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Hydrocortisone Reduces Auditory Sensitivity at High Tonal Frequencies in Adult Males

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BECKWITH, B. E., K. LERUD, J. R. ANTES AND B. W. REYNOLDS. *Hydrocortisone reduces auditory sensitivity at high tonal frequencies in adult males.* PHARMACOL BIOCHEM BEHAV 19(3) 431–433, 1983.—The present study was designed to investigate the effects of treatment with cortisol on auditory tonal detection. College males were given either 20 mg of hydrocortisone or a placebo (dextrose) in a double blind design. Thereafter, thresholds were determined for frequencies of 500, 1,000 and 4,000 Hz using the method of limits. These results were then converted to change scores by using thresholds obtained for the same subjects at the same frequencies prior to treatment. Planned comparisons indicated that treatment with cortisol reduced sensitivity at 4,000 Hz but had no effects at other frequencies. Also, an overall analysis of variance indicated greater right ear improvement and greater improvement at lower frequencies. These findings are explained as resulting from the ability of glucocorticoids to alter cellular metabolism or reduce levels of adrenocorticotropic hormone.

Auditory threshold Hydrocortisone Neuroendocrine Perception

IT HAS been believed for some time that mood states are modulated, in part, by adrenocortical secretions [4]. Furthermore, the hypothalamopituitary adrenocortical system appears to be activated by the expectancy of an event's occurring as opposed to the actual event occurrence [10,13]. Therefore, one might expect that the adaptive significance of this system may to some extent be involved in cue utilization and perception. Recent evidence has indicated that, indeed, pituitary peptides do modulate cue utilization (i.e., attention) [1, 2, 3] and that adrenocortical glucocorticoids influence perception [5,6].

Henkin, [5,6] has extensively studied the effects of cortisol on perception by utilizing patients with Addison's Disease (hypoadrenocorticalism) and Cushing's Disease (hyperadrenocorticalism). His basic finding has been that sensory detection thresholds in the former are greatly reduced whereas sensory detection thresholds for the latter are greatly elevated. This sensory change has been noted for sensations of taste, smell, touch, proprioception and hearing. Also, these systems return to normal levels of sensitivity upon return of cortisol to normal plasma values. Finally, Henkin has indicated that these changes are not restricted to clinical populations. He demonstrated that normal individuals have phases of high and low taste sensitivity within a diurnal cycle which are inversely correlated with the 17-hydroxysteroid (OHCS) pattern. These findings led Henkin [6] to suggest that sensory detection and integration are regulated by an interaction between the endocrine and nervous systems.

In apparently the only published investigation of the effects of cortisol administration to normal subjects, Kopell, Wittner, Lunde, Warricks, and Edwards [12] studied the actions of cortisol on visual evoked potentials, time estimation, alpha rhythm, and two-flash fusion threshold. They found that large doses of cortisol (3 mg/kg) given to males diminished the amplitude of the evoked response to flashes of light and induced an overestimate of time but had no effect on alpha rhythm, two-flash fusion threshold or scores on a mood adjective check list. Kopell *et al.* [12] suggest that these findings are consistent with an effect of interference with selective attention.

The purpose of the present study was to further explore the effects of cortisol on perception in normal human subjects. An auditory detection task was used to facilitate comparison with two of the most extensively described studies by Henkin [8,9] in which he investigated auditory threshold patterns in normal subjects as compared to patients with adrenocortical insufficiency.

METHOD

The subjects for this study were 26 healthy college males who were without acute or chronic hearing losses or

endocrine disorders. The subjects ranged in age from 18 to 26 and were given course credit for their participation in this experiment. All threshold testing was done between 1645 and 2000 hr.

Subjects were tested for hearing thresholds using a Grason-Stadler model 1701 audiometer while comfortably seated in an Industrial Acoustics Company double-walled sound treated chamber. The subject was separated from the experimenter, but visible through a double-paired glass window. All tones were presented to the subject using headphones.

Procedures

Upon reporting for the experiment the subject signed a consent form and was seated in the sound attenuated chamber. The subject was instructed to depress a hand held response indicator the moment a tone was detected. In determining thresholds, tones were presented manually for a one second duration in ascending and descending series of 2.5 dB increments at three different frequencies: 500, 1,000 and 4,000 Hz. The initial series was descending and started at suprathreshold intensity until two consecutive negative responses were observed. A detection was signaled by the subject's depressing the button he held which triggered a light on the consol of the audiometer. Five descending and five ascending series were presented in an alternating fashion for each frequency. This procedure was followed separately for each ear. Threshold for each descending and ascending series was determined at half-way between two intensity steps when a response change was first noted. The size of the series was varied to avoid expectancy effects confounding detection. Interstimulus time averaged two seconds and response time was set at a maximum of one second following presentation of a stimulus.

After completion of threshold determination at the three frequencies for each ear, the subject was escorted to an adjoining room where he was given a capsule of either dextrose or dextrose plus 20 mg of hydrocortisone in a double blind, randomized procedure. The subject swallowed the capsule with water and then read or studied for an hour to allow absorption of the hormone. Subjects were not permitted to smoke or consume beverages other than water during this time. After the hour passed, the subject was escorted back to the sound treated chamber and sensory thresholds were again determined at the same three frequencies. All thresholds within each session for a given frequency for right or left ear were averaged to determine a mean threshold for each particular frequency in a given ear.

RESULTS

Difference scores were calculated for each subject by subtracting the second threshold value from the first at each frequency and all analyses were performed upon the obtained difference scores. Although thresholds were determined separately at each frequency for each ear, cortisol did not affect the sensitivity of the ears differentially. Therefore, difference scores were calculated by averaging across ears and these data were analyzed by means of planned comparisons between groups treated with hormone and placebo at each frequency. Planned comparisons were chosen to give the most direct, powerful comparison between treated and control groups, which was the main emphasis in this study. As may be seen in Table 1, treatment with hydrocortisone reduced sensitivity for the 4,000 Hz tone, $F(1,72)=6.29$, $p<0.02$, by an average of 2.5 dB. The hormone administration had no effect on change in sensitivity at either 1,000 ($F<1.00$) or 500 Hz ($F<1.00$).

TABLE 1

SUMMARY OF MEANS FOR PRE- AND POST-HORMONE/PLACEBO CHANGE SCORES FOR EACH FREQUENCY AS MEASURED IN DECIBEL UNITS

	Group	
Frequency	Hydrocortisone	Placebo
500 Hz	2.606	2.625
1000 Hz	1.389	1.481
4000 Hz	-0.471*	1.981

*Different from placebo, $p<0.025$.

An overall mixed analysis of variance, 3 (frequency) × 2 (treatment) × 2 (ear), was then completed to provide an overall picture of the effects not tested by means of our planned comparisons and to assess possible interactions. In addition to replicating the above effect (i.e., the frequency by treatment interaction), the larger analysis also indicated an effect of frequency, $F(2,48)=4.35$, $p=0.02$, ear, $F(1,24)=14.63$, $p=0.001$, and an interaction between frequency and ear, $F(2,48)=4.39$, $p=0.018$. The three way interaction (ear × frequency × treatment) was not significant ($F<1.00$). These effects indicate that greatest improvement from pre- to post-testing occurred at 500 Hz (2.6 dB) and least improvement was noted at 4,000 Hz (0.8 dB, which was not significant) and that the right ear improved more than did the left ear (2.3 dB vs. 0.9 dB respectively). The frequency by ear interaction resulted from the fact that the right ear improvement advantage was found at only the lower two frequencies (500 and 1,000 Hz).

DISCUSSION

It appears that treatment with hydrocortisone reduces sensitivity at higher but not lower tonal frequencies in normal adult males. This hormone treatment, at the dose used here, had an effect which was independent of ear to which the tones were presented. This result is in agreement both with those of Henkin *et al.* [8,9] and Kopell *et al.* [12] who found that cortisol produced reduction in auditory sensitivity and visual evoked potentials.

Changes in sensitivity are presumably related to either changes in neuronal metabolism or modulation of neurotransmitter function. In the absence of cortisol, neuronal conduction speed along peripheral axons is increased and detection of faint signals should become easier; however, conduction speed across synapses is decreased which should worsen acuity [7]. These changes are postulated [6] to alter the timing of sensory signals into the CNS, especially within the reticular activating system [17], and hence to influence perception. Alternatively, glucocorticoids are also believed to influence synaptic function [14]. Recent evidence has indicated that glucocorticoids influence catecholamine and indolamine neurotransmitter systems [14,15]. Therefore, glucocorticoid influences on perception may be a function of altered catecholamine, indolamine balance which may in turn alter arousal and activation systems [16]. Alternatively, a main effect of cortisol is to reduce levels of adrenocorticotropic hormone (ACTH) via negative feedback control.

Hence, the current finding may also be a result of lowered levels of ACTH. However, a plausible explanation for the differential effects of cortisol at high frequencies is not readily apparent.

The significant frequency effect was expected. This result is in accordance with that reported by Henkin *et al.* [8] for normal subjects. Performance is better at the lower end of the auditory spectrum with a peak sensitivity at about 1,000 Hz. The overall greater improvement in right ear sensitivity as compared to left ear from pre- to post-testing was an unexpected finding. Previous research has shown a right ear superiority during dichotic listening which presents stimuli to each ear simultaneously but no advantage for either ear when stimuli are presented to each ear individually [11]. The current finding is interesting in that although no differences in absolute sensitivity were found for either ear, it appears that the right ear is better able to improve with repeated exposures to the same stimulus. Furthermore, it appears that improvement is greatest at lower frequencies as evidenced in the ear by frequency interaction, although this effect is not asymmetric. The accepted explanation for the asymmetry in ear performance in dichotic listening [11] does not easily accommodate the present findings.

In conclusion, treatment with cortisol does alter perceptual function in normal adult males. The results of this study suggest that exploration of the role that hormones play in modifying information intake may permit a better understanding of how systems such as the pituitary-adrenocortical axis mediate processes such as "expectancy."

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