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Incidence and characteristics of voluntary nystagmus

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SUMMARY A survey of a college age population revealed that 8% could produce voluntary nystagmus. Seventy-nine per cent of this sample had relatives who could also produce it. A systematic investigation of the characteristics of voluntary nystagmus under a number of stimulus conditions showed that it resembles pendular nystagmus in waveform, and certain ocular oscillations, such as ocular flutter and opsoclonus, in frequency. The results indicate that voluntary nystagmus can be differentiated from other forms of nystagmus by its frequency, duration, and occurrence in individuals whose neuro-ophthalmological examination is normal. Voluntary nystagmus probably involves the "hold" mechanism of the cerebellar nuclei because of its frequency correspondence to ocular oscillations which result from a dysfunction in this anatomical area.

Early in the 19th century several clinicians reported that certain individuals could initiate nystagmus-like eye movements (Duke Elder, 1949). This voluntary nystagmus—also known as voluntary ocular tremor, voluntary ocular fibrillation, and voluntary ocular oscillation—has been defined as a high frequency, low amplitude movement of the eyes initiated and terminated on command (Friedman and Blodgett, 1955; Wist and Collins, 1964; Blair *et al.*, 1967; Coren and Komada, 1972; Aschoff *et al.*, 1976).

Most neuro-ophthalmology texts give perfunctory accounts of voluntary nystagmus, considering it a "trick" exhibited to amuse friends (Walsh and Hoyt, 1969). As a trick voluntary nystagmus may cause some confusion during routine neuro-ophthalmological examination. To circumvent this problem the studies to follow estimate the incidence of voluntary nystagmus and provide an analysis of its differentiating characteristics. The mechanism is discussed in relation to these data.

Incidence of voluntary nystagmus

Voluntary nystagmus has been described in the literature for over 100 years and there are, to date, about 600 reported cases. Duke Elder (1949) provided 32 references dating from 1866. Wist and Collins (1964) compiled 39 references from different countries, and Sobrinho (1950) identified 300 cases in the South-American literature. Although the incidence of voluntary nystagmus has been suggested to be high (Duke Elder, 1949), it has not been determined.

To estimate the incidence, a questionnaire was administered to a large sample of students at Indiana University. The students were read the following statement: "The purpose of this questionnaire is to determine the incidence of individuals who have the unique ability to 'jiggle their eyes.' This is known as voluntary nystagmus. Certain signs usually are involved, but not necessarily, when voluntary nystagmus is produced, such as an apparent movement and blur of objects, strong converging or crossing of the eyes, and a feeling of muscle pull." The subjects were asked: "Are you able to produce voluntary nystagmus?" and "Does anyone in your family do this?"

Six hundred and thirty-four students, representing 2% of each academic class (freshman through graduate), were given the questionnaire. Fifty males and 28 females (12.3%) reported that they could "jiggle their eyes." These individuals were tested, using an infrared eye monitoring system to document the validity of their report.

Fifty-two subjects from this sample could initiate voluntary nystagmus, while four slightly oscillated their eyes, and 13 could not produce voluntary nystagmus or had another type of nystagmus—for example, congenital pendular

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nystagmus. Nine subjects could not be contacted for testing. Thus, this survey showed that 8% (52 out of 634) of this population could initiate voluntary nystagmus.

How and when an individual recognises this ability is unknown. One testimony is representative. A woman reported that she noticed, as a child, that if she moved her eyes quickly she could occasionally see "streaks of light." By placing "tension on her eyes" and defocusing she learned to elicit the desired sensory effect for brief periods.

Questioning of our subjects revealed that 39 (75%) first initiated voluntary nystagmus between 7 and 8 years of age, while the remaining subjects did so between 10 and 20 years. The younger age group usually learned to produce it without training, while the older group learned the response after observing a relative or friend.

Forty-one (79%) subjects reported that someone in their family could produce voluntary nystagmus. Twenty-six (62%) subjects were in the same generation—namely, 11 brothers (41%) nine sisters (38%), and six cousins (21%); 15 (37%) subjects were in a previous generation—namely, seven fathers (43%), five mothers (35%), and three uncles (22%). These data suggest, indirectly, a genetic element in support of previous investigators (Keyes, 1973; Aschoff *et al.*, 1976) but do not necessarily rule out the contention that voluntary nystagmus is a learned ability (Luhr and Eckel, 1933; Coren and Komada, 1972).

Characteristics of voluntary nystagmus

Most reports on voluntary nystagmus have been based on conjecture or clinical observation. Only recent investigations have manipulated systematically crucial variables (Wist and Collins, 1964; Blair *et al.*, 1967; Coren and Komada, 1972) and used electro-oculography (Westheimer, 1954; Goldberg and Jampel, 1962; Wist and Collins, 1964; Blair *et al.*, 1967; Keyes, 1973; Aschoff *et al.*, 1976; Jarrett *et al.*, 1977), cinematography (Friedman and Blodgett, 1955), or a photoelectric technique (Coren and Komada, 1972) to monitor the phenomenon.

Westheimer (1954) reported a nystagmus frequency of 10 Hz with an amplitude of 5°, while Goldberg and Jampel (1962) showed, for two subjects, frequencies of 23 and 19 Hz and amplitudes of 5° and 10°, respectively.

Wist and Collins (1964) reported a frequency of 12 to 13 Hz and an amplitude range of 1.2° to 5.9° for one subject. The frequency did not change for testing with and without a fixation target and in total darkness. The frequency when the eyes were closed was less than in total darkness, and a slight decline in frequency was found for positions 20° left and right of a straight ahead position, but not for 20° up and down. Convergence was not necessary for the initiation of voluntary nystagmus

Blair *et al.* (1967) found a frequency range of 16 to 18 Hz, an average amplitude of 5°, and durations for three subjects of 2.5, 4, and 9 s, respectively. There was no effect on the frequency and amplitude of voluntary nystagmus when spherical lenses (±3 diopters) and prisms were placed in front of the eyes, nor during occlusion of either eye, eyes closed or eye position (25° right, left; 15° up, down) conditions. Cycloplegia had no effect. Unilateral voluntary nystagmus was demonstrated during conditions of occlusion, eyes closed, and gaze position in one subject. Convergence was not necessary to initiate it, and there was no voluntary control over the rate or the amplitude.

Coren and Komada (1972) found modal frequencies of 20 and 12 Hz, and median amplitudes of 6° and 1° for the horizontal and vertical eye movements of one subject. The duration ranged from 25 to 35 s. An empty field, occlusion, and viewing horizontal and vertical lines of light did not alter the voluntary nystagmus. The subject showed no control over the frequency, and limited control of the amplitude.

Aschoff *et al.* (1976) found for two subjects a frequency of 18 Hz, an amplitude of 4°, and durations of 8 and 15 s. Voluntary nystagmus could be elicited at 20° gaze angle, in the dark, and with the eyes closed.

Jarrett *et al.* (1977) showed, for five subjects, a range of frequencies from 9 to 28 Hz, and, amplitudes from 1° to 9°. A spherical lens (+6.00

Table *Characteristics of voluntary nystagmus summarised from previous literature*

	Voluntary nystagmus		
	Minimum	*Maximum*	*Mean*
Frequency (Hz)	5	28	16
Amplitude (°)	1.0	20	5.2
Duration (s)	4	50	22.4
Subjects	13 male, 7 female		
Age range (yr)	8 to 48		
Age of initiation (yr)	6 to 9		
Occurring conditions	Conjugate, pendular; horizontal/vertical binocular/monocular; with/without convergence; all eye positions within 20 degrees; during darkness, occlusion, eyes open or closed		
Pathology	Healthy, normal with unremarkable neurological history; some may have slight colour and/or muscle weakness		
Aetiology	Genetic and/or acquired		

diopters) decreased it. Initiation of voluntary nystagmus was dependent upon convergence for three subjects and whether the eyes were open or closed.

The Table summarises the results of previous studies regardless of testing conditions.

These experiments neither manipulated the independent variables systematically nor used an adequate number of subjects. The present experiment was designed, therefore, to overcome these limitations, and to determine the extent of visual sensory and ocular motor system involvement in the initiation and maintenance of voluntary nystagmus. The subjects were drawn from those individuals identified by the questionnaire.

Subjects and method

Ten subjects, five men and five women, ranging in age from 18 to 24 years participated in this experiment. Optometric examination revealed corrected Snellen acuities to 20/20 in each eye for five subjects. The refractive error for four corrected subjects was within minus two diopters. The alternate cover test showed heterophoria for six subjects, esophoria or exophoria within four prism diopters for four subjects at 40 centimetres, and heterophoria at six metres for these subjects. Version and vergence amplitudes, near point of convergence, and the pupil response were normal for all subjects. Four male subjects had slight red-green deficiency (Farnsworth-Munsell 100 Hue Test). Ophthalmoscopic examination showed clear media and fundi in all subjects. The history of each subject was unremarkable, showing no trauma, ocular surgery, inflammation, or mental disease. The subjects had not taken any drugs and were under no medication at the time of testing.

EYE MOVEMENT MONITOR

Voluntary nystagmus was monitored by an infrared eye monitoring system (Space Sciences Model SGH/V-2). This system has a 100 Hz bandpass and a linear angular range horizontally to 20°. Voluntary nystagmus was recorded on a Grass polygraph model 7PCPA (25 mm/s) and separately stored on FM tape (Hewlett-Packard instrumentation tape recorder, model 3960H, series 936). The data could be analysed to within an accuracy of 0.5°. Electro-oculography with a 30 Hz bandpass and an accuracy of 1° was used for the eyes closed condition.

For each subject the frequency of the response was defined as the number of complete cycles occurring within a prescribed time period, usually 20 s, and the amplitude was the average peak-to-peak measurement for five full cycles occurring in the middle of each response.

EXPERIMENTAL TASKS

Luminance

Each subject was asked to initiate voluntary nystagmus while fixing the centre of a 60° white panel held at 1500 mm and varied in luminance (5, 50, 500 ft-L). Also included were eyes closed and darkness conditions.

Stimulus distance

Each subject was asked to initiate voluntary nystagmus while fixing one minute of arc Snellen letters located at various distances (100, 400, 1000, 1500, 3000, and 6000 mm) in front of and perpendicular to the subject's pupillary distance.

Radial position

Each subject was asked to initiate voluntary nystagmus while fixing a red 1° light-emitting diode located at 5°, 10°, 15°, and 20° to the right and to the left of a 0° position.

Response control

Each subject was tested on their ability to change the frequency of voluntary nystagmus while fixing a red 1° light-emitting diode located six metres in front of the subject.

Duration sequence

During each experimental task, the subject was asked to maintain voluntary nystagmus for as long as possible for each of three successive trials.

PROCEDURE

The subject was seated comfortably in an adjustable chair in front of an ophthalmic instrument table contained within a shielded light-tight room painted flat black. The subject's head was held firmly by a chin cup and an adjustable head clamp.

During each experimental task, the subject, on command from the experimenter, initiated voluntary nystagmus. Before starting, a time mark was placed on the polygraph and on the tape recorder by the subject depressing a hand-held switch. One practice trial per task was permitted. If the subject did not respond after 5 s, the task was terminated, and the instructions for the next task administered. Both monocular and binocular testing were done. Except for the duration sequence, the periods of testing were kept to a set duration of 2 min, with a 1 min rest interval between tasks. The data were obtained in two one hour sessions for each subject. Ten trials were obtained from each subject on each experimental task.

Results

GENERAL CHARACTERISTICS

The voluntary nystagmus of 10 subjects was pendular and conjugate. The ranges for the frequency, the amplitude, and the duration were between 4 and 24 Hz, 4° and 11°, and 2 s and 90 s respectively, across all experimental conditions. The overall means (and standard deviations) of the frequency, amplitude, and duration for all conditions were 16.3 (5.1) Hz, 6.1° (2.6°), and 19.8 (6.6) s respectively. The results found here agree in waveform, frequency range, amplitude, initiation procedure, and duration with most previous reports. No significant difference was found between the men and women, so subsequent analyses are based on the combined data.

LUMINANCE

Figure 1 shows the average frequency and amplitude for each eye of 10 subjects across the luminance (5, 50, 500 ft-L), eyes closed, and darkness conditions. The bars around each data point represent the range. The means (and standard deviations) of the frequency and amplitude for these conditions (luminance being combined) were 16.8 (5.6) Hz, 17.8 (5.9) Hz, 18.2 (3.1) Hz, and 6.7° (2.2°, 6.7° (2.5°), 6.8° (2.4°) respectively.

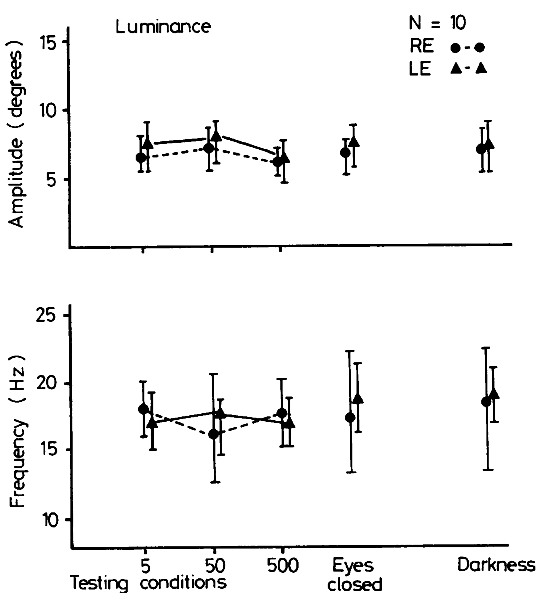

Fig. 1 *Frequency and amplitude of voluntary nystagmus for each eye under three luminance levels (5, 50, 500 ft-L), with the eyes closed, and in darkness. Each data point represents mean for 10 subjects. Bars represent range.*

These data are similar to the results of studies testing equivalent conditions (Wist and Collins, 1964; Blair *et al.*, 1967; Ashoff 1976; Jarrett *et al.*, 1977).

Figure 2 shows voluntary nystagmus for one subject across the occlusion, eyes closed, and darkness conditions. These data graphically demonstrate, contrary to some previous investigators (Goldberg and Jampel, 1962; Blair *et al.*, 1967), no effect on voluntary nystagmus across these conditions.

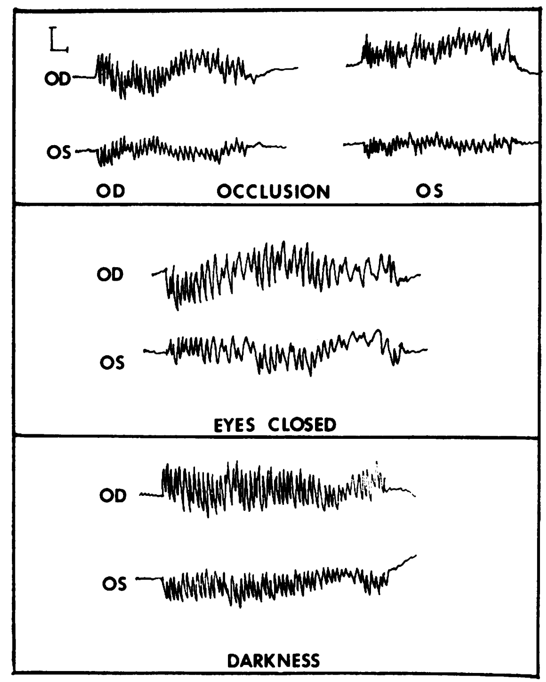

Fig. 2 *Infrared eye movement recordings of voluntary nystagmus for each eye during darkness and occlusion conditions, and electro-oculographic recordings with the eyes closed. Upper and lower records are for right and left eyes respectively. Scale factors shown at upper left are 5° (ordinate) and 200 ms (abscissa). Details of recording technique can be found in text.*

EYE POSITION

The means of frequency and amplitude for all eye positions across subjects are shown in Fig. 3. The bars represent the range. These data indicate a significantly decreased ($P<0.01$) frequency for the 15° and 20° eye positions on both sides of the 0° position. No trend was found for the amplitude. The voluntary nystagmus for one subject is shown in Fig. 4. These data support some previous observations (Luhr and Eckel, 1933; Friedman and Blodgett, 1955; Wist and Collins, 1964; Blair *et*

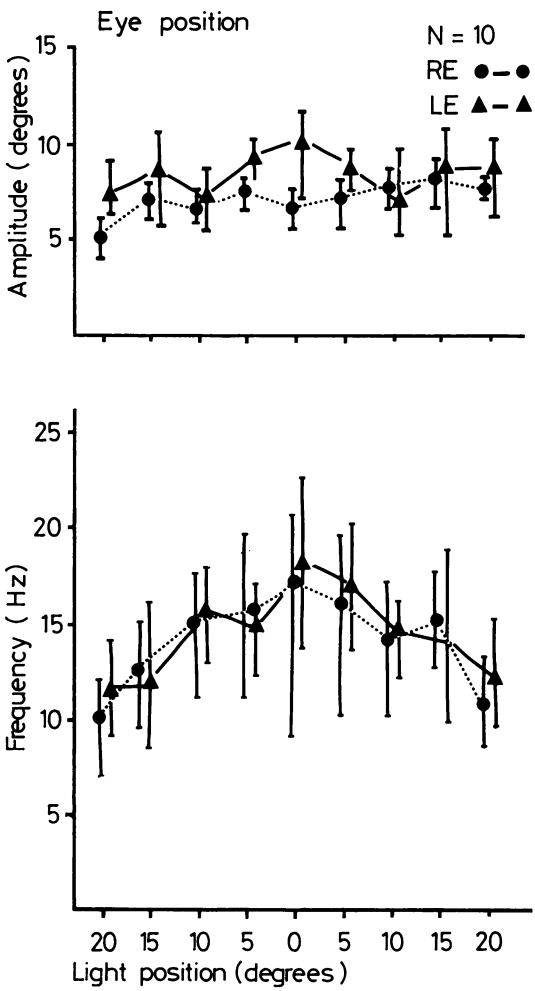

Fig. 3 *Frequency and amplitude of voluntary nystagmus while fixing a 1° red light-emitting diode located at various positions along the horizontal meridian. Each data point represents mean for 10 subjects. Bars represent range.*

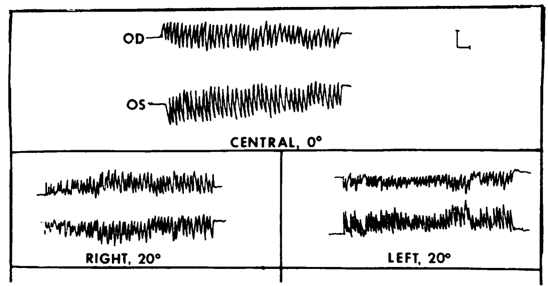

Fig. 4 *Voluntary nystagmus for each eye while fixing under normal room illumination a 1° light-emitting diode located at the 0° and 20° left and right positions along the horizontal meridian. Upper and lower records of each set are for the right and left eyes respectively. Scale factors shown at upper right are 5° (ordinate) and 200 ms (abscissa).*

al., 1967; Keyes, 1973) but not those of Goldberg and Jampel (1962).

STIMULUS DISTANCE

The means of frequency and amplitude for all subjects for different stimulus distances are shown in Fig. 5. The bars represent the range. The combined means (and standard deviations) are 12.1 (4.0) Hz and 7.1° (2.5°) respectively. These data and the tracings shown in Figs. 2 and 4 indicate, in agreement with others (Friedman and Blodgett, 1933; Westheimer, 1954; Goldberg and Jampel, 1962; Wist and Collins, 1964; Jarrett *et al.*, 1977,

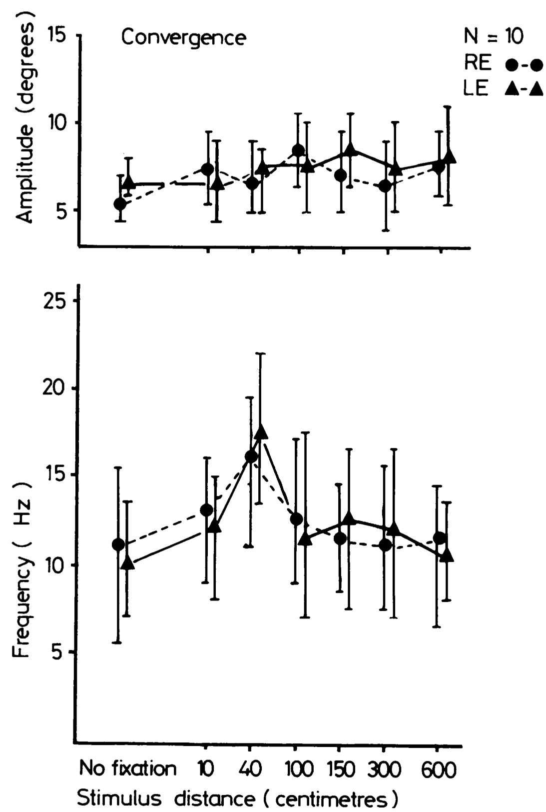

Fig. 5 *Frequency and amplitude of voluntary nystagmus for both eyes under normal room illumination while fixing on 1 minute arc Snellen letters located at various distances from the straight ahead position. Each data point represents mean for 10 subjects. Bars represent range.*

that stimulus distance (that is, convergence) may be associated with the initiation and, possibly, facilitation of voluntary nystagmus. Any confusion regarding the influence of convergence on voluntary nystagmus may be due simply to the fixation distance employed during testing.

RESPONSE CONTROL

One subject could vary the frequency of voluntary nystagmus. This can be seen in Fig. 6 (top). Average frequencies of 5.6 Hz, 10.7 Hz, and 18.4 Hz and amplitudes of 7°, 4.5°, and 1.5° were recorded. Unlike the subject of Coren and Komada (1972), the present subject maintained a continuous response, rather than "short bursts of activity, followed by resting periods." Furthermore, this control is contrary to Blair *et al.* (1967) and Aschoff *et al.* (1976) who report control over the duration but not the rate or amplitude of voluntary nystagmus.

DURATION SEQUENCE

The frequency and amplitude of voluntary nystagmus could be maintained on the average for 25 s under all conditions. Figure 6 (bottom) shows relatively constant frequency and amplitude components when the first and last 15 s were compared for one subject who could produce voluntary nystagmus for 90 s. After five to six trials separated by 10 to 30 s, the duration decreased and an extended rest period was required, suggesting that the duration varies inversely with the number of trials.

Discussion

Our survey showed that 8% of a college age population could produce voluntary nystagmus. The ability is usually recognised at about 8 years of age. Seventy-nine per cent of this population claimed to have a relative who could produce voluntary nystagmus.

Voluntary nystagmus is a type of pendular nystagmus. Its frequency is greater than that found for latent, miner's, and gaze-paretic nystagmus (4–5 Hz), less than the tremor component of physiological nystagmus (30–90 Hz), but similar to certain types of ocular oscillations such as ocular flutter and opsoclonus (13 Hz), and to the convergence tremor of Elsching (16–17 Hz), except that the latter requires converged eyes (Higgins and Stultz, 1953; Gay *et al.*, 1974; Ellenberger *et al.*, 1976). As noted here, convergence may increase the frequency of voluntary nystagmus at 400 mm

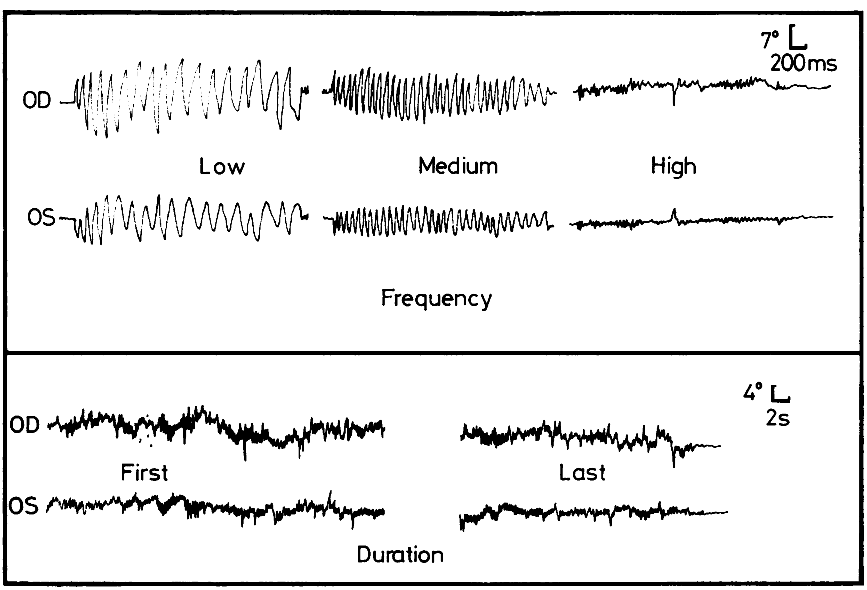

Fig. 6 *Upper records show infrared eye movement recordings for one subject while attempting to change the frequency of voluntary nystagmus. The terms low (6 Hz), medium (11 Hz), and high (18 Hz) refer to the frequency ranges. There was a two minute rest period between the three frequency measures. Lower records show frequency and amplitude of voluntary nystagmus for the first and last 15 seconds of a 90 second record.*

but it is not necessary to maintain voluntary nystagmus. Furthermore, unlike congenital pendular nystagmus (Dell'Osso and Daroff, 1975), voluntary nystagmus does not require fixation for initiation and is not abolished with eye closure or darkness.

Taken together, these data indicate that voluntary nystagmus resembles, in waveform, pendular nystagmus and in frequency certain forms of ocular oscillations.

Voluntary nystagmus cannot be maintained, on the average, for more than 25 s. Thus the duration and frequency of voluntary nystagmus permit differentiation from other forms of nystagmus. Furthermore, its similarity to oscillations which have been identified with dysfunctions of the cerebellar nuclei (Aschoff, 1974), in particular the "hold" mechanism (Kornhuber, 1974), suggest that voluntary nystagmus may be produced by this mechanism.

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Notes