulation during the last 3 sec of tone. In our experiment 12 naive subjects were presented with 20 trials of tone stimulation (adaptation) prior to the 50 conditioning trials. The results of only ten subjects could be used, two subjects showing consistent tendencies to drift off into dreamland that could not be checked by instructions for them to remain relaxed but awake.

Alterations in alpha activity (bipolar parieto-occipital leads) were evaluated during the 1 sec of tone stimulation and during the first second of tone coupled with photic stimulation. In all cases alpha activity was compared with that observed during the second preceding the start of tone stimulation. Alpha desynchronization was recorded if amplitude of alpha activity during stimulation fell below that during the preceding period, or if alpha desynchronization (LVF) appeared, or if both occurred. Alpha enhancement was tallied if the amplitude of alpha activity was enhanced during stimulation or if during stimulation alpha actively appeared against a background of either low voltage fast (LVF) or "drowsy" activity.

Figure 1 shows the results of this experiment. Twenty trials of tone stimulation produce some adaptation of the alpha desynchronization response, although adaptation is far from perfect at this time. If trials demonstrating alpha enhancement are excluded from the analysis, 69 percent of the first five trials show desynchronization, 58 percent during trials 6 to 10, 54 percent during trials 11 to 15, and 45 percent still show desynchronization during the last five trials. The greater degree of desychronization found in this experiment than in the work of Knott and Henry (*2*) is attributed to the higher intensity of tone stimulation used in the present experiment. Knott and Henry used a tone just above the auditory threshold of their subjects. Wells and Wolff presented no data on the adaptation portion of their experiment, except for the statement that tone was "repeatedly presented until at least five successive tone presentations failed to suppress alpha activity."

When tone and light are paired we observe enhanced alpha desynchronization during the first five trials (as compared with the last five adaptation trials). The "conditioning" curve, however, looks more like an adaptation than a conditioning curve. There is a relatively consistent drop in the alpha desynchronization response to tone going from early to later trials. Additional evidence in support of the view that this response is an adaptation response to a new stimulus complex (tone and light as compared with tone alone) is obtained from the curve depicting the response to light stimulation, to which some adaptation also occurs. The two curves are identical in inflection nine out of ten times, that is, as one curve goes down so does the other, as one goes up so does the other. Since the response to light is the unconditioned response, a decrease of which can only be attributed to adaptation, it would appear more parsimonious to refer to the changes in alpha desynchronization during "conditioning" as adaptation to a new stimulus complex. The results of recent studies on galvanic skin response conditioning by Stewart *et al.* (*4*) and Stern *et al.* (*5*), demonstrating a return of the adapted-out response when it is paired with a new stimulus, would thus also hold for alpha desynchronization conditioning. Knott and Henry have referred to this phenomenon as "sensitization," while the latter authors have referred to it as the return of the "orienting response." Insofar as alpha desynchronization can be considered an "orienting response," the results ob-

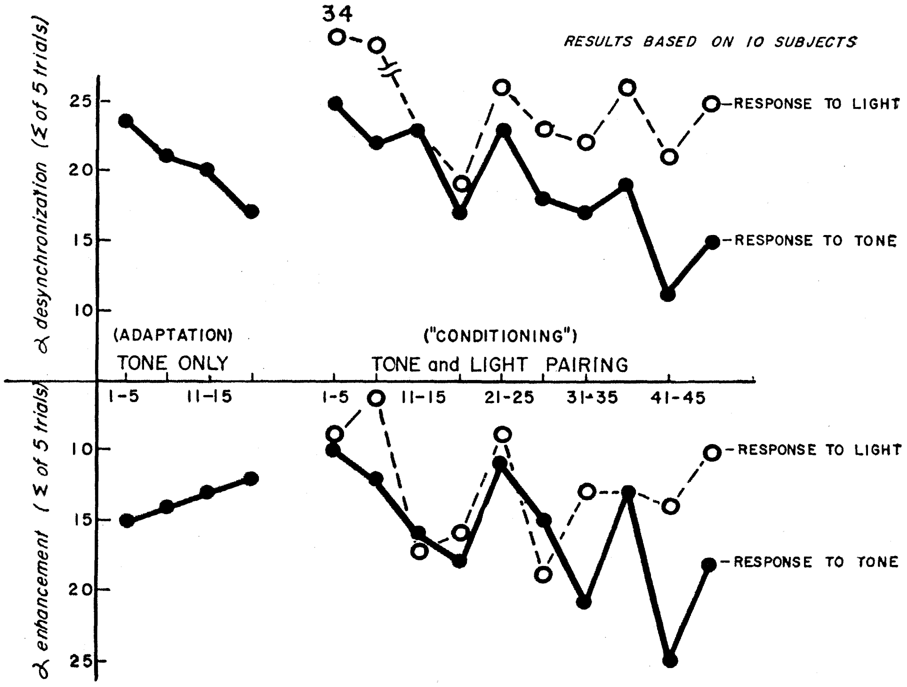

Fig. 1. Effect of tone stimulation and "conditioning" on alpha activity. The upper portion of the graph demonstrates alpha desynchronization in response to stimulation, while the lower portion is for alpha enhancement. (The maximum possible number of responses per unit is 50 to 10 subjects, five trials per subject.)

tained for galvanic skin response "conditioning" are also applicable to alpha conditioning.

If our interpretation of these data is correct, we would predict that if one measured speed of adaptation to tone stimulus alone, one should find that brain-damaged and chronically anxious patients should show adaptation to tone stimulation more rapidly than is true of control subjects. Experiments are presently under way to test this hypothesis.

Analysis of alpha enhancement is depicted in the lower portion of Fig. 1. A rise in the curve is indicative of increasing alertness; a drop, of increasing drowsiness. This interpretation is based on the finding that alpha enhancement or appearance of alpha activity in response to stimulation occurs only in drowsy subjects (*6*). During the 20 trials of tone stimulation, we see a consistent increase in alertness, while during "conditioning" there is consistent decrease of alertness, or a lapse into a drowsy state, despite instructions on the part of the experimenter aimed at keeping the subject alert and awake. The lack of parallelism between the curves demonstrating alpha enhancement to tone and to light (paired with tone) is attributed to the facts that (i) where there is alerting to tone, further alerting to light is not probable, since the period of analysis for light stimulation immediately follows that of tone stimulation, and (ii) since light is a more potent stimulus for producing alpha desynchronization, it is thus possible for a person to go from a drowsy record to an alert one with minimum or no evidence of alpha activity.

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References

1. C. E. Wells and H. G. Wolff, *Science* **131**, 1671 (1960).
→ J. R. Knott and C. E. Henry, *J. Exptl. Psychol.* **28**, 134 (1941).
3. C. E. Wells and H. G. Wolff, *Neurology* **10**, 335 (1960).
→ M. A. Stewart, J. A. Stern, G. Winokur, S. Fredman, *Psychol. Rev.* **68**, 60 (1961).
→ J. A. Stern, M. A. Stewart, G. Winokur, *J. Psychosomat. Research* **5**, 215 (1961).
→ G. C. Lairy-Bonnes and H. Fischgold, *Electroencephalog. and Clin. Neurophysiol.* **5**, 343 (1953); E. P. Adrian, *Nature* **153**, 360 (1944).

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New Arrangement of Interrenal and Chromaffin Tissues of Teleost Fishes

Abstract. An unusual morphologic arrangement of interrenal and chromaffin tissues has been observed in two families of teleost fishes. In most teleosts in which these cell types occur together in association with the postcardinal veins and their branches, the chromaffin cells are located between the lumen of the vein and the interrenal cells. This typical relationship is reversed in some of the Labridae and Scaridae.

The interrenal gland of teleost fishes, located within the anterior or head kidney, appears to be homologous to the adrenal cortex of mammals (*1, 2*). Chromaffin cells like those of the adrenal medulla, which react with chromic acid, are also found in the anterior kidney. These cell types were delineated first by Giacomini in 1902 (*3*); since then the interrenal and chromaffin tissues of about 80 species of teleosts have been described (*1, 4, 5*).

In order to extend these observations, over 125 species from 55 teleost families were collected from a variety of habitats (*6*). The anterior kidneys of these animals were fixed either in Bouin's or in Orth's (*7*) fluid. The latter fixative contains potassium dichromate, and was used to determine the distribution of chromaffin cells.

The interrenal morphology is extremely variable in these fishes. Furthermore, the surrounding tissues may be lymphoid or myeloid or both, and may or may not contain renal elements (*2*). The relationship of the interrenal to these tissues is also variable. Usually the interrenal is associated with the postcardinal veins or their branches or both, which ramify through the anterior kidney tissue. Chromaffin cells are always located within the walls of these veins. Often the interrenal and chromaffin tissues are separate, although more frequently there is some type of association between them.

When interrenal and chromaffin cells occur together around the veins within the anterior kidney, one of several possible arrangements may be found. The chromaffin tissue may be interspersed among the interrenal cells, as in the Cyprinidae and Cyprinodontidae (*5*). In the Gasterosteidae (*5*), clumps of interrenal alternate with clumps of chromaffin cells, the entire complex forming a cuff around the lumen of the postcardinal vein.

More often only the chromaffin cells are seen within the walls of these veins, either adjacent to the endothelium or embedded within the connective tissue of the vein wall. The interrenal is found external to both the vein wall and its associated chromaffin tissue. Such an arrangement is illustrated in Fig. 1 (*A, B*), which shows the interrenal and chromaffin tissue of a butterfly fish, *Chaetodon miliaris*. Even in the truly interspersed glands mentioned above, the chromaffin cells tend to be located closest to the vein lumen.

During the course of this investigation, an unusual arrangement of the interrenal and chromaffin tissues was seen. This arrangement has not been described previously, and has been observed only in fish from two closely related families: the Labridae (wrasses) and the Scaridae (parrot fishes). In some of these animals, the interrenal cells were found immediately adjacent to the endothelium of the veins, as a single layer of columnar cells. The

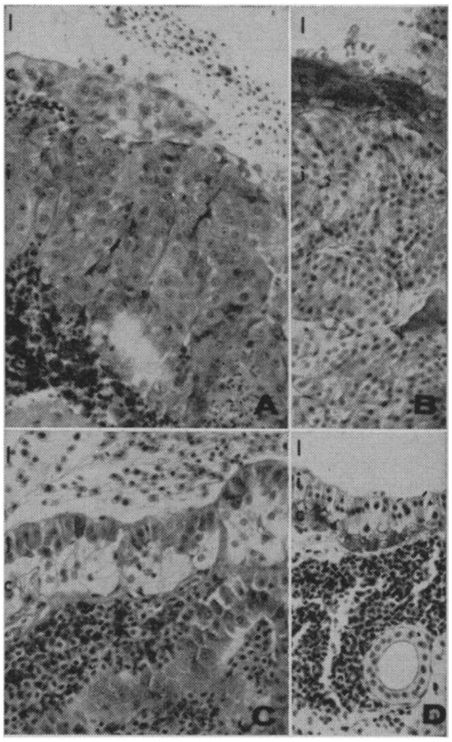

Fig. 1. Interrenal and chromaffin tissues associated with a branch of the postcardinal vein within the anterior kidney. Tissues were stained with hematoxylin and eosin; magnification is × 365. (*A*) *Chaetodon miliaris*, Bouin's fixation. (*B*) *Chaetodon miliaris*, Orth's fixation. (*C*) *Cheilinus rhodochrous*, Bouin's fixation. (*D*) *Cheilinus rhodochrous*, Orth's fixation. Abbreviations: *i*, interrenal cells; *c*, chromaffin cells (the positively reacting chromaffin cells appear dark after Orth's fixation); *l*, vein lumen.