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OBSERVATIONS UPON THE EFFECTS OF REPEATED STIMULATION UPON ROTATIONAL AND CALORIC NYSTAGMUS

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It has been recognized for many years that repeated angular acceleration of the head about its vertical axis brings about a progressive reduction of the resultant nystagmus.

The practical importance of this phenomenon is that it introduces a serious source of error into the quantitative assessment of the results of the turning tests in common use for the clinical investigation of vestibular function. The first clear account of the phenomenon appears to have been given by Griffith (1920) who used the conventional Bárány test in which the subjects were rotated at a constant velocity of 180° $\sec^{-1}$ for ten turns and suddenly brought to rest. Each subject was tested daily, five tests being applied with rotation to the left, and five with rotation to the right, while the individual beats of the post-rotatory nystagmus as seen by an observer were recorded on a smoked drum. Griffith found that nystagmus decreased considerably during the course of the first day's testing and thereafter more slowly in the following 30 days. He reports an average decrease in the duration of the response of 79% but refers to wide individual differences among his subjects. In a later publication (1924) he states that the decline in the response is persistent, and reports that in his own case these had not recovered after a rest interval of 4 years.

In a similar study with rabbits, Lumpkin (1927) reports that the response declined over a period of 1 week and during the course of the following 3 weeks maintained a constant level. He too reports no recovery.

Mowrer (1931) recorded the head nystagmus of pigeons following a stimulus consisting of a rapid acceleration to a velocity of 180° $\sec^{-1}$ followed by a period at constant velocity for fifteen turns followed again by a rapid deceleration to rest. Each bird was tested 6 times a day over a period of 32 days.

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Mowrer found that repeated tests of birds with the eyes closed caused a considerable fall in nystagmus which did not occur with the eyes open.

The origin of the phenomenon has been the subject of much speculation and controversy and has been variously attributed to fatigue or adaptation, these terms being generally applied without any clear specification of their implied physiological characteristics. In addition, Dodge (1923) has attributed the response decline to a third mechanism which he has termed habituation.

The present investigation has been undertaken to confirm and systematize our existing information upon the phenomenon and to obtain further experimental data bearing upon its nature and physiological mechanism. All the investigations previously reported have involved the application of stimuli which are far in excess of what is now considered to be the normal physiological limits of the cupula, and must for this reason be likely to involve its injury. Groen & Jongkees (1948), for example, have shown that a stimulus such as that involved in the Bárány test, i.e. a sudden stopping from a velocity of 180° $\sec^{-1}$, produces severe and lasting derangement of the responses to subsequent clinical tests of vestibular function, and consider this derangement to be due to pathological changes. Their own tests have been confined to stimuli no greater than a stopping velocity of 60° $\sec^{-1}$ calculated to produce a cupular deflexion of approximately 6°. In the investigations which follow we have restricted the stimulus used to one calculated in the human subject to produce a deflexion of the order of only 3°. This, as will be seen, is less than the maximal stimulus used by Groen & Jongkees, and very considerably below that used by previous investigators.

Our experiments have been on rabbits. In the first part of this paper nystagmic responses to repeated stimulation by rotation are considered; in the second, those to caloric stimulation.

PART I. ROTATORY STIMULATION

APPARATUS AND EXPERIMENTAL PROCEDURE

We used a revolving chair of new design, described elsewhere by Hallpike, Hood & Byford (1952), which permits the application of accurately controlled acceleration for long periods of time followed by prolonged rotation at constant velocity and subsequent deceleration to rest. Provision is made for the observation of nystagmus during rotation by means of an optical system which gives a stationary image of the eye to a stationary observer. The animal was tied upon a board with its head immobilized by means of a modified type of Czermak head clamp. So arranged, the animal's head was [redacted] lowered some 30° [redacted] below the horizontal in order to bring its horizontal canals into the plane of maximal reactivity, with its vertical axis coincident with the axis of rotation. In this position a magnified image of the animal's eye could be seen by the observer. Each nystagmic beat was recorded by pushing a button which made a sharp deflexion of the trace of a simple pen recorder.

In all the tests which follow, we have confined ourselves to a standard test procedure. This consisted of an acceleration of 5° $\sec^{-2}$ for a period of 10 sec followed by a period of rotation at constant velocity for 60 sec. The chair was then decelerated to rest at 5° $\sec^{-2}$. Nystagmus was recorded as described on both the acceleration and the deceleration, and a typical record is shown in Fig. 1.

RESULTS

In the initial series of experiments each rabbit was subjected at each session to four such standard tests with an interval of 1 min between each test, twice with the chair rotating to the right and twice to the left. Since each test consisted of an acceleration followed by a deceleration, it will be seen that the complete test sequence involved the application of eight stimuli.

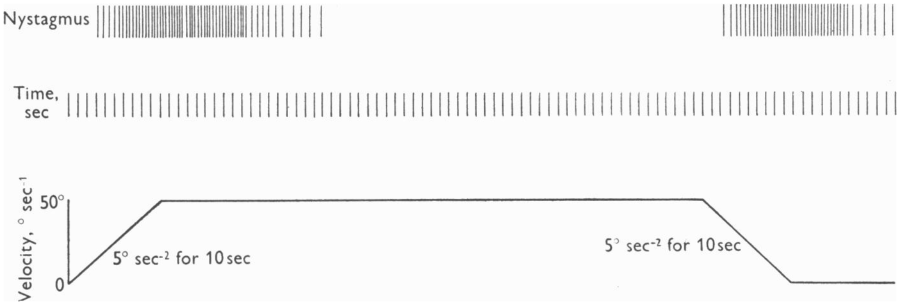

Fig. 1. Typical record showing nystagmic response to angular acceleration and deceleration of 5° sec^{-2} for 10 sec with intervening period of rotation at constant velocity for 1 min.

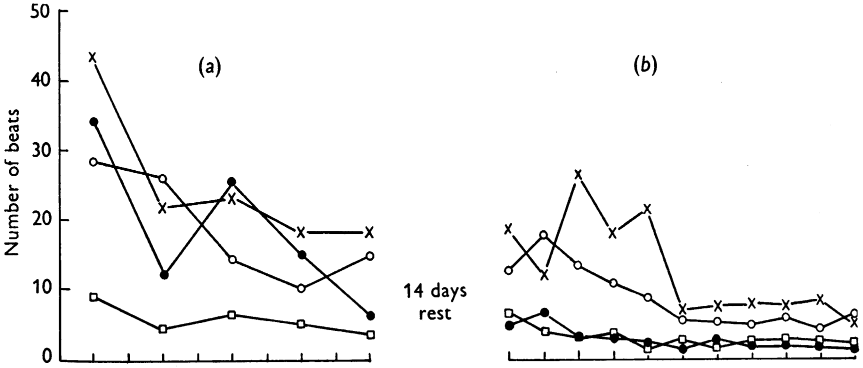

Fig. 2. (*a*) Reduction in number of nystagmic beats in four rabbits subjected to repeated angular accelerations at intervals of 2 days. Each point is the average of the responses from the eight stimuli, each of 5° sec^{-2} for 10 sec, applied at each session. (*b*) Further reduction in number of nystagmic beats in the four rabbits with continuation of repeated daily tests following a rest period of 2 weeks.

Each record was analysed under the following headings:

(1) Number of nystagmic beats.
(2) Duration of nystagmus.
(3) Latent period before the onset of nystagmus.

Eight rabbits were used and were tested in this way at 2-day intervals. The results obtained in four of the animals are graphically recorded in Fig. 2(*a*). Each point on the curves represents the average response for the eight stimuli administered at the particular test. The vertical scale refers to the average number of nystagmic beats while the time period covered by the experiment is represented on the horizontal scale. It will be seen that in three of the animals the responses pursued a steep downward course, their final values being considerably below their initial values. In the fourth animal the downward trend of the responses was less marked.

Analysis of the records obtained in this set of experiments showed a similar decline in the total duration of the nystagmic responses. This is graphically represented in Fig. 3.

Following a rest period of 2 weeks these same four animals were tested again, every day over a period of 2 weeks. The results are shown in Fig. 2(*b*). This shows that during the rest period, no recovery took place and that with further repetition of the tests the responses declined still further and finally reached a low and fairly constant level. The total amount of the response decline to its final low level averaged 85%.

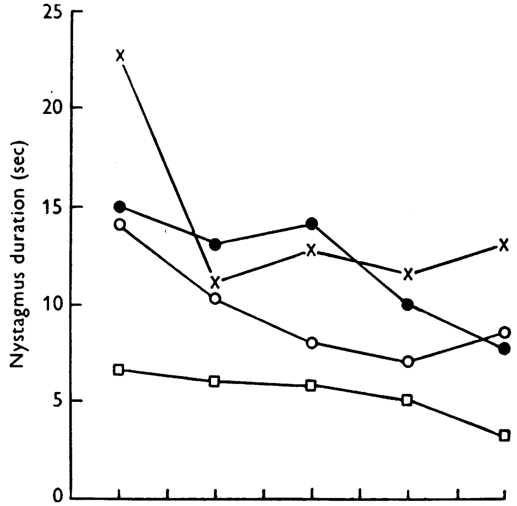

Fig. 3. Reduction in duration of nystagmus in the four rabbits under test conditions as for Fig. 2.

It seems evident, therefore, that no recovery took place during the comparatively long rest period of 2 weeks, and that the time which elapses between successive tests can, accordingly, play little part in determining the progress of the response decline. In order to confirm this we carried out a further set of investigations upon seven previously untested rabbits. Four of these rabbits were tested in the manner described above at intervals of 1 week over a period of 7 weeks. The results from one of these four are shown in Fig. 4. Here again, each point represents the average response for the eight stimuli administered at each session. In the three remaining animals the standard test was applied repeatedly at intervals of 1 min for periods of time of the order of 45 min with the chair rotating alternately to the left and right.

In one of these three animals this test period was followed by a rest period of 2 hr and thereafter by a further test period of 45 min. A further rest of 20 hr was given, followed again by a further test period. The results for this rabbit are given in Fig. 5. Each point represents the average response for every group of four successive stimuli.

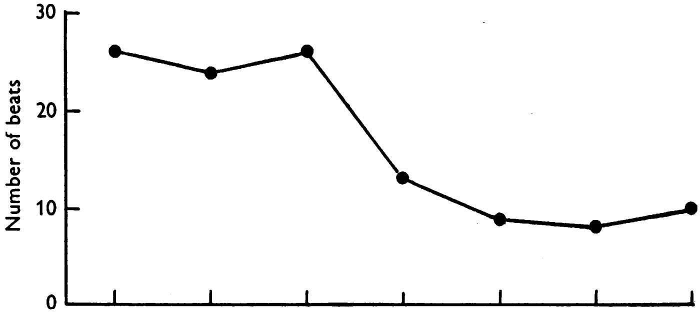

Fig. 4. Reduction in number of nystagmic beats in a rabbit subjected to repeated angular accelerations at intervals of 1 week. Each point is the average of the responses from the eight stimuli applied at each weekly session.

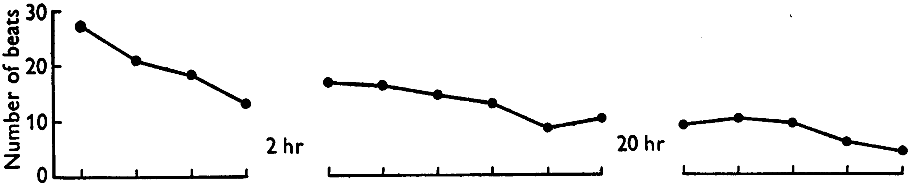

Fig. 5. Reduction in number of nystagmic beats in a rabbit subjected to repeated angular accelerations at intervals of 1 min for three periods of 30–45 min with intervening rest periods of 2 and 20 hr. Each point is the average of the responses from each group of four successive stimuli.

In all seven rabbits the response decline was found to follow a very similar course. It would seem, therefore, that the frequency of application of the tests is of relatively little importance in determining the course of the response decline. Instead, the vital factor is the number of tests which are performed.

This fact is clearly shown in Fig. 6 in which are given the results obtained in three rabbits, one tested repeatedly at intervals of 1 min, the second at intervals of 1 day and the third at intervals of 1 week. The details of the tests are given as follows.

Rabbit. 1. One standard test as specified on p. 131, giving two stimuli, was applied repeatedly at intervals of 1 min for three periods of 30–45 min during a total period of 24 hr. The results obtained are those shown in Fig. 5. Twenty-eight tests in all were applied giving a total of fifty-six stimuli.

Rabbit 2. A succession of four standard tests at intervals of 1 min was applied daily for 7 days again giving a total of fifty-six stimuli, broken up into daily groups of eight stimuli.

. *Rabbit* 3. A succession of four standard tests at intervals of 1 min was applied weekly for 7 weeks again giving a total of fifty-six stimuli, broken up into weekly groups of eight stimuli.

Each series of fifty-six stimuli was divided into fourteen successive groups of 4, and the average response for each group estimated.

These average values expressed as usual in terms of the number of nystagmic beats are recorded upon the ordinates of Fig. 6 while the fourteen groups are represented in numerical order upon the abscissae.

Since the shape of all three curves is very similar, we may conclude that the physiolgical mechanism which brings about these considerable reductions in the nystagmic responses arises from the summation of the effects of all preceding stimuli irrespective of the time interval between them. Moreover, the effect is a lasting one since in rabbits tested after a rest interval of more than a month no evidence of any recovery process has been observed.

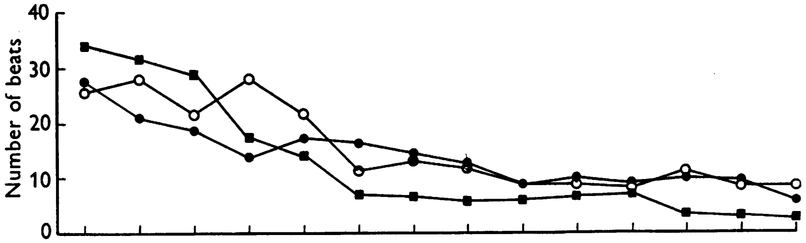

Fig. 6. Reduction in number of nystagmic beats in three rabbits tested as follows: ●—●, no. 1: every minute for three periods of 30–45 min during 24 hr (see Fig. 5). ■—■, no. 2: daily for 7 days. ○—○, no. 3: weekly for 7 weeks (see Fig. 4). Each point is the average of the responses from each group of four successive stimuli.

Many hypotheses have been advanced in explanation of the response decline which we have observed and in the discussion which follows it will be designated for convenience as the R.D. phenomenon.

It seems unjustifiable to attempt its explanation in terms of adaptation if this term is restricted to the process described by Matthews (1931) in the case of single muscle end organs. Matthews found the phenomenon to be an essentially transient one with certain highly characteristic features which have been confirmed by Hood (1950) and Hallpike & Hood (1953) in the cases of the sense organs both of the cochlea and the cupula in the human subject.

Fatigue has also been suggested as a possible explanation. This term, too, if its use be restricted to the phenomenon specified by Bronk (1929), would appear to be quite inapplicable to the R.D. phenomenon. Bronk's observations make it clear that the effects of fatigue, although less transient than those of adaptation, do not approach the very long lasting and apparently irreversible character exhibited by the R.D. phenomenon.

The long persistence of this R.D. suggests that it may be due to some structural damage of the cupular mechanism itself. It is, however, difficult to accept this explanation in view of the mild character of the stimuli used. Quantitative data upon this important point have been given earlier in this paper and additional evidence appears to be provided from our observations upon the latent period of the response. Van Egmond, Groen & Jongkees (1949) have clearly demonstrated the existence of a minimal perceptible deflexion of the cupula, about 0·25° in man, below which no sensation of turning can be elicited. The time which elapses between the onset of the stimulus and the onset of sensation, the so-called latent period, represents the time taken by the cupula to reach this minimal perceptible deflexion. A similar but longer latent period also exists for the onset of vestibular nystagmus.

TABLE 1. Latent period of nystagmic responses to repeated rotational stimuli (sec)

Test no.	Rotation to right		Test no.	Rotation to left	
	Acc.	Dec.		Acc.	Dec.
1	3	2·5	2	3	2·5
3	3·5	3·5	4	2·5	2·5
5	2·5	2·5	6	2	3·5
7	2·5	2·5	8	2	3·5
9	3	3	10	2	3
11	4	3	12	2·5	4
13	3·5	2·5	14	3	3·5
15	3	3	16	3	4
17	3	2	18	2·5	3
19	2	3·5	20	2·5	2·5
21	3	3·5	22	3·5	2·5
23	2·5	4	24	3·5	3
25	3	3	26	3	3
27	1·5	3·5	28	2·5	2
29	2·5	3	30	3·5	2
31	2·5	3	32	3	2
33	3	3	34	2	2·5
35	3	3·5	36	3	2

Loss of cupular sensitivity brought about by structural damage due to the use of excessive stimuli would seem almost certain to increase its minimal perceptible deflexion and hence would lead to an increase of the latent period. Our observations, however, do not reveal any such increase, as shown in Table 1. In this are given the results for one rabbit in which the responses fell by 90 %. It will be seen that the latent period has remained unaltered throughout the period of the tests. This has been a constant finding in all the rabbits we have tested.

In view of these findings it seems safe to say that the mechanical efficiency, at any rate, of the cupular mechanism, has been maintained unimpaired throughout the tests despite the response decline. This consideration leads us to believe that in the R.D. phenomenon we have to do with a complex central process which does not appear to have any clear counterpart elsewhere in the field of experimental psychology. In this connexion the observations of Griffith (1920) are of some interest. He observed that following violent exertion on a warm day the nystagmic responses of his subjects, reduced to a low level by previous rotational stimuli, underwent a dramatic increase with restoration of the initial high responses. This restoration, however, was only of a transitory nature and the responses soon fell to their previous low level.

These observations find an interesting corollary in the investigations of Hallpike, Harrison & Slater (1951) upon abnormalities in the caloric test results in certain varieties of mental disorder. These authors found that in thirty-five cases of anxiety neurosis the caloric responses exceeded the normal, a finding which it seemed possible to attribute to a state of chronic sympathetic over-action associated with the patient's mental disorder.

TABLE 2. Reduction of the R.D. phenomenon by adrenaline

	Initial high response		Response before adrenaline		Response after adrenaline	
Rabbit no.	No. of beats	Nystagmus duration (sec)	No. of beats	Nystagmus duration (sec)	No. of beats	Nystagmus duration (sec)
2	8	6·5	2	1	4	4·5
4	45	24	7	5·5	24	15
5	30	14	3	3·5	12	9
9	34	15	2	3	6	13

With these considerations in mind we have investigated the effects of adrenaline in restoring, in four rabbits, the responses which had fallen as a result of previous rotatory stimulation to a very low level. These we tested in the usual manner before and after intravenous injection of 0·3 ml. 1/10,000 adrenaline. The results are shown in Table 2.

It will be seen that in all cases the injection of adrenaline brought about immediate restoration of the responses but not to the initial level. This restoration was, however, only temporary and when the animals were tested on the following day the responses had relapsed to their previous low level. There would seem, therefore, to be some correlation between these findings and the observations of Griffith. It is of interest also to note that we have at times observed temporary increases in the responses in certain particularly nervous animals when they have been in an excited condition.

Whether or not the R.D. phenomenon can be regarded as the physiological antithesis of these observations, resulting, that is to say, from a progressive inhibition of sympathetic activity accompanying a decline of nervous excitability, must remain a matter of conjecture. It seems likely, however, that its mechanism involves complex central processes and this we have investigated by observations upon the effects of anaesthesia. A typical experiment is described as follows:

One rabbit, previously untested, was anaesthetized with ether and subjected to repeated tests at 1 min intervals over a period of 45 min. Following a rest of 1 hr, during which the animal regained full consciousness, it was again subjected to repeated testing for a further period of 45 min. Both responses are shown in Fig. 7. The irregularity of the responses under anaesthesia can, we think, be attributed to the practical difficulty of maintaining the animal at the same level of anaesthesia throughout the test. The most interesting feature of this experiment, however, is the normal appearance of the response curve following the rest interval of 1 hr.

The rapid initial decline shown in this curve is a feature we have observed only in previously untested animals. The results can be compared with those shown in Fig. 5 for a similar series of tests applied to a conscious animal. Here the influence of the initial testing period upon the second testing period is at once apparent.

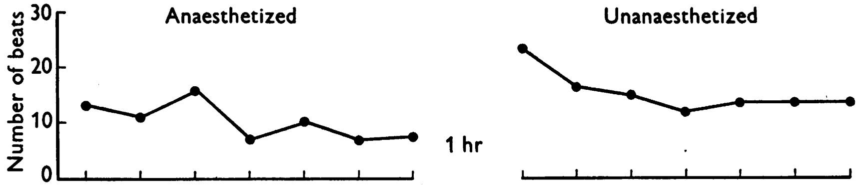

Fig. 7. Responses from rabbit tested at intervals of 1 min under ether anaesthesia. The anaesthesia was then discontinued and further tests applied after a rest period of 1 hr. Each point is the average of the responses for each group of four successive stimuli.

DISCUSSION

In the light of these results we may conclude that anaesthesia inactivates the mechanism, central or otherwise, which is responsible for the development of the R.D. phenomenon, or alternatively that consciousness is essential for its development.

Dodge (1923) was the first to use the descriptive term 'habituation' to designate the R.D. phenomenon and in the light of its definition which has in recent years come to be accepted by experimental psychologists it appears to have been a particularly apt choice.

Thus, Thorpe (1950) describes habituation in its widest sense as a simple learning *not* to respond to stimuli which tend to be without significance in the life of the organism; a tendency merely to drop out responses. He goes on to define it 'as an activity of the central nervous system whereby innate responses to certain relatively simple stimuli, especially those of potential value as warning of danger, wane as the stimuli continue for a long period without unfavourable results', a definition which appears particularly applicable tc the R.D. phenomenon.

Vestibular nystagmus arising from rotatory acceleration is an unphysiological response; one which the animal would never be called upon to experience in its normal environment and so provides it with no sensation or experience of any value. It seems reasonable, therefore, to suppose that in common with other useless responses it undergoes a process of central elimination or inhibition.

The importance of the R.D. phenomenon to clinical turning tests is obvious. Unless due care is shown in their design, its presence can and undoubtedly will play a very important role in influencing the results obtained and in complicating their interpretation.

PART 2. CALORIC STIMULATION

The caloric tests of semicircular canal function devised by Bárány (1907) play a particularly important part in the clinical investigation of vestibular function. According to modern practice the tests are carried out with the subject lying supine upon a couch with the head inclined upwards some 30° to the horizontal. In this position the lateral semicircular canals are brought into the vertical position. With cold irrigation of the left canal, nystagmus is evoked with its quick component to the right, while with hot irrigation the nystagmus is to the left; these two modes of stimulation are equivalent, therefore, in their effect, to angular acceleration to the right and left respectively.

For clinical purposes the tests have certain obvious advantages over the rotational tests which they have largely supplanted. The advantages are that the caloric stimulus is limited to a single labyrinth and usually to a particular sense organ, namely the cupula of the lateral semicircular canal. The resulting response can, therefore, be taken to represent the functional state of this sense organ. With the rotational tests, however, the stimulus involves both labyrinths and the resulting response is difficult to analyse.

Bárány's view, which has received general acceptance, was that the physiological effects of thermal stimulation were due to cupular movements brought about by thermally induced convection currents in the endolymph. Thus, a cold stimulus would produce an ampullo-fugal flow and a hot stimulus an ampullo-petal flow of endolymph. Since, therefore, on this reasoning the activation of the cupular end-organ by thermal stimuli would appear to be dependent, as in the case of rotational stimuli, upon mechanical deflexions of the cupula, we should expect the former to bring about the habituation so characteristic of the latter.

Clinical tests carried out according to the technique described above have been in constant use at Queen Square since it was first described in 1942 by Fitzgerald & Hallpike. On many occasions repeated tests have been applied both to normal subjects and to others affected by various forms of vestibular disease, and no evidence has ever been obtained that the resulting responses have been vitiated by anything resembling the habituation process which occurs with rotational stimuli. We have, therefore, subjected this apparent anomaly to an experimental investigation, in which we have applied to rabbits repeated caloric stimuli of an intensity considered likely to parallel those used for our rotational tests.

METHODS

The animal was held on a board in the manner we have described previously with its head inclined upwards to bring the external canals into the optimal position for stimulation. Water from a tank some 4 ft. above the animal's head was directed into the meatus by way of a fine cannula, and the nystagmus recorded as previously described by means of a push button and recording device.

The tests were carried out at intervals of 2 days over a period of 2 weeks. The same stimulus was maintained throughout all the tests, namely a flow of water at temperature of 25° C, i.e. 13° C below body temperature, for 10 sec; this was usually sufficient to produce a brisk and measurable response of fairly long duration.

The test procedure was attended by a number of technical difficulties. The chief of these was the accumulation of wax and debris in the ears which repeated syringing forced into the meatus blocking the passage of water to the tympanic membrane. When this occurred it was usually impossible to elicit any response. In the same way, too frequent irrigation often led to an external otitis with blocking of the meatus.

RESULTS

The results of some initial experiments carried out upon two rabbits are shown in Fig. 8. Each graph represents the response of one ear of each animal. It will be seen that although there is some irregular variation in the total number of nystagmic beats, there is no evidence of any progressive decline in the response, as observed with rotatory stimulation. The curves for nystagmus duration, on the other hand, remain remarkably constant throughout.

It is clear, therefore, that with the time intervals used the phenomenon of habituation does not occur.

A further series of observations was made using caloric stimuli repeated at shorter intervals. The stimulus was applied repeatedly with rest intervals of 5 min usually over a period of 45 min to two rabbits. In Fig. 9(*a*) are shown the results of tests upon rabbit no. 1. Throughout the entire testing period the responses remained unchanged and were as brisk at the conclusion as at the beginning of the experiment.

The second graph, Fig. 9(*b*), shows the results from the second animal. Here the responses fell markedly during the first three tests in a manner rather similar to that observed with repeated rotatory stimulation. The rabbit was rested for 30 min and the tests then resumed. During the rest period there was complete recovery, but the responses again relapsed with the renewal of the stimuli. Following a further rest period, this time of 2 hr duration the tests were again repeated and once more complete recovery, followed by a decline in the response, occurred. The temporary character of the response decline observed in these experiments is clearly atypical of habituation. One notable feature, namely, the complete recovery which occurred following each rest period is more characteristic of fatigue as specified by Bronk (1929) to which perhaps it may be attributed.

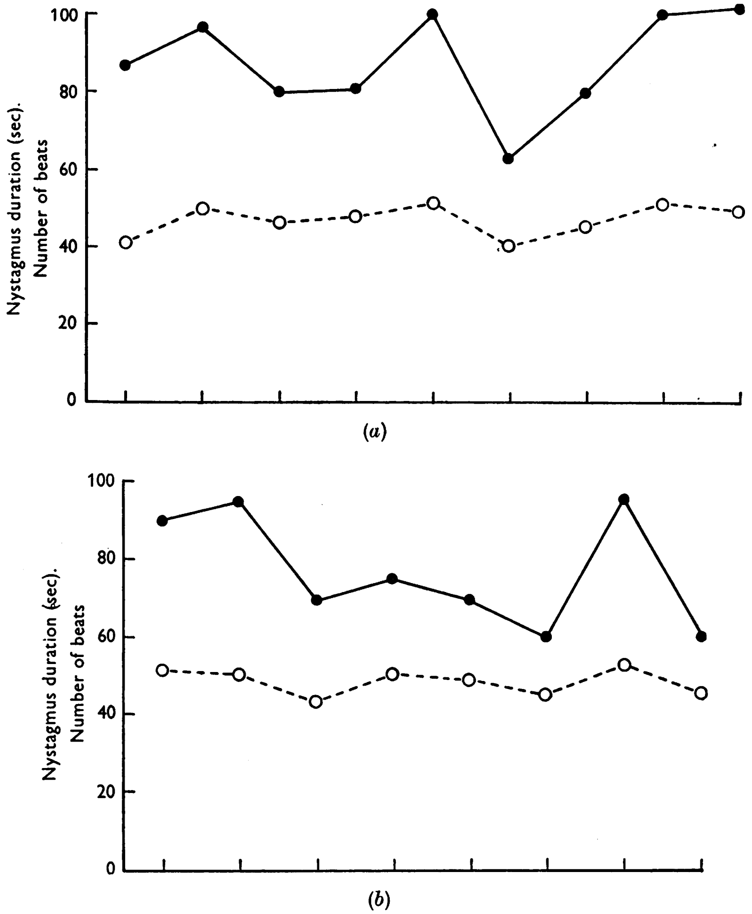

Fig. 8. Responses from two rabbits subjected to caloric stimulation in one ear at intervals of 2 days. ●—●, number of beats; ○ - - - ○, nystagmus duration.

The apparent independence of the nystagmic responses to rotational and caloric stimulation was confirmed by a further series of tests upon two rabbits, previously untested, which were subjected to caloric stimulation in the manner described, followed by repeated rotational stimulation over a period of 45 min. During the course of the latter tests, habituation brought about, as usual, a considerable decline in the nystagmic responses. The usual caloric stimuli were then reapplied and the original response levels found to be unimpaired.

DISCUSSION

The experimental results obtained make it clear that although with repeated caloric stimulation a reduction may sometimes be observed in the total number of nystagmic beats, nevertheless there occurs no fall in the response as assessed by the total duration of the nystagmus.

In other words, the nystagmic response to caloric stimulation is not subject to habituation, a finding which is in good agreement with our clinical experience to which earlier reference has been made. The difference is in line, furthermore, with our general experience that sensitivity to the two types of stimuli do not go hand in hand. Thus, rabbits which exhibit a brisk response to rotational stimuli may give a poor caloric response and vice versa. The physiological independence of the two varieties of response is difficult to explain. It might, at first sight, be supposed that Bárány's view, namely, that caloric and rotational stimulation both activate the cupula by mechanical displacement is incorrect, and in support of this possibility may be quoted the work of Kobrak (1918) who considered that the caloric responses are mediated not so much by cupular displacement as by reflex vascular changes in the labyrinth. Nevertheless, Kobrak's observations are of an indirect character and would appear to be contra-indicated by the direct observations of Steinhausen (1931) of cupular displacements seen to take place in response to caloric stimulation. In other respects, too, Bárány's original observations upon the behaviour of the caloric responses in response to alteration in the spatial disposition of the

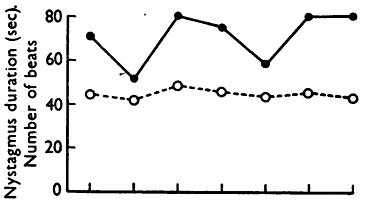

Fig. 9(*a*). Responses from a rabbit subjected to repeated caloric stimulation at intervals of 5 min. ●—●, number of beats; ○ - - - ○, nystagmus duration.

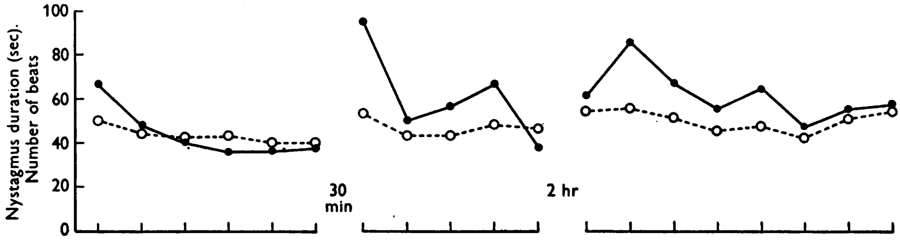

Fig. 9(*b*). Responses from a rabbit subjected to three periods of repeated caloric stimulation with intervening rest periods of 30 min and 2 hr showing decline and recovery of responses. ●—●, number of beats. ○ - - - ○, nystagmus duration.

stimulated canal make it reasonably certain that cupular displacements must be the chief factor in the mediation of the caloric responses. On the whole, therefore, it would seem more reasonable to explain the finding that habituation affects the rotational responses and not the caloric responses, by adopting the suggestion already made that habituation exerts its influence by means of some central mechanism, acting at a high level of the central nervous system at which the simultaneous responses from the two labyrinths have become integrated.

With such an arrangement, a monaural caloric stimulation would in some way, not at present clearly understood, be immune to habituation. Beyond this conjecture it is at present impossible to carry the matter.

The practical aspects of our experimental findings would appear to possess some significance. Thus, the caloric responses, as at present elicited in clinical practice, may be relied upon to resist modification by repetition. The rotational responses, however, will certainly be modified on repetition by habituation, a fact which demands careful consideration in the interpretation of the results.

SUMMARY

1. Rabbits have been subjected to repeated angular accelerations of low intensity at intervals varying from one minute to one week. Records were made of the resulting nystagmic responses.

2. The nystagmic responses were shown to undergo a marked decline termed for convenience the R.D. (response decline) phenomenon.

3. The development of the R.D. phenomenon was found to be dependent upon the number of stimuli applied and not upon the interval between them.

4. The R.D. phenomenon was unaccompanied by any change in the latent period of the nystagmic response.

5. The R.D. phenomenon was not found to develop if the stimuli were applied during light anaesthesia. Its mechanism was therefore thought likely to depend upon some central process involving consciousness and allied in all probability to that of habituation as described by Thorpe (1950).

6. The nystagmic responses to repeated caloric stimuli of comparable intensity were not found to exhibit any significant decline.

7. The nervous mechanism of the R.D. phenomenon and the finding that it affects rotational but not caloric nystagmus is briefly discussed.

Our thanks are due to Dr C. S. Hallpike for suggesting the comparative study of the effects of repeated stimulation upon rotational and caloric nystagmus, and for much helpful discussion. Also to Mr C. Best, Mr R. Bolam and Mr G. H. Byford for help with the experiments, and to Mr J. P. Poole for drawing the figures.

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