Glossary for Chapters 9 through 11

Amplitude The size of an eye movement (measured in angular degrees), either horizontal or vertical excursion (e.g., "The amplitude of the saccades was 20°").

Ballistic Having characteristics similar to the trajectory or path of motion of a projectile after it is launched. Implies lack of any ongoing control or guidance. Used in reference to fast eye movements (saccades), the course of which is regarded as ballistic.

Bandwidth Range of input signal frequencies processed without major distortion by a given piece of electronic equipment or by a given physiologic system.

Closed-loop system In control-systems theory, a system that has feedback by the way of some connection, such as a neural pathway. In such systems the output signal is monitored and fed back to the input signal; it can be either added to or subtracted from the input signal. In the control of eye movements, the output (eye movement) may be fed back by measurement of the retinal error to determine accuracy. If there is a retinal error, a corrective eye movement may be made (see also Fig. 9–7).

Continuous Uninterrupted in time. In eye-movement control, this refers to a system that is continuously monitoring eye position or velocity (*e.g.*, the pursuit system performs accurate tracking of a moving target by continuously recognizing differences between velocities [rates of change] of the target and of the eye).

Control system A mechanism that functions to maintain its output at a given level dependent upon an input reference signal. In eye movements, a system that functions to bring images from the peripheral retina to the fovea and/or to maintain foveation, as during pursuit of a moving target. The output is the eye movement; the input reference signal is the position or velocity of the retinal image.

Cyclopean eye A reference eye theoretically located midway between, and in the same place as, the two anatomic eyes.

Damp (damping, damped) To retard the energy or reduce the amplitude of a movement (*e.g.,* convergence may damp the oscillation of the eyes in congenital nystagmus).

Differentiation A mathematical operation that yields a measure of the rate of change of a variable (*e.g.,* the slope of a straight line). Differentiation of eye position with respect to time will define velocity at a given instant.

Discontinuous Interrupted in time. In eye-movement control, this refers to a system that samples eye and target positions at discrete intervals (*e.g.,* the saccadic system intermittently samples differences between target and eye positions).

Discrete Consisting of separate, individual parts or date points. In eye-movement control, this refers to a system that is monitoring eye position or velocity at or during finite intervals (*e.g.*, the saccadic eye-movement system).

Displacement The total distance that a target, retinal image, or eye has moved.

Exponential A mathematically defined motion with a constantly increasing or decreasing rate of change. Graphically seen as a curving rather than a straight line.

Feedback Return of portions or entire output signal information to influence the input signal (*e.g.*, continuous return of eye-movement data [output] to the system controlling eye movements). See **Closed-loop system.**

Feedback (negative) Subtracting portions of a system's output from its input (*e.g.*, subtracting a new retinal image position closer to the fovea from a prior image position further in the periphery in an attempt to reduce the eccentric image position [retinal error] to zero and produce foveation).

Feedback (positive) Adding portions of a system's output to its input. In eye-movement control, such addition causes greater retinal error.

Foveate (foveation, refoveation) To bring a peripheral retinal image onto the fovea (by way of a saccade) or to maintain the image on the fovea during target movement (by way of pursuit).

Frequency Number of oscillations per second or cycles per second, measured in Hertz (Hz) (*e.g.*, a nystagmus cycle [slow and fast phase] that is completed five times per second has a frequency of 5 Hz).

Gain The ratio of a system's output to its input (*e.g.*, when the eyes move 20° [output] in response to a retinal-image position error of 20° [input], the gain of the eye-movement system is output/input: 20°/20°=1).

Generator The source of a signal. The pontine reticular formation is regarded as the final prenuclear source or generator (pulse generator) of the neural signal for horizontal eye movements.

Hertz (Hz) See **Frequency**.

Input The information signal upon which a system operates (*e.g.*, retinal-position error [image not on fovea] that elicits voluntary ocular refixation to new target positions [with image on fovea]).

Integrator (integral, integrate) A mathematical function/operation analogous to summation. The inverse operation is differentiation (*e.g.*, in eye movements the integral of the velocity yields eye position). A brainstem neural integrator processes information to produce a signal proportional to eye position. If the integrator is imperfect or leaky, the neural signal

tends to change and the eye drifts from an eccentric gaze position toward primary position, resulting in nystagmus (see also Fig. 9–8).

Latency   Reaction time after a specific stimulus (*e.g.*, with a shift in target position, there is a 200-millisecond interval before eye movements begin [see Fig. 9–3]).

Linear (nonlinear)   Can (cannot) be described by a simple straight-line relation.

Neutral zone   That eye position (region of gaze angles) in which a reversal of direction of jerk nystagmus occurs and in which any of several bidirectional waveforms, pendular nystagmus or no nystagmus, may be present.

Null   Field of gaze in which nystagmus intensity is minimal (see Fig. 11–12).

Open loop   A control system with no feedback from output to input (*e.g.*, the vestibulo-ocular system is open loop, since there is no feedback from the output [compensatory eye movement] to the input [acceleration stimulating the semicircular canals]).

Output   The outgoing signal resulting from a system's response to an input signal or signals (*e.g.*, a saccadic eye movement [output] in response to a peripheral retinal image or target displacement [input]).

Plant (plant dynamics)   The globe, muscles, check ligaments, fascia, and fatty supporting tissues of the orbit have physical properties described as viscoelastic (including inertia); these characteristics can be defined mathematically. In general, the orbital plant dynamics have a braking (damping) effect on eye movement.

Position error   Discrepancy between position of eccentric retinal image and the fovea. Represented in space by the difference between target position and visual direction of the eye. Position error is the stimulus for foveation and is an example of a feedback signal.

Pulse   A high-frequency burst of neural firing beginning and ending at well-defined times (see Fig. 9–5B).

Pulse-step   A high-frequency burst followed by a constant frequency of neural firing beginning and ending at a well-defined time. It is pulse-step of neural firing

that brings about a saccade or rapid change in eye position (see Fig. 9–5B).

Ramp   A linearly increasing frequency of neural firing beginning at a well-defined time (see Fig. 9–5C).

Rectilinear   In a recording system, this refers to pen motion perpendicular to paper motion.

Retinal error   Distance on the retina between eccentric image and fovea. See **Position error.**

Retinal-slip velocity   Rate of change of retinal error.

Saccade   A fast eye movement, voluntary or reflex, usually accomplishing foveal fixation.

Sampled data   System operating on information gathered at separate time intervals, as opposed to continuous data analysis (*e.g.*, the saccadic eye-movement control system has been considered a sampled-data system).

Signal   An electrical or neural analog to a physical quantity (*e.g.*, input and output signals).

Sinusoidal   A mathematical function that describes the motion of a pendulum. Ordinary house current is sinusoidal. In pendular nystagmus the eyes oscillate in a sinusoidal fashion.

Step   A constant frequency of neural firing beginning at some well-defined time (see Fig. 9–5A).

Step-ramp   A constant frequency added to a linearly increasing frequency of neural firing beginning at a well-defined time (see Fig. 9–5D).

Target   An object of regard. Stimulus for foveation and fixation.

Time constant   A measure of the response time of a system to a transient input (*e.g.*, the response of a system to a step change in input is usually considered to be the interval given by 3 to 5 time constants).

Trajectory   The motion of a target or eye in time and space.

Transfer function   The mathematical function that is the ratio of a system's output to its input, the magnitude of which is the gain of the system.

Velocity error   The rate of change of position error (*e.g.*, the difference between the velocity of the tracking eye and of the target).

Neuro-ophthalmology

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