References and Notes

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The Cutaneous "Rabbit": A Perceptual Illusion

Abstract. *Anomalous localizations of mechanical and electrical cutaneous pulses are produced when widely separated bodily points are successively stimulated with trains of taps. The observer experiences a manifold of discrete "phantom" impressions connecting the points actually touched. The theoretical basis for this perceptual phenomenon is not understood, but some boundary conditions are specified.*

In the course of designing some experiments on the cutaneous perception of mechanical pulses delivered to the back of the forearm, it was discovered that, under some conditions of timing, the taps produced seemed not to be properly localized under the contactors. For example, if five brief pulses (2-msec duration each, separated by 40 to 80 msec) are delivered to one locus just proximal to the wrist, and then, without break in the regularity of the train, five more are given at a locus 10 cm centrad, and then another five are added at a point 10 cm proximal to the second and near the elbow, the successive taps will not be felt at three loci only. They will seem to be distributed, with more or less uniform spacing, from the region of the first contactor to that of the third. There is a smooth progression of jumps up the arm, as if a tiny rabbit were hopping from wrist to elbow. If the original timing is retained and the number of taps (N) at each locus is reduced, the hops get longer; if N is increased (up to a limit), the hops become shorter.

An adequate explanation of this striking phenomenon is not yet at hand. Several hypotheses have led to interesting experiments and, in a few instances, to crucial ones that have destroyed the hypotheses. It is thus possible to identify with certainty some principles not at work; it is more difficult to demonstrate vital contingent conditions.

The experimental arrangements should be described briefly. Two or more contactors, made of short lengths of Lucite rod (0.6 cm diameter) slightly rounded at the tips and mounted rigidly on the free ends of Clevite bimorph benders, are driven by trains of square-wave pulses from a system comprising a Tektronix 162 waveform generator, a 161 pulse generator, and a Langevin power amplifier. This combination permits a pulse of constant duration (2 msec) but with interpulse durations varying over a wide range. Intermediate between the bimorphs and the electrical driving system is a Tally tape reader. Eight-channel tapes may be prepared with any desired program of pulses; N, interstimulus interval (ISI), and overall duration can be made to vary independently of each other. In our experiments the contactors, two to five in number, rested on the skin with an initial static pressure of 15 g. The forearm rested on foam rubber and was immobilized with small sandbags.

Several interrelated questions arise at once. Is the rabbit effect an accident of the direction in which the contactors are successively energized? Is distance important? Is the ISI crucial? How does the effect vary with N? Does irregularity of pulsing alter the result? Are repetitions of a given sequence necessary to induce the effect?

Direction of sequence is not a vital matter; hopping can go down the arm as well as up it. Indeed, it is possible to have hopping in both directions at once. Five contactors were set on the forearm in lineal array. Contactor 3 was first energized, then contactors 2 and 4 (simultaneously), then 1 and 5 (also simultaneously), five successive pulses being delivered to each. The reverse (a "rabbit" collision) occurred when the sequence was reversed. It would be interesting to investigate other possible collision courses, since there is typically the impression that the taps extend beyond the terminal contactor.

Hopping has been observed when two contactors are as close together as 2 cm and as far apart as 35 cm. In one experiment it was possible to induce a vivid hopping that traveled up one arm, across the neck, and down the other arm by the use of five contactors, two widely separated on each arm and one on the nape of the neck.

The time between taps is not very critical; good, well-spaced hopping occurs over a wide range of ISI values. The first incipient stirrings from under the contactors—what we have dubbed the "threshold of exodus"—occurs with an ISI of about 200 msec. Two observers gave exodus thresholds (method of constant stimuli) of 193 and 205 msec, respectively. As ISI is shortened, N remaining constant at 5, there is wider apparent straying from the contactor locus, and at about 100 msec the hops are becoming somewhat evenly spaced. With further reduction of the ISI the trains of taps become faster until an ISI is reached (40 to 60 msec) for which the hopping is optimal in regularity and vividness. With further shortening of ISI, the perceived N becomes illusory. The 15 taps delivered to the three contactors may seem to be only six when the ISI is 20 msec.

The role played by N is not very important so long as not too many pulses are delivered at one locus. An N of 2 is adequate, though the effect is better with N of between 4 and 6. An N of 18 is too large; the taps tend then to get "anchored" under the contactor, and hopping does not occur. The effect occurs when N is 12, but less impressively. Probably N and ISI are interrelated; a systematic experiment would be needed to establish the facts.

Irregularity of pulsing disturbs the rabbit effect. With four pulses on each of three contactors the omission of a single pulse between trains does not destroy the effect but reduces its distinctness; faster overall presentation rates are then required to preserve the effect. Insertion of two blank intervals brings about an irregular rhythm at some speeds. Three and four blanks seem impossible to bridge; the effect is then totally destroyed. The interrelations among N, ISI, and gap length would be worth investigating.

No repetition of sequences at all is necessary to produce the rabbit effect. With favorable ISI, hopping may be induced with a few pulses on one contactor and (without break in rhythm) only a single one on a spatially removed contactor. With such paucity of stimulation the effect is not a lively one, but it is unmistakably there.

As to theoretical bases, an early hypothesis was that a traveling mechanical shock wave was being sent through the skin and underlying tissues with each brief pulse of the contactors, and that the anomalous localizations produced must represent reflections, impingements of surface waves on stationary contactors, and perhaps standing waves of some complexity. Such speculation was brought to naught when the "traveling wave" idea was tested by eliminating the wave but preserving comparable stimulation. This was done by substituting for the mechanical tap an electrocutaneous one.

The "rabbit" could not be electrocuted. Three pairs of electrodes, each pair separated from the others by its own isolation transformer, were arrayed on the forearm in a fashion analogous to that with the mechanical contactors. Trains of five 2-msec pulses separated by ISI's between 300 and 30 msec were delivered sequentially to the electrodes. Painless although sharp "taps" were felt at all loci, and, more important, the rabbit effect was present as with mechanical taps. Not all the variables investigated with the mechanical pulses have yet been studied with the electrocutaneous ones, but there appears to be no essential difference in the effects of the two modes of stimulation. The electrocutaneous rabbit effect is more vigorous because of its qualitative advantage—the taps are sharper—but timing is much the same in the two instances and the optimal effect is in the same parametric range.

A comparison can be made with synthetic movement ("phi" phenomenon), reported commonly for visual and also for haptic, especially vibrotactile, stimulus arrays (*1*). Any simple equating of the present phenomenon with apparent movement on the skin is discouraged by qualitative considerations, however. Vibrotactile movement is perceived as a vibrating, continuous "gouging" of the skin between loci of stimulation. The rabbit effect gives a quite discontinuous and altogether superficially localized impression, as unlike apparent vibrotactile movement as light contact is from deep pressure. Moreover, vibrotactile movement never yields a discrete tap between stimulus loci and this, of course, is the very essence of the rabbit effect.

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Metacontrast and Saccadic Suppression

Abstract. *A vertical slit of light illuminated during horizontal saccadic eye movements appeared as a horizontally extended smear when stimulation was terminated before the saccade ended. However, on trials for which duration of illumination of the slit was extended into the period after the saccade, the smear appeared shorter and dimmer, and a clear image of the slit was seen. With further increases in duration, no smears were seen at the highest luminance of the slit employed, although smears were more than 2 log units above threshold when flashes were brief. This saccadic suppression is discussed in terms of metacontrast, with the accumulated luminance in the period after the saccade primarily responsible for masking the effects of the stimulation received during the movement of the eye.*

When an individual changes his direction of gaze by means of a saccadic eye movement, an image of the environment sweeps across his retina at very great speeds (*1*). However, the blurring of perception that might be expected from this rapid movement does not occur under ordinary viewing conditions. The perception of the saccadic smear is suppressed (*2*).

Suggestions about a major cause of this suppression grew out of experiments in which we presented flashes of fixed luminance during saccades and varied the duration of the flash from trial to trial. In preliminary work, these flashes were presented on an otherwise dark field as the eye crossed the midpoint of a 2° horizontal saccade. The resulting spread of light on the retina was perceived as a luminous pattern, the apparent length of which was a function of the duration of the flash. For stimuli that were extinguished before the end of the saccade, this saccade-generated pattern appeared simply as a horizontally extended smear, which increased in length with increasing durations of the flash. When the flash extended sufficiently far into the period after the saccade, a sharp image of the flashed stimulus was seen at one end of the smear. These results are in simple correspondence with the spatial distribution of light on the retina. However, on trials with flashes of longer duration (extending further into the period after the saccade) the smeared portion of the perceived pattern appeared shorter and dimmer. When duration of the flash was increased even further, no smear was seen at all, and the stimulus appeared as it did when presented to the fixating eye. These results with longer flashes would not be predicted from the classical theory that attributes saccadic suppression to a central inhibition; neither would they be expected of suppression that is due to a shearing of the retina produced by the movement of the eye (*3*). Instead, they suggest that temporally backward and spatially lateral inhibition (metacontrast) occurs when the duration of the flash is long enough to permit sufficient temporal integration of illumination in the period after the saccade to develop a "mask" (*4*). This inhibition prevents perception of stimulation that the flash produced during the movement of the eye. If this explanation of the saccadic suppression found in our study is correct, the suppression is determined essentially by the spatiotemporal pattern of illumination produced on the retina by the saccade and is only incidentally contingent on the occurrence of the eye movement itself. It could, therefore, easily account for reports that "saccadic suppression" can be found when the eye is held still and the environment is moved rapidly with a mirror (*5*). It is also consistent with an experiment in which no saccadic suppression was found when a stimulus was presented on a dark field and in which suppression increased as the complexity of a background against which the stimulus was presented increased (*6*).

To study the above phenomenon