METHODS & DESIGNS

A pseudoperceptual display system for investigating human statistical decision processes

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A CRO display system is described in which a random sequence of dots appears on the CRO derived from a Gaussian distribution with a specified mean and standard deviation. Os are required to make judgments about the statistical parameters of the distributions.

Many recent studies of perceptual problems have utilized a normative decision model as a description of human perceptual decisions (e.g., Green & Swets, 1966). However, there have been difficulties in measuring directly the efficiency of such perceptual judgments, since in most cases the statistical parameters of the stimulus situation cannot be measured exactly. The present paper describes a situation in which the relevant parameters can be specified precisely.

The experimental task involves judgments about parameters of a random Gaussian distribution of dots displayed sequentially on an oscilloscope screen along the vertical (Y) axis only. By this means, both "noise" or background (B) and signal (S) values are normally distributed, with the standard deviation of the distributions directly measurable. A signal consists of an upward deviation (or shift) of the dot distribution along the vertical axis. In addition, signal sample size is determined precisely by the number of observations in the sample or, in this case, the number of dots displayed sequentially on the CRO screen in a given sampling period. The O's task is to decide, on each trial, whether a given sample or sequence of dots came from the "noise"

distribution or from the deviated (signal) distribution.

In contrast with many typical perceptual situations, sensory transformations do not contribute directly to the magnitude of the "noise" involved. Investigations using the system are concerned directly with the actual decision processes involved in the perceptual task. Thus, ideal performance can be specified in all respects, enabling direct measures of efficiency to be obtained from a comparison of ideal and O performance.

The experimental setup involves a random sequence of dots appearing on a CRO screen, derived from a Gaussian distribution with a measurable mean and standard deviation. A shift in the mean level of this distribution during a specified temporal interval constitutes a signal.

Figure 1 shows the block schematic arrangement of the apparatus. An input (Y1) to the display oscilloscope from the random signal generator produces a random Gaussian waveform along the Y-axis only when the X time

base is switched off (i.e., a one-dimensional display). The control unit incorporates a device for modulating the trace brightness and a variable-frequency multivibrator (MV). At each pulse from the MV only a single small illuminated dot can be seen on the screen at a position along the Y-axis determined by the variable output from the random signal generator. Consequently, a discrete random sequence of dots appears on the CRO screen at a given frequency (i.e., a single dot appears sequentially at random positions up and down a single centralized vertical line—the Y-axis). Mean level and standard deviation are measured by a standard voltmeter and a rms meter. An observation interval or sequence on each stimulus trial is indicated by an equivalent sequence of auditory "pips" through a loudspeaker or earphones.

Signal "intensity" is determined by an upward shift of the mean level of the random noise distribution of dots along the Y-axis. This is achieved by applying to the Y input a bias voltage, directly related to the mean value and standard deviation (or rms V) of the distribution. Stimulus presentation, intensity values, and signal sample size are controlled by means of a programmed output from a tape reader, driven by an amplified pulse output from the MV. Alternative

Fig. 1. Block schematic diagram of the CRO display system.

Fig. 2. Temporal representation of a typical CRO dot display, with a signal sample of four dots indicated by n at a signal intensity of 1.0 SD. The ordinate represents the vertical position of the dot along the Y-axis of the CRO screen. Dots indicate auditory pips defining the sample set.

Fig. 3. Circuit diagram of the control unit.

Table 1
Component Designations for Control Unit

R1	2.2K	R13	10K	C1	0.01 mfd	VT1	BSY95
R2	10K	R14	100K	C2	0.003 mfd	VT2	BSY95
R3	6.8K	R15	10K	C3	25 mfd	VT3	BSY95
R4	2.7K	R16	11K	C4	1.6 mfd	VT4	BSY95
R5	3.3K	R17	10K	C5	0.001 mfd	VT5	BSY95
R6	2.2K	R18	1.6K	C6	1.6 mfd	VT6	BSY95
R7	1.6K	R19	1K	C7	0.001 mfd	VT7	OC200
R8	2.7K	R20	10K	C8	0.1 mfd	VT8	OC84
R9	10K	R21	47 ohm			VT9	OC84
R10	1 megohm	R22	6.2K				
R11	15K	R23	2.2K				
R12	100K		All resistors 0.125W				
RV1	10K Preset	S1	course frequency control				
RV2	100K Preset	S2, S2a	free run or "one-shot" selection				
RV3	220K Preset	S3	tape-reader on/off switch				
RV4	470K Preset	S4	tape-reader contacts				
D1	OA200	S5	push button for "one-shot" mode				
D2	OA5	RL/1	12 V dc, 160 ohm coil				

systems of programmed switching may, of course, be used instead.

The CRO used in the present setup is an Airmec 279 display oscilloscope with a 17-in. tube. Its Y sensitivity range is linearly related to the voltage applied. The random-signal generator is a Servomex Type RG 77, which incorporates a thyatron source producing a flat noise spectrum over the frequency range of 30 Hz to 30 KHz. Its output is variable up to 5 V rms; for present purposes it is typically set at 1 V rms.

The control unit (see Fig. 3) consists of a free-running,

emitter-coupled multivibrator (MV) with a bistable driving the output stage. This type of MV has excellent rise and fall time characteristics (Lewis, 1967), giving a good square wave at very low frequencies. In the present setup, the MV has switched resistive frequency components to give frequencies of 1, 2, 4, and 8 pulses/sec; fine frequency control is obtained by preset miniature potentiometers. There is also a "one-shot" setting, allowing one pulse to pass whenever a manual pushbutton is depressed. This is used in "deferred decision" procedures, when Os are

allowed to make as many observations as they need in order to reach a decision about the parameters of the sampled distribution (e.g., Swets & Birdsall, 1967). The circuit utilizes Emitter Followers VT3 and VT6 as interstage buffers. The output of the bistable is fed into an amplifier (VT7 and VT8), which drives a 12-V relay and a pulse output from VT9 via a capacitor (C7) to the Z modulation socket of the CRO. A capacitor value of 0.001 mF was selected to produce a small well-focused spot on the CRO screen.

The bias network is used to control signal levels and contains a small 15-V dc power supply. This is applied via a bias on/off switch to a three-position rotary switch connected to potentiometers. Preset bias voltage levels, giving variable shifts along the Y-axis, can thus be switched in according to a given programmed sequence.

REFERENCES

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