 66-10,229

McKENZIE, Hugh Stratton, 1935–
RESPONSE STRENGTH AS A FUNCTION OF BRIGHTNESS.

University of Arizona, Ph.D., 1966
Psychology, experimental

University Microfilms, Inc., Ann Arbor, Michigan

RESPONSE STRENGTH AS A FUNCTION OF BRIGHTNESS

by

Hugh Stratton McKenzie

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 6 6

THE UNIVERSITY OF ARIZONA

GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my direction by Hugh Stratton McKenzie entitled Response Strength as a Function of Brightness be accepted as fulfilling the dissertation requirement of the degree of Doctor of Philosophy

James E. King
Dissertation Director

Apr. 11, 1966
Date

After inspection of the dissertation, the following members of the Final Examination Committee concur in its approval and recommend its acceptance:*

Ronald H. Pool	April 11, 1966
Jack C. Capehart	Apr. 11, 1966
Robert W. Lansing	apr. 11, 1966
Richard Coan	April 12, 1966

*This approval and acceptance is contingent on the candidate's adequate performance and defense of this dissertation at the final oral examination. The inclusion of this sheet bound into the library copy of the dissertation is evidence of satisfactory performance at the final examination.

STATEMENT BY AUTHOR

This dissertation has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this dissertation are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Hugh S. McKenzie

ACKNOWLEDGMENTS

The author is grateful to Dr. James E. King, dissertation director and major professor, for his aid and encouragement during the planning and execution of this study. Special accord is also due Drs. Robert W. Lansing and Ronald S. Pool who served on the dissertation committee and provided additional assistance. The help of Drs. Jack E. Capehart and Richard W. Coan is also gratefully acknowledged.

This investigation was both supported and aided by a National Aeronautics and Space Administration Fellowship which was awarded the author in 1964.

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

The experiment was designed so that the Hullian and Perkins-Logan theories of stimulus intensity effects could be comparatively tested.

College students were asked to predict the outcomes of a series of simulated horse races. Three Munsell Neutral Color cards (white, medium gray, and black) each represented a horse. The brief lighting of a card in a tachistoscope signified a race. Ss bet after each race whether that particular horse would win or lose and were told by E whether their bet was right or wrong. Each horse raced 60 times. Two horses won 50% of their races, while a third won 0%. For one group, the white horse was the 0% winner. For the other group, the black horse was the 0% winner.

Response strength to each Munsell card (horse) was measured as the number of win responses emitted to that card.

Results generally supported the Perkins-Logan theory, while failing to support the Hullian theory.

INTRODUCTION

The effect of stimulus intensity on response strength was first given systematic treatment by Hull (1949). Hull termed this effect <u>stimulus intensity dynamism</u> or <u>V</u>. Within the Hullian behavior system, V is the stimulus intensity component of reaction potential and acts multiplicatively with other positive components in its effect on response strength.

Two of Hull's deductions (Hull, 1949, p. 73) from the postulation of V are pertinent to the present paper:

1. Other components being equal, response strength is greater to a stimulus of high intensity than to one of low intensity.
2. Other components being equal, generalization is greater from low to high intensity stimuli (i.e., the generalization gradient has less slope) than from high to low intensity stimuli.

The only other theory of stimulus intensity effects on response strength which has received empirical support is that of Perkins (1953) and Logan (1954). These workers independently proposed that the dynamism effects asserted in the above two Hullian deductions can be attributed to generalization of inhibition from a zero-intensity stimulus to which responses are emitted but not reinforced. Such a zero-intensity stimulus has typically been present in experiments which yield the above dynamism effects (Gray, 1965b).

From the Perkins-Logan (P-L) theory it follows that the two dynamism effects Hull deduced are the result not of the absolute intensity of the positive stimuli but rather of the contrast in intensity between, or the discriminability of, the positive and negative stimuli.

It is also a consequence of the P-L theory that differential training must be involved in order that the two above V effects occur. Direct experimental evidence that this is the case has been offered by Perkins (1953) and Gray (1965a); and Gray (1965b) in his comprehensive review of the literature on stimulus intensity dynamism has noted that studies in which differential training is not involved typically find no evidence for V, while studies which do involve differential training generally yield results consistent with the postulation of V.

The P-L theory is further distinguished from the Hullian theory since the former predicts that, if responses emitted to lower intensity stimuli are reinforced while responses emitted to the highest intensity stimulus are not reinforced, the two Hullian predictions would be reversed. That is, response strength would be greater to a stimulus of low intensity than to a stimulus of higher intensity, and generalization would be greater from high to low intensity stimuli than from low to high. Experimental evidence supporting the above contention has been offered by Bragiel and Perkins (1954), Champion (1962), Johnsgaard (1957), and Nygaard (1958).

With the above discussion, it should be apparent that the P-L theory of stimulus intensity effects is not a dynamogenic theory, as it proposes that these effects are particular examples of generalization of inhibition. On the other hand, Hull's theory is a dynamogenic one since it proposes that stimulus intensity effects on response strength are due to intensity alone and are independent of other behavioral influences.

As mentioned above, Gray (1965b) has recently concluded that experimental evidence predominantly favors the P-L theory. One study which Gray offered as supporting the P-L hypothesis is that of Bass (1958). Bass's study is of particular interest since it involved human Ss and voluntary responses and since Gray's interpretation of Bass's results in terms of the P-L theory is not justified. Moreover, the methodology employed by Bass is highly similar to the methodology of the present experiment. Consequently, it will be worthwhile to review the Bass study in some detail.

At the outset, it should be noted that Bass did not perform her experiment with the intent of lending support to one of the two theories of stimulus intensity effects. Her interest was in demonstrating the generalization of voluntary responses along a non-spatial dimension in human Ss. However, as the dimension she employed was reflected light intensity, or, in psychological terms, brightness, her study is relevant to the effects of stimulus intensities.

Bass employed a simulated betting situation with silhouettes of horses which differed in shade of gray. Four different silhouettes were employed, one of which "won" 80% of its races, while the other three each won 40%. The silhouettes ranged from a light gray to a black and were projected on a background which was brighter than the light gray silhouette. For one group of Ss, the light gray "horse" was the 80% winner, while the black was the 80% winner for the second group. Bass's measure of response strength was the mean percentage of win responses emitted to the silhouettes.

Bass analysed her data in terms of three variables.

The generalization variable--a repeated measures variable--was the brightness differences among the three 40% winners ordered in steps removed from the appropriate 80% winner. As Bass was interested in testing for generalization, she did not analyse differences between response strengths to 80 and 40% winners, since any such differences could be attributed to differential reinforcement as well as to generalization. Bass found the generalization to be significant ($p < .001$), thus indicating a reliable inverse relationship among response strengths to the 40% winners and their distances from the 80% winners.

The second variable--a between Ss variable--was that each of the two groups had a different 80% winner. Results indicated that Ss in the group with the light gray 80% winner gave a significantly greater number of win responses ($p < .005$) to their 40% winners than did Ss in the group with the black 80% winner. Bass attributed the significance of the second variable to the fact that Ss demonstrated an initial preference to bet win to the black silhouette with the result that more win responses were emitted to the darker silhouettes.

The third variable--also a between Ss variable--was eight different random sequences of silhouette presentation. This variable was not significant.

None of the interactions of the above three variables achieved statistical significance.

For Bass's experiment, Hull's theory clearly predicts that generalization should have been greater for the group with the black silhouette as the 80% winner than for the group with the light gray 80% winner, since in the former group generalization was from low to high intensity stimuli rather than from high to low as in the light gray group. This is a clear case of the second Hullian deduction which was given above. However, if this were the case, the interaction of the generalization and 80% winner variables should have been significant. Since this interaction was, in fact, not significant, Bass's study may be interpreted as failing to support the Hullian position.

Gray (1965b) to the contrary, it is apparent that Bass's experiment offers no test of the P-L position. For in the Bass experiment, the P-L theory would predict a steeper generalization gradient for the group with the black silhouette as the 80% winner only if inhibition was in fact accruing to the background stimulus. However, Bass did not report whether responses were in fact emitted to the background stimulus (which was also the intertrial stimulus) and not reinforced. Moreover, as this stimulus was present when win responses were reinforced, as it was the background for the silhouettes, it seems more probable that excitation rather than inhibition would accrue to it. Consequently, the assumption of such inhibition to the background and intertrial stimulus is gratuitous, and the P-L theory does not apply to the Bass experiment.

The study reported here involved modifications of Bass's methodology so that the Hullian and P-L theories would make differential predictions in regard to experimental results.

There were two crucial modifications of Bass's methodology. First, a "horse" was presented which never won. And, second, horses other than the above 0% winners all won an equal number of their "races" so that generalization of excitation would not be confounded with generalization of inhibition.

If generalization of inhibition reliably occurred in this experiment, the P-L theory would predict no difference in slopes of generalization gradients. On the other hand, Hullian theory must predict a difference in the slopes of these gradients.

These measures were taken both before and after the experiment was conducted. Prior to the experiment, the brightness of the N 9.5/card was measured at 280 footlamberts, the N 5.5/ at 80, and the N 1.5/ at seven footlamberts. After the experiment had been completed, the brightness of the N 9.5/card was measured at 270 footlamberts, the N 5.5/ at 78, and the N 1.5/ at eight footlamberts. For both before and after measures, the brightness of the intertrial stimulus was found to be zero footlamberts measured to 0.1 footlamberts.

A two second lighting of a Munsell card signified a race. The Ss then bet whether the horse (the particular Munsell card) just presented--i.e., lighted--would win or lose the race and were told by the experimenter whether the bet was right or wrong. Ss were instructed to take careful note of how often each horse won so that the accuracy of their predictions would be maximal.

Ss were randomly divided into two main groups--C_W and C_B--with 18 Ss in each group. For the C_W group, the white horse never won, while the medium gray and black horses each won 50% of their races. For the C_B group, the black horse never won, while the gray and white horses each won 50% of their races.

The predetermined win-lose pattern was the same for 50% winners in both C_W and C_B. This pattern was random except that each 50% winner won five times in its first ten

METHOD

The Ss were 36 volunteers from the introductory psychology course at the University of Arizona.

Munsell Neutral Color cards N 9.5/(white), N 5.5/ (medium gray), and N 1.5/(black) represented individual "horses." Thus, each "horse" was distinguishable in terms of brightness, with four jnd's separating the white and medium gray, four the medium gray and black, and eight jnd's the white and black "horses."

The Munsell Color cards were viewed by Ss through the viewing hood of Scientific Prototype's Dodge Tachistoscope. The cards were lighted in the tachistoscope for two seconds and between these presentations of the cards the lights of the tachistoscope were off for ten seconds. This ten second intertrial stimulus was seen by the Ss as darkness.

Brightnesses of the Munsell cards when lighted by the tachistoscope were measured by the Gamma Scientific, Inc. 220-1 Luminance Standard Head, 700 Log Linear Photometer, and 700-2 Photometric Telescope. The 700-2 Photometric Telescope was equipped with the two degree aperture, and the brightnesses of the cards were measured from a distance of approximately four feet, the distance of Ss' eyes from the cards.

races, five times in its second ten races, etc., and a horse neither won nor lost more than three consecutive races.

A sequence for presenting the three stimulus cards was composed of 20 presentations of each card, or 60 card presentations in all. This sequence was formed by assigning each card 20 places in the sequence. Thus, each card could be said to occupy one position in the sequence, with each position being composed of 20 different places.

The assignment of places in the sequence was random except that each card appeared twice in a row four times in the sequence, each card appeared ten times in every thirty presentations, and each card appeared no more than twice in a row.

Each C group was randomly divided into six subgroups. These subgroups are represented by the D variable. The D variable indicates permutations of the cards within the three positions of the sequence. One permutation was the white card in the first position, the black in the second, and the gray in the third. A second permutation was the black in the first, the gray in the second, and the white in the third. Since there were three cards and three positions, there were 3! or six permutations of cards in positions. Thus, the D variable was established to control for order effects in the presentations of the three brightnesses.

The sequence of 60 card presentations was repeated three times so that there were 180 card presentations in all, 60 of each card. The three repetitions of the sequence are represented by the A variable--a repeated measures variable.

A second repeated measures variable was the steps removed from the 0% winners. This variable is represented by B. For the C_W condition, B_1 was the gray horse since it was one step (four jnd's) removed from the white 0% winner, while B_2 was the black horse as it was two steps (eight jnd's) removed from the white 0% winner. For the C_B group, B_1 was again the gray horse as it was one step removed from the black 0% winner, while B_2 was the white horse since it was two steps removed from the black 0% winner.

Prior to the races, Ss were required to correctly identify each of the three Munsell cards which were presented four times each in a random series. This series was repeated up to four times until every card was correctly identified for an entire series of 12 presentations. Six Ss were unable to meet this criterion and were not used in the experiment. Thirty-six Ss were successful in the discrimination task and participated in the entire experiment.

RESULTS

The measure of response strength to the various stimuli was the number of win responses emitted in the presence of these stimuli. The mean total win responses emitted to the three stimuli of each C group are presented in Table 1 below.

Table 1

Mean Win Responses to Stimuli

The mean of the number of the total win responses emitted to stimuli in each of the C conditions. The letter in parentheses following each mean indicates the brightness for that particular condition. B_1 and B_2 are one and two steps removed, respectively, from 0% winners.

	0% Winner	B_1	B_2
C_W	3.527 (W)	29.166 (G)	36.944 (B)
C_B	2.888 (B)	35.500 (G)	39.111 (W)

Data from 0% winners were not included in the statistical analysis, as one would expect fewer win responses emitted to these 0% winners as opposed to the 50% winners on the basis of differential reinforcement rather than generalization of inhibition. Accordingly, the win response frequencies to the 50% winners only were evaluated through the analysis of variance which is summarized in Table 2 on page 14.

The B effect--the differences in win responses to 50% winners--was significant with $p < .005$. This indicates a highly reliable degree of generalization of inhibition from 0% winners.

The C effect--the difference in win responses between groups with different 0% winners--was found to be significant with $p < .01$. For the present study, this indicates that a reliably larger number of win responses was emitted to 50% winners when the black horse was the 0% winner than when the white was the 0% winner. Further analysis of C for simple effects indicated that C was statistically significant for B_1 with $p < .01$, while C for B_2 could be attributed to chance with $p > .25$.

The interaction of the B and C effects (BXC in Table 2) did not achieve statistical significance. This fact indicates that no statistically reliable difference in slopes of the two gradients was found.

Neither the main effect of the repetitions of sequence variable (A) nor the permutations of cards in positions variable (D) achieved statistical significance.

None of the interactions of any of the four variables was statistically significant.

It was noted that during the pre-race discrimination task (after each card had been presented once) 25 Ss

Table 2

The Summary of the Analysis of Variance

Source	df	MS	F
Between Ss	35		
C	1	109.797	8.797*
D	5	4.966	
CXD	5	14.163	1.134
error (c)	24	12.481	
Within Ss	180		
A	2	.542	
AXC	2	.365	
AXD	10	6.092	1.128
AXCXD	10	2.449	
error (a)	48	5.398	
B	1	196.463	9.786**
BXC	1	26.741	1.332
BXD	5	21.696	1.080
BXCXD	5	12.174	
error (b)	24	20.074	
AXB	2	.504	
AXBXC	2	3.810	
AXBXD	10	4.355	
AXBXCXD	10	7.109	1.071
error (ab)	48	6.633	
Total	215		

*$p < .01$

**$p < .005$

confused at least once the white and gray cards, while eight Ss showed no confusions, two Ss showed confusions for white, gray, and black cards, and only one S confused the black and gray cards. After each card had been presented once, no Ss confused the black and white cards. As measured by the number of Ss who confused cards in the discrimination task, it is evident that it was more difficult for Ss to discriminate between the white and gray horses than between the black and gray horses. This was true in spite of the fact that, according to the Munsell specifications, each of these pairs was separated by four jnd's.

A statistical test of whether the white and gray horses were more difficult to discriminate than the black and gray horses was undertaken by hypothesizing that white-gray and black-gray confusions would occur with equal frequency.

All Ss who did not show white-gray confusions were placed in the black-gray confusion category. Consequently, there were 25 Ss in the white-gray category and 11 in the black-gray. Then, with one degree of freedom,

$$\text{Chi Square} = \frac{(25 - 18)^2}{18} + \frac{(11 - 18)^2}{18}$$

$$= 5.44.$$

A Chi Square of 5.44 with one degree of freedom is significant with $p < .025$, so that we have confidence in the statement that the white and gray cards were more difficult to discriminate (or more often confused) than the black and gray cards.

DISCUSSION

That the present data indicated a reliable generalization of inhibition (the B effect, $p < .005$) allows a test of the P-L theory. The Hullian theory is also subject to test since generalization of excitation has not been confounded with generalization of inhibition and a wide range of intensities (from eight to 270 foot-lamberts) has been employed.

Since the interaction between the steps removed from the 0% winners (the B variable) and whether the white or black horse was the 0% winner (the C variable) was not statistically significant, we may conclude that the data of the present experiment allow us to retain the Perkins-Logan theory of stimulus intensity effects. At the same time, this result offers no support for the Hullian theory. Thus, the results of this experiment are in general accordance with the Gray (1965b) conclusion.

The fact that C at B_2 did not attain statistical significance ($p > .25$) further weakens the Hullian position, since Hullian theory must predict greater response strength to the white card (B_2 at C_B) than to the black card (B_2 at C_W).

Neither the Hullian nor the P-L theory predicts that B_1 at C_B should accrue greater response strength than

B_1 at C_W. They are in fact the same stimulus card (gray). This difference, significant with $p < .01$, can be attributed, however, to the fact that the majority of the Ss (25) had difficulty in discriminating between the white and gray horses only. Consequently, more generalization of inhibition should occur from the white to the gray horse than from the black to the gray, and this would explain the greater response strength to B_1 at C_B.

This greater confusion of gray and white horses and its consequences raises the problem of the appropriate scaling of stimuli in the study of stimulus intensity effects. For, in the present case, had confusions of white and gray and black and gray horses been equal (i.e., had the white and gray been as discriminable as the black and gray), we would expect the mean number of responses to the gray horse to be approximately the same under both C conditions. It is possible, had these confusions been equal, that the slopes of the generalization gradients under the two C conditions would have been reliably different in a direction predicted by Hullian theory. However, such a possibility is highly speculative and can be checked only through further experimentation.

In summary, then, the present experiment offers support to the P-L theory of stimulus intensity effects while weakening the Hullian position. Consequently, it furthers the argument that what has been termed stimulus intensity dynamism is the result of generalization of inhibition and is not, thereby, a true dynamogenic effect. For, in this experiment, the intensities of stimuli had no reliable effect on response strength in and of themselves, but rather were increasingly effective as they differed from the stimuli which accrued inhibition.

REFERENCES

Bass, B. Gradients in response percentages as indices of non-spatial generalization. Journal of Experimental Psychology, 1958, 56, 278-281.

Bragiel, R. M., and Perkins, C. C., Jr. Conditioned stimulus intensity and response speed. Journal of Experimental Psychology, 1954, 47, 437-441.

Champion, R. A. Stimulus intensity effects in response evocation. Psychological Review, 1962, 69, 428-449.

Gray, J. A. Relation between stimulus intensity and operant response rate as a function of discrimination training and drive. Journal of Experimental Psychology, 1965, 69, 9-24. (a)

Gray, J. A. Stimulus intensity dynamism. Psychological Bulletin, 1965, 63, 180-196. (b)

Hull, C. L. Stimulus intensity dynamism (V) and stimulus generalization. Psychological Review, 1949, 56, 67-76.

Johnsgaard, K. W. The role of contrast in stimulus intensity dynamism (V). Journal of Experimental Psychology, 1957, 53, 173-179.

Logan, F. A. A note on stimulus intensity dynamism (V). Psychological Review, 1954, 61, 77-80.

Nygaard, J. E. Cue and contextual stimulus intensity in discrimination learning. Journal of Experimental Psychology, 1958, 55, 195-199.

Perkins, C. C., Jr. The relation between conditioned stimulus intensity and response strength. Journal of Experimental Psychology, 1953, 46, 225-231.