An N-channel stroboscopic tachistoscope for typewritten stimuli¹

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The n-channel tachistoscope described employs the principle of "stopping" a continuously moving list of words by means of stroboscopic flashes of light. It can present as many as 50 stimuli per trial at any rate between 5 and 40 items per second. Stimulus materials can be prepared on an electric typewriter. It provides only partial control over the various time parameters.

In a recent article, Ericksen, Schurman, and Richter (1969) have reviewed the relative merits of various n-channel tachistoscopes, including two of their own design. As they indicate, computer-controlled displays have the advantages of precise control of time parameters, flexibility in programming, and essentially an unlimited number of channels. Their major disadvantages are high cost, which puts them well beyond the reach of most laboratories, and the unfortunate property of displaying stimuli as white dot patterns on a darker ground. The two tachistoscopes described by Ericksen et al, based on conventional optical devices, are less expensive and have equally precise time control. But they provide at most 10 channels, require photographic preparation of stimulus material, and are relatively complex in construction. These restrictions are a considerable handicap when each S must be tested on a considerable range of stimulus items, as is the case in studies of word recognition, visual search, and immediate memory. For such studies, it would be desirable to have an n-channel tachistoscope in the Ericksen et al price range but with additional channels, more easily prepared stimulus materials, and simpler construction and maintenance features. The stroboscopic tachistoscope described in this article meets these requirements but with the sacrifice of some control over time parameters. It is appropriate mainly for studies using verbal materials; it is not readily adaptable to other types of stimulus material or for precise studies of visual processes.

Two considerations determined the design of the present apparatus. Primarily, we wanted to be able to prepare all stimulus items on a conventional typewriter. While this would restrict the range of material to phrases, words, letters, and like symbols, it would minimize the labor involved in generating stimulus items, and it would provide a flexible way of changing the sampling and sequencing of items for successive trials. Secondly, we wanted to eliminate complex optical systems for presenting the stimuli, and elaborate electronic systems for controlling the time parameters and sequencing, so as to minimize cost and construction difficulties. It proved relatively easy to meet these requirements once it was observed that words typed on regular paper were easily read when the page was illuminated from behind by means of stroboscopic flashes of light. It seemed apparent that this would still be the case

when the list of words, typed in a vertical column, was driven mechanically at a continuous rate behind a viewing aperture. If the strob light was flashed only when each word was centered in the aperture, the brief duration of the flash should "stop" the word, and the high intensity of the flash should produce a sharp image. This is the principle employed in the stroboscopic tachistoscope.

The front of the apparatus consists of black fiber board attached to a vertical frame. The viewing aperture, a horizontal slot 1½ in. long and 3/16 in. wide, is located 12 in. from the bottom of the frame. Directly in back of it is a metal holder for Polaroid filters that control the intensity of the light. Between trials, the aperture is dimly illuminated from the rear in order to permit S to focus on the surface of the stimulus sheet prior to initiating a trial. Normally, a rectangular reading glass that magnifies the stimulus image in the

Fig. 1. Back view of the stroboscopic tachistoscope, with the strob lamp pivoted to the side and the stimulus-list holder open for the insertion of a new list.

ratio of 1.1 to 1 is mounted in front of the aperture. An adjustable chinrest, 15 in. in front of the apparatus, provides a constant alignment for S's head on successive trials.

A back view of the stroboscopic tachistoscope is shown in Fig. 1. (The strob lamp has been pivoted to one side and the stimulus holder lowered for the insertion of a new stimulus list.) The basic unit is the sliding plate, a piece of aluminum, 12 x 12 x 1/16 in., fitted into the milled grooves on the sides of the rectangular steel frame, 12 x 24 in. It is bolted to a notched timing belt that runs over the two notched timing pulleys (12L). The lower of these two pulleys is directly attached to the shaft of a Bodine dc motor (Model NSH-34 RH with a 10-to-1 reducing gear). The Minarik control (Model Sh-33) for this motor has been rewired through a system of relays. An upward motion of the sliding plate is initiated by an S-controlled switch, and a "positive" braking action is applied when the plate contacts a microswitch at the top of the frame. A downward motion is initiated by an E-controlled switch, and the brake applied upon contact with a microswitch at the bottom of the frame. The speed of movement is preset by E on the Minarik control. In addition, S has a second switch that stops the sliding plate at any point during the upward movement. This is used in studies involving reaction-time measures.

With the present gearing system, the sliding plate can be moved at any value between 2/3 and 8-1/3 in./sec. In terms of typewritten material with 6 lines per inch, this is a range of 4 to 50 lines per second or, in terms of interstimulus interval (ISI), 250 to 20 msec. The practical upper limit of the present model, however, is 40 lines per second (an ISI of 25 msec) because of limitations in the photocell system, as described below. These rates are calibrated and monitored by means of a Standard electric timer, recording to the nearest 1/100 sec, that is activated throughout the duration of the upward movement. Their consistency from trial to trial is indicated by the results of a calibration study. The control was set for 5, 10, 20, 30, and 40 items per second, and 25 consecutive times were recorded for each setting. When the range of these 25 times was divided by the initial time setting, the relative variability (which includes both random intertrial variation and systematic drift) was less than 1.5% for each setting. Nor was there any systematic change in this value with different absolute rates. It should be emphasized, however, that the motor speed is quite sensitive to changes in line voltage.

The stimulus list holder is shown in the oper. position in Fig. 1. It consists of two thin aluminum plates. The inner one is a

rectangular frame, 8½ x 11 in., that holds the stimulus list. It can be moved vertically with respect to the outer plate by means of a rack and pinion. This permits the positioning of the stimulus list so that each item appears in the center of the viewing aperture. The outer plate of the stimulus list holder is attached to the sliding plate by means of hinges at the bottom and a magnetic latch at the top. Each of these plates has a cut-out vertical slot, 3 x 10 in., so centered that the light of the strob lamp passes through the paper and the viewing aperture.

On the left side of the sliding plate, a series of 66 holes, .055 in. in diam, are spaced 1/6 in. apart in a vertical column. Aligned with this column is a 7-W clear-glass filament lamp fastened to the front of the vertical frame and a photocell (Clairex CL-603) fastened to the back of the frame. The latter is inserted in a metal capsule with a 1/8-in. horizontal slot on the end facing the sliding plate. A set of adjusting screws permits the light from the lamp filament to be imaged on the photocell. A variac in the light circuit controls the intensity. Thus, the photocell is activated each time the sliding plate moves 1/6 in. or the equivalent of one line of type.

The output of the photocell is fed into a light-impulse detector that was built locally. It, in turn, produces an electrical impulse of the appropriate voltage and duration to trigger the strob lamp. Its characteristics, of course, are specific to the photocell and stroboscopic unit employed. In the present apparatus, it also produces a second signal that activates a Hunter Klockounter (Model 120A), so as to permit monitoring of the photocell's reliability.

Two different stroboscopic units have been used in the present apparatus, the Grass Photo Stimulator (Model PS-2) and the General Radio Stroboslave (Type 1539-A). The former produces a relatively white light and its lamp is reasonably quiet, but it is expensive. The inexpensive Stroboslave has proven to be quite adequate, despite the bluish cast to its light and its relatively noisy lamp. At high rates of stimulus presentation, each of these strob lamps must be run at less than maximum intensity in order to insure reliable and continuous firing. This restriction on intensity is unimportant in most cases, however, as Polaroid filters are usually inserted between the stimulus sheet and the viewing aperture in order to further reduce the intensity.

The preparation of stimulus material must be standardized to insure consistent results. Initially, we attempted to use the printout from a PDP-8 computer as

stimulus material. It soon became apparent that there were gross differences from list to list in the blackness of the letters and in the positioning of the first word of a list with respect to the top edge of the page. These variations resulted in marked changes in contrast and in the centering of items in the viewing aperture from list to list. To correct these faults, it was necessary to retype each list on an electric typewriter with a film ribbon. This provided uniform contrast. Consistent positioning on successive sheets was achieved by printing guide marks for the typist on the stimulus sheets.

The adequacy of the present device as a simple tachistoscope is indicated by the following exploratory study. A pool of 500 common six-letter words was accumulated and each word was centered and typed on a single sheet of paper. Each of eight naive Ss was then given 50 consecutive trials at each of 10 speeds between 6 and 40 flashes per second. A hundred trials were run in each 50-min session. The S saw a bright preexposure field generated by 30 flashes of the strob light, the stimulus word on the 31st flash, and a bright postexposure field generated by the remaining 35 flashes. Irrespective of speed, the Ss correctly identified 99% of the words.

Nonetheless, the present apparatus has a number of limitations as an n-channel tachistoscope. It was designed for typewritten material and is not readily adapted to geometrical forms or like stimulus material. Also, it does not permit control over many of the important variables in visual research. No variations in stimulus intensity are possible within a given trial. Nor does E have any control over the stimulus-exposure duration. Commercial strob lamps have a fixed flash duration in the range of microseconds. The two variables that E can manipulate are the speed of movement of the sliding plate and the spacing of items on the stimulus list. The former controls the length of the dark period between flashes, i.e., the interflash interval (IFI), and the two combined control the interstimulus interval (ISI) as well as the number of flashes interpolated between stimuli. This restricted control has some unfortunate effects at slow rates of stimulus presentation. If the items are single-spaced so that IFI and ISI are equal, i.e., a new item appears with each successive flash, flicker effects become highly noticeable and distracting when 10 or fewer items per second are presented. If items are double- or triple-spaced and the speed is increased correspondingly so that ISI remains the same but IFI decreases, flicker effects are no longer distracting, but instead, there appear to be slight changes in contrast. Finally, it should be noted that E

has only limited control over successive ISI in a given list. For instance, if the ISI between Items 1 and 2 is fixed, then the ISI between Items 2 and 3 must be some multiple of this value. This results from the fact that the only way to vary ISI for a fixed speed is to vary the spacing between items.

As indicated previously, the shortest feasible ISI with the present apparatus is 25 msec. The photocell system is unable to follow at shorter intervals due to unavoidable scattering of light as it passes through the hole in the sliding plate. To shorten the interval, it would be necessary to change the gear ratios as well as to

modify the photocell system. It would appear feasible to have two parallel columns of holes on the sliding plate, the holes in one column aligned with the odd-numbered stimulus lines and the holes of the other aligned with the even-numbered lines. Then, if each column had its own independent light source, photocell, and light-impulse detector, the two outputs could be fed in common to the strob unit. Theoretically, the wider spacing of the holes in a given column should handle the problem of light scatter while permitting the present minimum ISI to be halved.

The costs of the major components were

as follows: motor and control unit, \$130; stroboslave, \$195; and light-impulse detector, \$60.

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The use of hypothermia in split-brain surgery on the rat¹

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A method of simple split-brain surgery on the rat is described. Rats were anesthetized, subjected to hypothermia, and split-brain surgery was performed. With precautions to avoid overdose of anesthetic, limit the minimal temperature to 22°C, and regulate the rate of rewarming, animals survived and on the day following surgery showed no adverse effects. No extensive tissue degeneration was found.

In the past decade much interest has been aroused by research involving split-brain preparations. Generally, publications based on this method of animal research have come from laboratories with facilities large enough to house and maintain larger animals (e.g., cats and primates). These laboratories have also been equipped for antiseptic surgery, the surgical procedure involving careful aspiration of neural tissue connecting the two brain halves (Sperry, 1968). In an animal smaller than a cat, the small size of the decussation and the limited skull area available for access makes this surgery very difficult.

In an effort to devise a more practical surgical method for use with the laboratory rat, the use of hypothermia was explored. By reducing body temperature and using an anesthetic to prevent thermogenesis by shivering (Boba, 1960), it is possible to reduce heart rate, cardiac output, arterial pressure, and oxygen consumption, and increase blood viscosity (Bigelow, 1950; Bullard, 1959).

The brain also shows a general reduction

of metabolic rate during hypothermia, which is completely reversible upon rewarming (Fazekas & Himwich, 1939; Lougheed, Sweet, White, & Brewster, 1955; Rosomoff & Holaday, 1954).

In humans, all measurable nervous activity disappears below 25°C to 20°C (Henderson, 1966). In other homeotherms, the temperature at which activity ceases varies. The rat, at 22°C, shows activity greatly reduced from that recorded at 36°C, according to electrocorticograms made locally.

Of special importance in neurosurgery is the fact that brain volume, intracranial pressure, cerebrospinal fluid pressure, and venous pressure are also reduced (Rosomoff & Gilbert, 1955). In comparing an experimentally produced injury during hypothermia with one produced during normothermia, it has been shown that the area of inflammatory reaction is more localized under hypothermia and that the progress from the exudative stage to the reparative stage is more rapid (Rosomoff, 1959). In the Rosomoff study, hypothermia was discontinued 1 h after injury. Continued hypothermia was unnecessary to obtain the desired effects (Rosomoff, 1959).

While body temperature in dogs has been reduced experimentally to 1.5°C with complete recovery (Gollan, Tysinger, Grace, Kory, & Meneely, 1955), in practice, a minimum temperature of 22°C should be observed in surgery with the rat. Fatal ventricular fibrillations occur in most homeotherms between 20°C and 22°C (Nielsen, Owman, & Rosengren, 1968; Bennett, Smookler, & Buckley, 1968). These fibrillations appear to be the result of sympathetic nervous-system activity.

Normal rhythmic activity has been maintained below 20°C by using an adrenergic blocking agent (Nielsen et al, 1968) or by reducing epinephrine output to practically zero by drug effect (Bennett et al, 1968).

Respiratory failure is also a problem at 22°C (Boba, 1960). It has been suggested that this may be the result of an overdose of the anesthetic. With the reduced metabolism, less and less anesthetic is required as the body temperature drops and an overdose easily occurs (Boba, 1960).

METHOD

Rats of approximately 300 g were anesthetized with a 3% solution of chloral hydrate, using 1 cc for each 100 g of body weight. An incision was made through the skin, and the skull was scraped clean. Four small holes were drilled through the skull as far laterally from the central sagittal suture as possible. These holes assist in the release of any pressure build-up during or after rewarming.

Rectal temperature was monitored. Temperatures ranged from 34.5°C to 36°C.

Cooling was initiated by laying the animal on a plastic bag filled with crushed ice and placing another bag of ice on its back and neck. Body temperature fell at a rate of approximately 3°C in 5 min, depending on the body area in contact with the ice bags and the surface-to-mass ratio.

Caution was exercised to prevent the reduction of the temperature below the minimum desired. As the method is one of indirect bloodstream cooling, the area in contact with the ice bags will be cooler than the core temperature measured by the