learned control (*18*). To this extent, these results clarify earlier specificity findings and provide a new framework for research and theory in the control of multiautonomic functions. It is suggested that the present technique may be a tool for studying and controlling not only the relationship between visceral responses but the interaction of visceral responses with somatic and central behavior as well (*19*). This could be accomplished by assessing the extent and ease with which specific patterns of activity can be learned. The importance of considering feedback and reward in biological perspective is stressed, since natural physiological relationships and constraints do occur (*20*). It may be possible to apply these techniques to the treatment of specific clinical disorders; for example, to condition decreases in BP and HR to reduce the pain of angina pectoris (*21*).

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5. A complete description of the ID model and the present experiment can be found in G. E. Schwartz, thesis, Harvard University (1971).
6. For this report, no formal distinction is made between feedback (implying response information) and reinforcement (implying response contingency). Since both terms require experimental procedures for systematically producing changes in the environment which closely follow changes in behavior, their similarities (in obtained results) rather than differences (in theoretical underpinnings) are emphasized. Although I have primarily used the terminology developed in operant conditioning, feedback terminology can be easily substituted; the major implications and conclusions remain the same.
7. These definitions depart somewhat from those generally used in biology, where the term integration refers to any consistent pattern of unified activity, regardless of direction, while differentiation refers to a separation of one response from others (here called specificity).
8. For example, if a response decreases naturally from the beginning to the end of an experiment this changing operant baseline must be taken into account to measure the direction and extent of learning. See A. Crider, G. E. Schwartz, S. R. Shnidman, *Psychol. Bull.* **71**, 455 (1969).
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10. A similar approach has been used to train rats to differentially control blood volume between the two ears. See L. V. DiCara and N. E. Miller, *Science* **159**, 1485 (1968).
11. A preliminary experiment on learned cardiovascular integration in which the procedure was tested can be found in G. E. Schwartz, D. Shapiro, B. Tursky, *Psychosom. Med.* **33**, 57 (1971).
12. No subjects showing initial systolic blood pressures of 135 mm-Hg or more during the last adaptation or random reinforcement trial were included in this experiment.
13. Analyses of variance were performed on an IBM 360 computer with the Biomed 08V program. Groups was the between factor and trials was the within factor. The degrees of freedom for the group by trial interaction was 34/612. For the BP data, the analyses of variance (comparison of two groups at a time; six possible combinations) revealed that over trials the two BP^{up} conditions were each significantly higher than each of the two BP_{down} conditions ($P < .0001$), but were not different from each other. For HR, all two-group comparison trials were significant ($P < .01$ to .0001) except BP^{up} HR^{up} with BP^{up} HR_{down}, and BP^{up} HR_{down} with BP_{down} HR^{up}. The corresponding group main effects for these comparisons were also significant for BP ($P < .025$ to .005) and HR ($P < .10$ to .0001).
14. For example, separate analyses of variance on each of four groups, with measures (2) (change in BP versus change in HR) and trials (35) as within factors, indicated that BP_{down} HR^{up} reinforcement was the only condition that produced a reliable divergence between BP and HR during trials (d.f. = 34/306).
15. Sinus arrhythmia, a condition in which HR leads BP, is discussed by A. M. Scher, in *Physiology and Biophysics*, T. C. Ruch and H. D. Patton, Eds. (Saunders, Philadelphia, 1965), p. 660.
16. This pattern of results is also consistent with physiological theory suggesting that the parasympathetic system is capable of finer differentiation than is the sympathetic system. Raising the HR while lowering the BP may constitute a parasympathetic pattern, since HR may be increased by a decrease in vagal tone. Unlike elevation of HR, elevation of systolic BP requires sympathetic activity, hence the observed difficulty in lowering HR at the same time.
17. Finer analysis procedures (for example, coincidence measures of BP, HR, and respiration) may be necessary to assess such effects.
18. Predictive power of the ID model will, by definition, be limited to the extent that (i) operant (feedback) theory adequately handles the learning of individual responses (the interaction of other variables such as cognitive set and motivation is yet little understood); and (ii) physiological mechanisms and constraints can be empirically assessed in the given situation.
19. The recently published report by E. E. Fetz and D. V. Finocchio [*Science* **174**, 431 (1971)], which demonstrates operant conditioning of specific patterns of neural and muscular activity in the monkey, strongly supports this view.
20. For example, when changes at each beat in diastolic (as opposed to systolic) BP are reinforced, some conditioning of HR also takes place (D. Shapiro, G. E. Schwartz, B. Tursky, *Psychophysiology*, in press). This implies that diastolic BP and HR are partially (but not completely) integrated with respect to phase. Analysis of BP^{up} HR^{up} and BP_{down} HR_{down} coincidence responses has confirmed this prediction (average phasic integration is 70 percent). Research is required to determine the extent to which these two integrated functions can be separated through operant differentiation reinforcement (for example, requiring the subject to decrease diastolic BP by reducing peripheral resistance, while at the same time increasing HR).
21. The circumstances under which cardiac oxygen requirements in angina pectoris can be reduced if both HR and BP are lowered are discussed by E. Braunewald, S. E. Epstein, G. Glick, A. A. Wechsler, N. H. Wechsler, *N. Engl. J. Med.* **277**, 1278 (1967); E. H. Sonnenblick, J. Ross, E. Braunewald, *Amer. J. Cardiol.* **22**, 328 (1968).
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Backward Enhancement?

Abstract. *Presentation of a masking stimulus enhances, rather than detracts from, detectability of certain multisegment targets. Present theories of backward masking cannot account for this "backward enhancement" effect, which resembles another puzzling phenomenon, previously reported as target recovery or disinhibition. An explanation in terms of interaction between retinal excitatory and inhibitory fields is offered.*

Under proper circumstances the second of two successively presented visual stimuli can reduce, and sometimes entirely eliminate, the recognition and even the mere detection of the first (*1*). Depending on experimental paradigm, theoretical orientation, and personal preference, this retroactive inhibitory effect in perception is variously referred to as "metacontrast," "erasure," or "backward masking." For convenience, and following current practice, we use the terms, backward masking, or masking, in this paper. We refer to the first stimulus as the "target" and the second as the "mask."

Empirical investigations of backward masking have covered the effects of a host of temporal, luminance, and configurational variables. Several theoretical accounts of masking have been offered (*2*), some based on the neurophysiological concept of inhibition, and some more specifically on "lateral inhibition." The latter models have been quite successful in accommodating large portions of the reported empirical

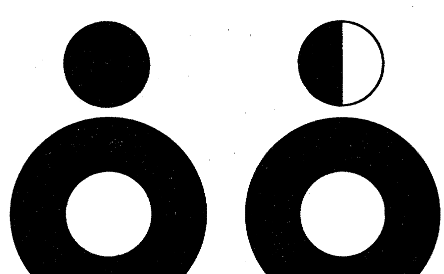

Fig. 1. Target stimuli and masks. As a control, the 2-segment target was varied by 90°, 180°, and 270° rotations between subjects.

findings, although no one model of backward masking has yet been generally accepted.

Certain empirical findings pose especially difficult problems for the models. For example, Robinson (*3*) and Dember and Purcell (*4*) have reported that target detection can be increased if a second mask is introduced into the standard target-mask sequence. Rather than adding to the inhibition imposed on the target, the second mask acts to decrease the net amount of inhibition—that is, to act, in Robinson's terms, as a disinhibitor. Whatever the specific mechanism involved, this effect, which we call "target recovery," clearly reveals that the first mask does not simply erase or degrade the target; rather it must be that the target is transformed by the mask in the standard paradigm, and that in the recovery case, the second mask, by a complementary transformation, restores the target at least partially to its initial, nonmasked perceptual status.

We report here a new finding, somewhat analogous to target recovery and equally challenging to masking models. The experiments follow the standard target-mask paradigm, but the effect of the mask is to *enhance*, rather than to decrease, target detection; hence we have chosen the label, "backward enhancement."

The possibility of backward enhancement was suggested in data collected to test the hypothesis, derived from Werner's (*5*) classical research, that internal contours render a target less susceptible to masking. We first tested (*6*) this hypothesis by comparing the maskability of homogeneous black disks with that of half-black, half-white disks, as illustrated in the top panel of Fig. 1. As expected, the half-black, half-white targets (with a single internal contour) yielded higher detection percentages than a homogeneous black disk. In that experiment, as in subsequent ones, the mask was comprised of two rings, arranged as shown in the bottom panel of

Table 1. Mean target duration at which detection occurred.

No. of target segments	Duration (msec)			
	Light field		Dark field	
	No mask	Mask	No mask	Mask
Black disk	3.26	22.77	4.68	23.18
2	2.89	7.47	4.62	12.34
4	3.89	4.96	8.11	7.42
8	5.87	4.47	7.21	7.55
16	12.48	6.41	15.84	9.48
32	6.02	24.26	9.74	24.83

Fig. 1. The target was randomly located over a series of trials so that it fell within one of the two rings, and the subject's task was simply to indicate, by saying "left" or "right," within which ring the target was located. A second experiment was conducted (*7*) to see if resistance to masking was quantitatively related to the number of internal target contours. A set of targets was constructed (Fig. 2), consisting of either 2, 4, 8, or 16 black-and-white segments; a homogeneous black and a homogeneous white target were also used, and the masking rings were either both black or both white. All stimuli were presented on a gray background. To assure that any differences in maskability were not confounded by differences in target detectability per se, we added a control condition in which target detection was measured in the absence of the masking rings. The subject's task throughout was simply to locate the target (left or right), but in this and in subsequent experiments target detection was measured by the double staircase variant of the method of limits (*8*), which, as we employ it, yields a duration threshold. Four paid college students served as subjects; each was tested once in each condition.

The original hypothesis was verified in the data, but we found two unexpected trends: (i) in the nonmasking, "control" condition detection threshold increased as the number of target segments increased; (ii) introduction of the black masking rings slightly *decreased* the threshold of the 16-segment target.

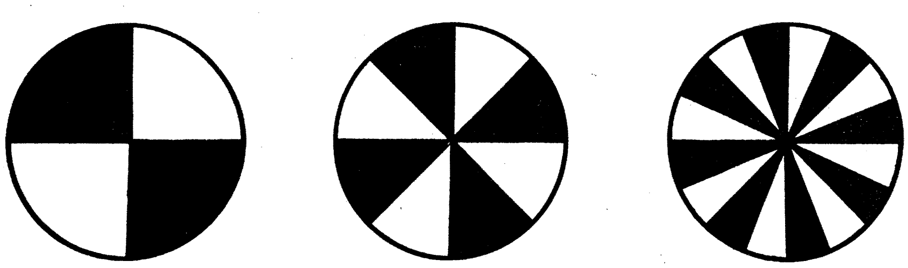

Fig. 2. Additional target stimuli. A 90° rotation of the 4-segment target was utilized between subjects.

To follow up those trends we conducted a third study (*9*), using eight new subjects and identical methodology, but omitting the white mask and using only the 4, 8, and 16-segment targets. Both trends were replicated, but only the first at an acceptable level of statistical significance. At this point, having seen it twice, though not entirely confident of its reality, we coined the phrase "backward enhancement" to refer to the second trend.

In further pursuit of these two trends we ran the following experiment. The target stimulus set consisted of a homogeneous black disk and disks comprised of 2, 4, 8, 16, and 32 black-and-white segments, like those shown in Fig. 2. The masking stimulus was the standard one consisting of two black rings. Disk diameter was 8 mm, as was the inner diameter of the rings; the outer diameter of the rings was 16 mm. The distance between ring centers was 20 mm. Mask onset coincided with target termination; mask duration was 105 milliseconds. Target-field and mask-field luminance were fixed at 10 foot-lamberts (34 candelas per square meter). On half of the trials, the pre- and post-exposure adapting fields were given the same luminance as in the preceding studies, and on the other half these fields were dark. Each of the four students served as subjects in each of the conditions. Viewing was monocular. A duration threshold using the double staircase method, as previously described (*9*), was obtained once from each subject in each condition, but a different random order of conditions was used for each subject. Preceding the collection of data, each subject was given approximately 3 hours of training on the psychophysical task.

Mean duration thresholds averaged over the subjects are given in Table 1. Examination of the data reveals the same trends noted previously, though they obviously break down somewhere between the 16- and 32-segmented target stimuli; the latter stimulus acts very much like the homogeneous black disk. The trends seem clearer under the illuminated than under the dark adapting-field condition.

The data were subjected to an analysis of variance to assess the statistical significance of the main effects of the three independent variables, number of segments, masking condition, and adapting-field luminance, as well as their interactions. All three independent variables yielded statistically significant effects. The interaction between masking condition and number of target segments was also significant ($P < .01$); this interaction reflects the decreased detectability of the multisegmented targets and their decreased susceptibility to masking.

The reliability of the backward enhancement effect was assessed by simple *t*-tests, comparing the mean ratios of masking to nonmasking thresholds with the hypothetical ratio of 1.00 for the 16-segment target under both adapting-field conditions and for the 8-segment target under the light adapting-field condition only. Enhancement would be indicated where these ratios had values significantly less than 1.00. While the mean ratios associated with the 16-segment targets were both statistically significant ($P < .02$), the ratio associated with the 8-segment target was not ($P = .10$).

As a further test of the reliability of the enhancement effect for the 16-segment target, we combined data from the present study for the light adapting-field condition with that from the preceding one (*9*). Of the 12 subjects, 10 had ratios less than 1.00, a distribution which departs significantly from chance as assessed by a simple sign test ($P < .05$).

We are by now fairly confident in the reality of backward enhancement. How might it be interpreted? We favor at this point the following explanation. Any target generates both excitatory and inhibitory effects. Some targets, such as those with many internal contours, generate more inhibition than others, perhaps through the mechanism uncovered by Hubel and Weisel (*10*) in their electrophysiological investigations of retinal receptive fields. For such targets, the masking stimulus serves as a disinhibitor (analogous to the function of the second mask in the case of target recovery). That is, the mask acts primarily to reduce, or transform, the target-generated inhibition, leaving the excitatory component dominant and thereby yielding "backward enhancement." For simple targets, which generate little inhibition (relative to excitation), the mask serves primarily to reduce or transform target-generated excitation, thereby yielding the conventional backward masking effect.

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6 October 1971

Buffer Systems and PAGE

The applicability of polyacrylamide gel electrophoresis (PAGE) to the entire *p*H range has recently been achieved. By use of the theory and computer program of Dr. T. M. Jovin we were able to generate 4269 multiphasic (discontinuous) buffer systems and give a complete physical description of these systems which operate at 0° and 25°C, in the cationic and anionic direction of migration. The systems are available in magnetic tape form from the National Technical Information Service (NTIS), Springfield, Va. (PB 196085–196089). The background and significance of this advance has been discussed and a portion of the output for a single, representative buffer system was shown [figure 7 in (*1*)].

A catalog of these multiphasic buffer systems (PB 196090) and instructions for its use (PB 196091) are also available from NTIS at a cost of $3. This catalog allows the user to determine the buffer system number of his choice.

The hardbound copy printout of all these buffer systems requires almost 15,000 pages of full-size computer output. Thus the distribution of these systems was, until recently, greatly hindered by cost, space requirements, and labor involved in printing and storage of the information available in magnetic tape form.

A retrieval program has now been formulated that makes it possible for the user of PAGE to obtain a copy of the system of his choice by entering the desired system number into the computer console (IBM 2741) or teletype machine stationed in the laboratory. Upon request, the desired tape is entered from the tape library into the active memory of a IBM 360 computer, the buffer system is typed out instantly in the user's laboratory, and the tape returns to the library until called again. This service is operative now at the National Institutes of Health only, but should become available over the various time-sharing companies when users will express an interest in the buffer system formulations. To the user of PAGE equipped with computing facilities the new retrieval program is available from NTIS (PB 203016).

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Aerosol Concentrations: Effect on Planetary Temperatures

Rasool and Schneider (*1*) have presented a model for planetary radiation balance which predicts that an increase in the atmospheric burden of aerosol would result in decreased planetary temperatures. We wish to point out that this conclusion is critically dependent upon the assumptions of their model, and that other reasonable assumptions can produce an opposite conclusion.

Specifically, they assume 50 percent cloud cover with aerosol effects operating only in the cloudless fraction; that is, the top of their aerosol layer is confined below the cloud tops. If, however, an aerosol is present above the cloud