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Visual Velocity Discrimination: Effects of Spatial and Temporal Cues

Abstract. Weber ratios were obtained for visual velocity discrimination under three topographic conditions with the same subjects and psychophysical procedures. The conditions differed regarding the presence of either temporal or spatial cues, these being correlated in magnitude with stimulus velocity. Systematic effects of the cues upon the level of velocity discrimination were noted.

While several investigators (*1*) have studied visual velocity discrimination, a consistent theoretical position has not emerged regarding the relation between spatial and temporal discrimination and visual velocity discrimination (*2, 3*). Attempts to analyze velocity discrimination into two parts, temporal discrimination and spatial discrimination, have resulted in divergent conclusions. J. F. Brown has suggested: "the velocity of moving objects is perceived directly and does not depend upon indirect judgments" (*2*). On the other hand, the position has been taken that some cognitive operation relating the perceived magnitude of a spatial displacement to the perceived duration of the displacement is necessary for a velocity judgment. The implications of this position have been observed by Boring who, in discussing perception of movement and time, notes that "both perceptions have been considered to be, in their essentials, independent of the properties of the particular organs of sense and thus almost wholly dependent upon the action of the central nervous system" (*3*).

A problem inherent in the measurement of velocity discrimination is that either spatial or temporal cues may be regularly related to the stimulus velocity, depending upon the kinds of displays adopted by the experimenter. The method used most frequently is one in which the standard and comparison stimuli move in a field of equal and fixed spatial dimensions. Accordingly, the relative velocity of the comparison stimulus may be inferred from its relative duration in the movement field. R. H. Brown's review of the subject describes nine studies, eight of which employed viewing conditions which were essentially "isometric" in the foregoing sense (*1*). In the ninth study, both standard and comparison targets were presented together and initially superimposed. In this case, an angular offset occurs between the targets, and the target which is "ahead" at any moment is the one that is moving faster. Weber ratios obtained under the latter condition were substantially lower ($\Delta\omega/\omega = .00128$) than the average for the other eight studies ($\Delta\omega/\omega = .1074$).

This large difference, while suggesting the influence of temporal and spatial cues upon velocity discrimination, cannot be attributed to these variables alone. The data were obtained by means of a variety of psychophysical procedures, with different subjects, and under unmatched overall conditions.

Our study was designed to permit comparison of Weber ratios gathered under three conditions, differing only with respect to the spatial or temporal cues which accompanied each stimulus presentation. The conditions common to all phases of the experiment were: psychophysical method, constant stimuli; stimulus object, spot of light 0.030 inch in diameter on the face of a cathode ray tube; velocities of the six standards, 20.06, 40.12, 80.25, 177.21, 256.35, and 512.71 minutes of visual angle per second; and subjects, two female college graduates with emmetropic vision. A trial consisted of a single traversal from left to right of the standard velocity stimulus followed within 4 to 5 seconds by a single traversal of one of the five comparison stimuli. "Faster" or "slower" responses were required. For one-half of the trials the order of standard and comparison was reversed. Blocks of 25 trials under each of the following conditions were presented in counterbalanced order:

Isometric. The standard and comparison stimuli traversed equal extents (343.2 minutes of visual angle), hence the duration of the stimulus transit varied inversely with the velocity.

Isochronal. The standard and comparison were in motion for equal durations (0.6 second). The extent of traverse varied directly with velocity.

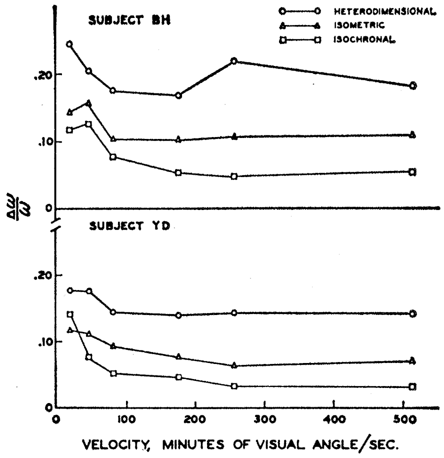

Fig. 1. Weber ratio functions for both subjects under the heterodimensional, isometric, and isochronal conditions.

Heterodimensional. The stimuli moved over extents and for durations which were "randomly" changed from presentation to presentation. In this condition velocity could not be successfully inferred from either the extents or the durations of the comparison stimuli.

Difference thresholds based on 100 trials for each standard were computed by an algebraic equivalent of the average *z* score method (*4*). The difference thresholds ($\Delta\omega$) were converted to Weber ratios ($\Delta\omega/\omega$) and plotted as a function of angular velocity (Fig. 1). Two other subjects had been tested under the same conditions in an earlier pilot study. The order of their Weber ratios as a function of stimulus conditions was the same as in Fig. 1 (*5*).

The hierarchy of Weber ratio functions for both subjects indicates that—at least for the range examined—discrimination is finest when a spatial cue is present, intermediate in the presence of a temporal cue, and poorest when neither a spatial nor a temporal cue is related to the stimulus velocity.

In view of the finding that both types of cues are effective in improving velocity discrimination, it appears reasonable to assume that the cue which is more effective is the one which can be more readily detected. This interpretation implies that within the ranges of spatial (12.04 to 307.63 minutes of visual angle) and temporal (0.67 to 17.16 seconds) values over which the stimuli were seen to move, spatial discrimination is relatively finer than temporal discrimination [that is, $(\Delta s/s) < (\Delta t/t)$]. This inference is consistent with the directly measured precision of visual spatial judgments (*6*) as compared with the precision of differences in temporal intervals (*7*).

In general, the results of the experiment here reported suggest that J. F. Brown's hypothesis (*2*) may be overly restrictive, since it is demonstrated that the precision of velocity judgments is at least partially dependent upon the systematic presence of either spatial or temporal cues (*8*).

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Persistent Vaginal Cornification in Mice

Abstract. Persistent vaginal cornification induced in A/Crgl mice by brief postnatal treatment with estrogen is not prevented by later ovariectomy, adrenalectomy, or hypophysectomy. Transplantation of the persistently cornified vaginae into ovariectomized normal mice or into ovariectomized persistently estrous mice also does not eliminate cornification in the majority of transplants. Administration of "anti-estrogenic" steroids temporarily alters the vaginal picture in some but not all of these mice. The vaginal epithelium of the persistently estrous mouse appears to represent an altered cell population which does not require estrogen for its constant keratinization.

Table 1. Effects of steroid hormones on persistent vaginal cornification in ovariectomized A/Crgl mice. There were five mice in each group, individually identified by letters.

Injection series	Daily treatment (mg)	Individual mice showing		
		Persistent estrus	Intermittent estrus	Constant diestrus
		Group I		
1	2.50 progesterone	A, B	C	D, E
2	2.50 progesterone	A, B	C	D, E
		Group II		
1	2.50 progesterone	F, G	H	I, J
2	1.25 cortisol	F, G	H	I, J
		Group III		
1	2.50 testosterone	K	L, M, N	O
2	2.50 progesterone	K	L, M, N	O
		Group IV		
1	1.25 deoxycorticosterone	P	Q, R, S	T
2	2.50 progesterone	Q	P, R, S, T	

Persistent cornification of the vaginal epithelium of rats and mice can be initiated by the injection of large doses of estrogen during the early postnatal period (*1, 2*). So-called persistent estrus also occurs spontaneously in certain mice (*3*). Mice of the strains A/Crgl, C3H/Crgl, BALB/cCrgl, C57BL/Crgl, and RIII/Crgl, receiving five daily subcutaneous injections of 5γ estradiol-17β, starting on the day after birth, show persistent vaginal cornification beginning on the 15th to the 40th day of life (*2*). Ovariectomy, or transplantation of the ovary into the spleen after ovariectomy, abolishes the persistent vaginal cornification in rats (*4*) and in spontaneously constant estrous mice (*3*). However, A/Crgl mice with persistent vaginal cornification resulting from postnatal estrogen treatment continue to show a cornified vaginal epithelium despite ovariectomy, or ovariectomy and adrenalectomy, or ovariectomy and hypophysectomy (*5*). Furthermore, the ability of estrogen to produce persistent cornification is restricted to infantile mice. The administration of large amounts of estrogen to adult A/Crgl mice results in vaginal cornification only during the period of treatment (*5*).

These facts suggest two alternative explanations of the estrogen-induced phenomenon of persistent estrus in mice. Either the vaginal epithelium is subject to abnormal neurogenic influences caused by the early postnatal estrogen treatment, or it becomes permanently altered after this treatment. The former of these two possibilities was eliminated by observing that, when persistently cornified vaginae were transplanted to new sites, cornification was not abolished in the majority of either ovariectomized normal hosts or ovariectomized hosts showing persistent vaginal cornification (*5*). Thus, persistence of cornification must be an inherent characteristic of the vaginal epithelium.

Androgen, progesterone, and adrenal corticoids are capable of inhibiting the response of the normal vagina to estrogen (*6*). If the persistently estrous vagina was similarly inhibited from cornification, and then returned to its initial state upon withdrawal of the inhibitory steroid, one might conclude that there was a permanent alteration in such vaginal tissue.

To test this hypothesis, daily doses of 0.1 ml of an aqueous suspension of 2.5 mg of progesterone, 2.5 mg of testosterone, 1.25 mg of deoxycorticosterone acetate, or 1.25 mg of cortisol acetate were injected subcutaneously into persistently estrous A/Crgl mice, which had been ovariectomized 20 to 36 days previously. Injections were continued for 15 days. Daily vaginal smears revealed (Table 1) inhibition of persistent estrus in some but not in all of the mice. The majority showed either persistent estrus or intermittent estrus (1 to 2 days of estrus following 1 to 4 days of diestrus) despite the steroid injections. During the interim period after the first treatment with the steroid, the persistently estrous state was resumed in all cases. Thus, the capability of the vaginal tissue to show persistent cornification was not permanently altered in any mouse by these inhibitory agents.

A second course of inhibitory hormones was given (Table 1). In three of the four groups of animals, the response of the vaginal epithelium to the inhibitory hormones was similar to that in the initial treatments, although the first and second inhibitory hormones were different in two of the three groups. The fourth group was treated initially with deoxycorticosterone and subsequently with progesterone; three of the five mice showed different responses to the two steroids. A total of 17 out of 20 vaginae showed a consistent pattern of responsiveness to the first and second courses of in-