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REACTIONS OF THE NORMAL LABYRINTH: RECENT EXPERIENCE IN THE UNITED STATES AVIATION EXAMINATIONS.*

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There has never been any accepted routine for making a functional examination of the activity of the vestibular nerve. Otologists, as a rule, have developed individual schemes of testing the canal reactions in accordance with the investigations of Bárány. In examining the candidates for the United States Aviation Service a plan of procedure for testing the vestibular reactions was originated by Major Isaac Jones, United States Army, acting under Colonel Lyster, and this procedure has been carried out in a definite way at all the United States aviation examination stations. After this work is finished it is possible that a definite routine for examination of the vestibular nerve will be established that will be followed by otologists in their private practice.

The opportunity to test out in aviation work a large number of normal men gives to us who are engaged in otologic work great assistance in determining how much to depend upon abnormal reactions in patients who are sent to us with suspicion of labyrinthine or retrolabyrinthine disease. One is certainly impressed by the regularity in the normal reaction responses to these tests in normal men. But, as in so many other things, no test or series of tests is infallible. Later in this paper I will speak of a few cases where abnormal reactions were found in men who were apparently normal—that is, perfect hearing was found and perfect general condition existed; yet the vestibular reactions, as found by douching as well as by turning, were abnormal.

Normal Vestibular Reactions.—It is not my intention to

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take your time in reviewing these reactions, for the reason that they are well known to you. I wish to go over the tests as standardized by the United States Army Aviation Service. This service has a routine that is carried out at all the stations throughout the United States. A standard revolving chair with a foot-stop pedal is used—the Bárány chair, improved by Jones. A stop-watch is used to accurately time the reaction. The applicant is seated in front of a window with no objects in the foreground, so that distant vision is secured. The steps of the tests are as follows: (1) Spontaneous nystagmus is looked for, with eyes forward, with eyes deviated to the right, with eyes deviated to the left. (2) The after-nystagmus is timed (by stop-watch) after revolving ten times in twenty seconds to right and again after revolving to left. The head should be upright with the imaginary line joining the external auditory meatus, and the external canthus of the eye parallel to the floor. The amplitude of the nystagmus is noted. (3) Spontaneous past-pointing with each arm is tested, with eyes closed. (4) The applicant is then turned ten times in ten seconds to the right and the past-pointing with each arm is tested. The same is done after turning to the left. (5) The falling reaction is tested by revolving the applicant five times in ten seconds, with the head forward on the knees during the turning, the reaction by falling being seen when the applicant sits upright. If any abnormal reactions are found vestibular reactions from douching with water 68 degrees are excited, in one ear and then in the other, as follows:

Right ear syringed with head upright (the line joining the external auditory meatus and external canthus of eye must be parallel to the floor). (1) The length of time to the onset of nystagmus is reported. (2) The past-pointing with each arm (eyes closed) is at once tested. The head is then turned backward 90 degrees. (4) The nystagmus is seen to change from rotary to horizontal in character. (5) The past-pointing with each arm is taken with the head in this position. (6) The patient is then asked to stand upright with the eyes closed and the falling reaction noted. The left ear is then syringed and the same steps just given are repeated.

In testing over 800 applicants at our station we have made some observations which may be worth reporting to you. It
should be said at the beginning that all these vestibular reactions, supposedly normal, did occur in such an overwhelmingly large percentage that there seems to be no doubt whatever of the value of this definite scheme of carrying out the Bárány-series of tests.

(1) As to spontaneous nystagmus it was not once found.

(2) As to after-nystagmus from turning, we found that the average duration in 282 applicants was 23.49 seconds after right rotation and 24.17 seconds after left rotation—15 to 35 being the extremes in about 99 per cent of the applicants examined. Ruttin quotes Leidler's case report of complete absence of rotation after nystagmus without explainable cause. No such case occurred in over 800 normal men examined at our aviation examination station. One can only doubt that Leidler's case was a normal one.

More important than the duration of after-nystagmus is the point of the difference in seconds in after-nystagmus from right turning and left turning, because in diseased cases the rotation test is chiefly valuable because of the difference in after-nystagmus as shown on right rotation and left rotation. To show this point, the examinations of the first 200 applicants were considered. It is interesting to see that the average difference in seconds in after-nystagmus from right rotation and left rotation was 27\(^\frac{1}{2}\) seconds. In only two of the 200 cases was there a difference of 10 seconds, and in no case more than 10 seconds between the right and left rotation after-nystagmus. In one of these cases the result was 20 seconds and 30 seconds, and in the second case the result was 25 seconds and 30 seconds' duration of after-nystagmus from right to left rotation. Such results in cases suspected of diseased conditions would hardly make one suspicious, because the duration of after-nystagmus is entirely too great to make one suspect an inactive canal or nerve on either side. These two cases were the only two where there was much difference in after-nystagmus from right to left turning. For example: In only eleven of the 200 cases was there a difference of over 5 seconds. If more than 10 seconds' difference occurred one should be suspicious and resort to the caloric test. So that it seems reasonable to conclude that this test, if applied exactly as required by the Army Aviation Service (10 times in 20
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seconds), will rarely show a difference of over 10 seconds in right and left rotation after-nystagmus.

Some points should be emphasized in this test. The patient should hold his head in the correct position as given above, so that the horizontal canal is really horizontal to the floor. He should be turned exactly ten times in twenty seconds. While we think we learn to know the exact speed required without timing with the watch, we are apt to make an error unless we use a watch, and especially a stop-watch. We found that the best plan is to start the stop-watch on beginning to turn, and after turning ten times, note whether the second hand is at 19, 20 or 21, and time the after-nystagmus from that point. This enables one to be sure of turning ten times in twenty seconds, even to note after five turns whether you are turning too fast or too slow, and one can get the exact time of after-nystagmus by subtracting the 19, 20 or 21 from the number of seconds recorded when watch is stopped at the end of nystagmus reaction.

Spontaneous past-pointing was not found. Tendency to past-pointing was often seen to be due to a tight fitting coat (which should be removed) or to a large muscular chest, which, of course, makes one tend to point a bit to the right with the right arm and to the left with the left arm. The one to be tested should be shown just how the pointing test is to be done by the examiner going through the test. This will save much time and much confusion, and often prevents having to repeat the test. The arm should be kept extended, raised not too quickly to a vertical from the shoulder, and slowly but steadily and without muscular tension come down to touch the examiner's finger with his forefinger. He should be cautioned not to go too fast, nor to stop where he thinks he should, but continue letting the arm "drift down," even if he misses the finger of the examiner. It is often the last of the "drifting down" when the past-pointing will be most marked. Finally he should be told to remember to keep his eyes tightly shut until told to open them. The examiner on his part should hold his right hand, with the index finger extended, supported by the left hand, both elbows against his hips to keep a steady position; otherwise he will involuntarily
move a bit, especially if he is watching the down stroke of the one being tested.

(4) Past-Pointing After Turning.—The above precautions against error are to be noted. The army requires turning ten times in ten seconds, which for a man of medium weight, is about as fast as one can turn. It was not infrequent to find at this rate that such loss of equilibrium occurred that the applicant's arm, especially his left one, would be brought down without any muscular control, and so fast that it might past-point or cross-point badly on the first stroke. An unnecessarily abrupt stop would produce by its shock a similar extreme loss of equilibrium, rendering the test uncertain. A repetition often a bit more slowly or without the extreme shock of the stop on the tenth turn would often cause the usual normal response. Nevertheless, a stop device to lock the chair is an absolute necessity, and no past-pointing is accurate or consistent when a revolving chair without the locking pedal is used. The past-pointing reaction was elicited according to rule in about 90 per cent of those examined. The average number of times of past-pointing in 283 cases was as follows:

- Right arm, 2.22; left arm, 1.91 (after right turning);
- Right arm, 2.18; left arm, 1.96 (after left turning).

One good past-pointing movement, however, is sufficient to indicate the reaction. Of 700 applicants 47 cross-pointed with one or both arms on turning for past-pointing, as follows:

- On right turning, 5 crossed with right arm, 26 with left arm.
- On left turning 18 crossed with right arm, 21 with left arm.

The right arm crossed 23 times to 47 with left arm. This seems to us to be explained in this way: There is in right handed men a better control over the right than left arm, and during the loss of equilibrium that is extreme in a certain proportion of those turned, there was a greater loss of control over the left than the right arm. The fact that only 5 of the 47 cross-pointed with the right arm on right turning is to be explained, we think, in this way: that for the right arm to cross-point on right turning (that is, to cross the chest to the left), there is interference because of the large muscular development of the chest in right handed men. The following conclusions seem warranted: (a) In turning for past-pointing we must allow in some individuals or the extreme loss of
equilibrium that results, in which case the cross-pointing is not an evidence of disease but possibly a hypersensitive condition of the end organ in the labyrinth. (b) In all cross-pointing we should remember that the left arm is more apt to cross-point than the right arm, especially on right turning.

(5) The Falling Reaction.—This, too, should be explained by the examiner by a demonstration and the following points emphasized: (a) The applicant must be warned not to open his eyes until told to do so; (b) To sit upright without strain when told to do so; (c) to avoid any muscular control resisting the tendency to fall. The falling reaction was found to be abnormal only 11 times in 257 times on right turning, and 10 times in 259 times on left turning. Many times where the reaction obtained was abnormal it was found on retesting that the applicant was resisting the induced tendency to fall.

In conclusion permit me to cite a few of the relatively small number of cases where abnormal reactions occurred both from turning and from douching. These are interesting because the applicants were young, apparently healthy young men with normal hearing. The hearing tests (watch or whisper) demanded by the United States Army Aviation Service are inadequate, so far as ruling out unilateral nerve deafness. The writer for his own purpose therefore made tuning fork tests of applicants who showed any reduction in hearing to watch or whisper, as well as many applicants with apparently normal hearing. This tuning fork test as practiced was as follows: The applicant was tested in a quiet room, apart from others. The $C_2 512$ d. v. fork was selected for routine use. Bone conduction and air conduction was each taken by a stop-watch and recorded thus: A. C. (normal or $+$ or $-$ blank sec.) exceeds B. C. (normal or $+$ or $-$ 1 blank sec.) by blank seconds. By this test I wished to determine, for my own satisfaction, in a series of cases what was normal bone and air conduction for this fork as well as the Rinné in seconds. I believe that this test fairly well proved that there was no nerve deafness in the cases where abnormal labyrinthine reactions occurred.

CASES WITH ABNORMAL REACTIONS.

No. 9. Vestibular reactions, as follows: Nystagmus after right turning, 21 seconds; after left turning, 21 seconds.
pointing: After right turning, touches with right arm, past-points three times with left arm; after left turning, past-points two times with right arm; two times with left arm. Falling reaction normal after right turning; normal after left turning. On account of failure to past-point with the right arm after right turning, this applicant was douched, with the following result: Right ear, water 68 degrees, nystagmus, rotary, appears after one minute and nine seconds; past-points with each arm normally. Head bent backward 90 degrees, nystagmus changes to horizontal; past-points normally with each arm; when stood erect, falls normally. Left ear douched in the same manner, reaction appeared in one minute and four seconds and all responses normal. As the douch test for each ear produced normal reactions, this applicant was passed.

No. 14. Vestibular reactions, nystagmus after right turning, 25 seconds; after left turning, 24 seconds. Past-pointing, after right turning, one time with right arm, cross-pointed with left arm; after left turning, touched with right arm, touched with left arm. Falling reaction after right turning, none; after left turning, normal. This applicant was douched with absolutely normal responses from each ear, and accordingly was passed.

No. 15. Vestibular reactions from rotation were all normal, except that the after-nystagmus was of short duration, ten seconds after right turning and thirteen after left turning and of small amplitude. He was therefore douched with the following results: Right ear, 68 degrees, rotary nystagmus appeared after three minutes (feeble response); no past-pointing with right arm, fair past-pointing with left arm. On bending head 90 degrees backward, the rotary nystagmus changed to horizontal, but no past-pointing with right arm, fair past-pointing with left. Falling reaction subnormal. Left ear, douched, no response after six minutes with water at 68 degrees. Past-pointing with right arm, but not with left arm. Head then bent backward 90 degrees, whereupon horizontal nystagmus appears and past-points with right arm but not with left arm. Falling reaction, subnormal. Hearing test, normal. Result: rejected for flying, recommended for balloonist.

No. 16. Vestibular reactions, as follows: Nystagmus, after
right turning, 40 seconds; after left turning, 40 seconds. Amplitude of each is large. Past-pointing, after right turning, five times with right arm, five times with left arm. After left turning, cross-pointing with right arm, cross-pointing with left arm. Falling reaction, normal after right and after left turning, with nausea. Recommended for balloonist because of hypersensitive condition.

No. 100. Vestibular reactions, nystagmus, after right turning, 25 seconds; after left turning, 29 seconds. Past-pointing, after right turning, right arm, three times; left arm cross-pointing; after left turning, right arm, two times; left arm, two times. Falling reaction, after right turning, subnormal; rotary, after douching 38 seconds (water 68 degrees), past-after left turning, normal. Douched: Right ear, nystagmus, pointing with right arm normally, but no past-pointing with left arm. With the head back 90 degrees, nystagmus, horizontal, but no past-pointing with either arm. Falling reaction, subnormal. Left ear (douched), nystagmus after 42 seconds, past-pointing with right arm and with left arm. With head back, nystagmus, horizontal; past-pointing with each arm normally. Falling reaction normal; no nausea. This candidate was rejected because of the above abnormal reactions.

No. 112. Vestibular reactions, nystagmus, after right turning, 17 seconds; after left turning, 20 seconds. Past-pointing, after right turning, right arm, two; left, arm, two. After left turning, right arm, three; left arm, cross-points. Falling to right, normal; to left, normal.

Douched: Right ear, no response after three minutes thirty seconds. No past-pointing with either arm. Head back (90 degrees), nystagmus horizontal appears. No past-pointing with either arm. Falling, normal. Left ear, rotary nystagmus faint after one minute thirty seconds. Past-pointing, none with right arm; yes, with left arm. Head back, horizontal nystagmus; no past-pointing with right arm, faint with left arm. No falling reactions. Middle ear normal. Hearing normal to watch and whisper, and normal bone and air conduction with C₂ fork. Result: recommended for balloonist, not for flying.

It is useless to detail other cases with abnormal reactions. The above gives a fair idea of the abnormal cases. It is not
my purpose to attempt to explain these abnormal reactions. On the contrary, they are so inexplicable by our knowledge of what reactions do occur in diseased cases that one is justified in believing that they could not possibly mislead one into incorrect diagnosis.