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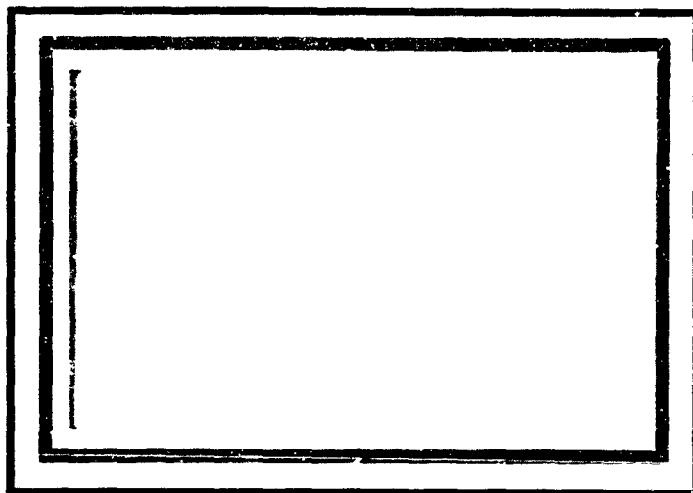


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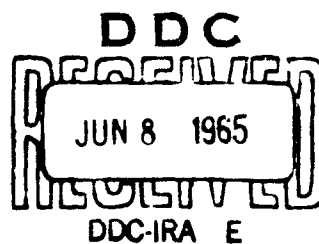
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KANSAS STATE UNIVERSITY

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Technical Reports 29-32

**The Evaluation of Perceptual
Frames of Reference**

These reports describe work under contract Ncnr-3634(01) between Kansas State University and the Physiological Branch, Office of Naval Research.

The principal investigator is William Bevan.

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Department of Psychology

May, 1965

Technical Report No. 29

Response latency as a function of the statistical
structure of a prior schedule of presentation intervals¹

Edward D. Turner & William Bevan

Kansas State Univeristy

1. This report describes an experiment performed under contract Nonr-3634(01) between Kansas State University and the Physiological Psychology Branch, Office of Naval Research. It is part of a project entitled "The Evolution of Perceptual Frames of Reference."

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May, 1965

Response latency as a function of the statistical
structure of a prior schedule of presentation intervals¹

Edward D. Turner & William Bevan

Kansas State University

A. INTRODUCTION

Recognition of the significance of context for the organization of perception has been widespread since the heyday of Gestalt psychology. The influence of context upon sensory judgments has been assessed by the proponents of Adaptation-Level Theory. However, the importance of context for responsivity in general has received less attention, and this of relatively recent vintage. During the past decade, reaction-time experiments have been instigated by considerations of information theory (cf. 7) and a whole literature on vigilance has accumulated. The vigilance experiment is an excellent device for the study of responsivity, and the expectancy theories of vigilance (1, 2, 6) are also theories of context effects.

Early studies indicate that reaction time is enhanced as the number of alternative stimuli is increased (9, 10). However, Welford (14) reports that with practice, differences in reaction time as a function of the number of choices disappears, and Leonard (12) states that with a "stimulus-compatible" response, reaction is nearly invariant with differences in the number of stimulus categories used.

Klemmer (11) used foreperiods of variable duration and found that reaction time increased with both length and range of intervals used. However, Boulter & Adams (4) failed to find a relationship between response latency and temporal uncertainty. Bevan, Hardesty, and Avant (3) examined the relationship between length of interval and response latency over a range of from 5 to 320 sec. They found a negatively accelerated increase in response latency with increased duration, with variable-interval schedules giving consistently longer latencies than constant-interval schedules.

Some attention has been directed toward the relation of the statistical structure of the presentation-sequence to response latency. Crossman (5) has reported that unbalanced frequencies among alternative stimuli lower average reaction time and Leonard (12) that when one of five lights occurred more frequently than the others, response time was shorter.

More recently, Hardesty and Bevan (8), elaborating upon a study of Baker (1), and using Mowrer's (13) paradigm for studying the central locus of set, have found that response latency following a single test interval of from 5 to 80 sec., increased from the mean response latency for a series of twenty adaptation trials as the duration of the test interval differed from the average duration of the adaptation series. These results obtained for both constant and variable interval schedules and the arithmetic mean, compared with the mode and the midrange, proved to be the subject's best estimate of the test interval.

The present experiment was concerned with response latency as a function of the statistical structure of a prior adaptation series. Four independent groups each received an adaptation series of 25 trials followed without notice by two test trials, the first after an interval of mean duration (15 sec.) and the second after an interval (5 sec.) at one extreme of the range employed in the experiment. Three groups received variable-interval schedules and one a constant-interval schedule at the mean of the other three. Group I was presented a rectangular distribution of five durations (5, 10, 15, 20, and 25 sec.), randomly ordered. Group II received a randomly-ordered normal distribution, the two extreme values each occurring 8% of the time, the two intermediate values 20% of the time, and the middlemost value 44% of the time. Group III received the same distribution as Group II, but non-randomly sequenced: the first 10 signals were presented as a rectangular distribution of the five durations; the next nine as a rectangular distribution of the three intermediate values; and the last six as a constant-interval schedule of the middlemost value. Group IV received all 25 trials at 15 sec.

B. METHOD

1. Subjects

Each group consisted of 36 S's, 16 males and 20 females, recruited mainly from sections of Introductory Psychology. A few subjects needed to fill the groups were drawn from beginning Education courses.

2. Apparatus and Procedure

A large black screen separated S and E, seated on opposite sides of a table. At the center of the screen on S's side, a one-half in. circular aperture backlit by a small signal lamp with amber filter constituted the stimulus display. A small silent switch mounted at E's station was connected so that manipulation started a Standard electric clock reading in 1/100 sec. and illuminated the light. A

similar switch in front of S extinguished the light and stopped the clock. S was fitted with Willson Sound Barrier Ear Muffs equipped with earphones through which he received 75 db white noise to mask possible auditory distractions.

Each S was seated before the display and told that he was participating in a reaction-time experiment. He was instructed to keep his eye on the aperture and his hand on his switch, and to turn off the light as soon as he saw it come on. He was allowed to ask questions about procedure before trials began to insure that he thoroughly understood the task. The 25 adaptation trials and the two test trials were run as an integrated series.

C. RESULTS AND DISCUSSION

1. Response on the Initial Test Trial

Fig. 1 presents the mean reaction time for each group in milliseconds on both test trials. Examination of the mean response latencies for the several groups on the first test trial indicate them to vary between 316 and 348 msec. These means, however, are not significantly different from each other ($F_{3,140} = 1.64, P > .05$) and compare closely with the average response latencies for the several adaptation series (Gp. I: 334 vs. 341; Gp. II: 348 vs. 338; Gp/ III: 333 vs. 338; Gp/ IV: 316 vs. 323). These results confirm Hardesty and Bevan's earlier conclusion that the subject's best estimate of the interval's probable duration is the arithmetic average of the prior intervals. Since expectancy is assumed to be maximal for this value, response latencies for intervals of corresponding duration--in this case 15 sec.--are anticipated to be of maximal efficiency, i.e. shortest. It would appear that when program conditions are optimal, that is when the expected and the actual durations coincide, the statistical properties of the stimulus program are irrelevant for responsivity.

2. Response on the Second Test Trial

The second test interval examines the possible influence of the statistical structure of the adaptation series upon response latency under less than optimum conditions of expectancy. It represents an abrupt shift from the optimum interval to the most deviant of the distribution used.

In the case of Group I, since all intervals are equally probable, the subject is assumed to have no basis for expectation and duration is eliminated as an effective guide to performance. Under such circumstances, one may assume that the subject will be maximally alert for all intervals. Hence performance on the second trial should not differ from that on the first. This is borne out by inspection of Fig. 1.

In Group II, with the randomly sequenced normal distribution of intervals, one might expect mean latency to be increased on the second test trial. Fig. 1 fails to confirm this expectation. Subjects are equally efficient on both trials. This result conflicts with the earlier results of Hardesty and Bevan and at present cannot be reconciled with them, except perhaps in terms of the variable of kurtosis. A future experiment should compare responsivity in the two test-trial situation with bell-shaped distributions of different amplitude.

Group III also received a normal distribution of intervals, but the non-random temporal order effects a systematic narrowing of the interval range and a regression toward the constant-interval condition. Under this circumstance, performance does not differ from that of the constant-interval group and demonstrates the importance of recency as a determinant of strength of expectation.

Group IV, with an invariant adaptation interval of 15 sec., may be expected to be maximally set for a 15 sec. test interval and minimally set for an interval of any other duration that is discriminable from it. Therefore, it was anticipated that the shift from the 15 to the 5 sec. interval on the test trials would be accompanied by an increase in response latency. This is borne out by Fig. 1. A simple analysis of variance confirms a between-groups difference on the second test trial ($F_{3,140} = 7.76, P < .01$). Duncan's New Multiple Range Test indicates Groups I and II, on the one hand, and Groups III and IV, on the other, not to differ from each other. Meanwhile, Groups II and III are significantly different.

D. SUMMARY

Four independent groups of 36 Ss each were used in a study of response latency as a function of the statistical structure of a prior schedule of presentation intervals. Each group received an adaptation series of 25 trials followed without interruption by two test trials. For three groups the adaptation series were variable interval schedules: a rectangular, a randomly sequenced normal, and a non-randomly sequenced normal schedule. The fourth group received a constant interval schedule set at the mean duration of the other three (15 sec.). The test intervals were consecutively 15 sec. and 5 sec. The groups did not differ from each other, nor from their pretest response latency, on the first test trial. The groups receiving the rectangular and randomly sequenced normal distribution of presentation intervals showed no change in response latency from the 15 sec. to the 5 sec. test trial. In contrast, the groups on the non-random normal and the constant-interval adaptation schedules showed a significant increase in response latency on the 5-sec. test trial. These results, except for those of the random normal group, conform to predictions from Expectancy Theory.

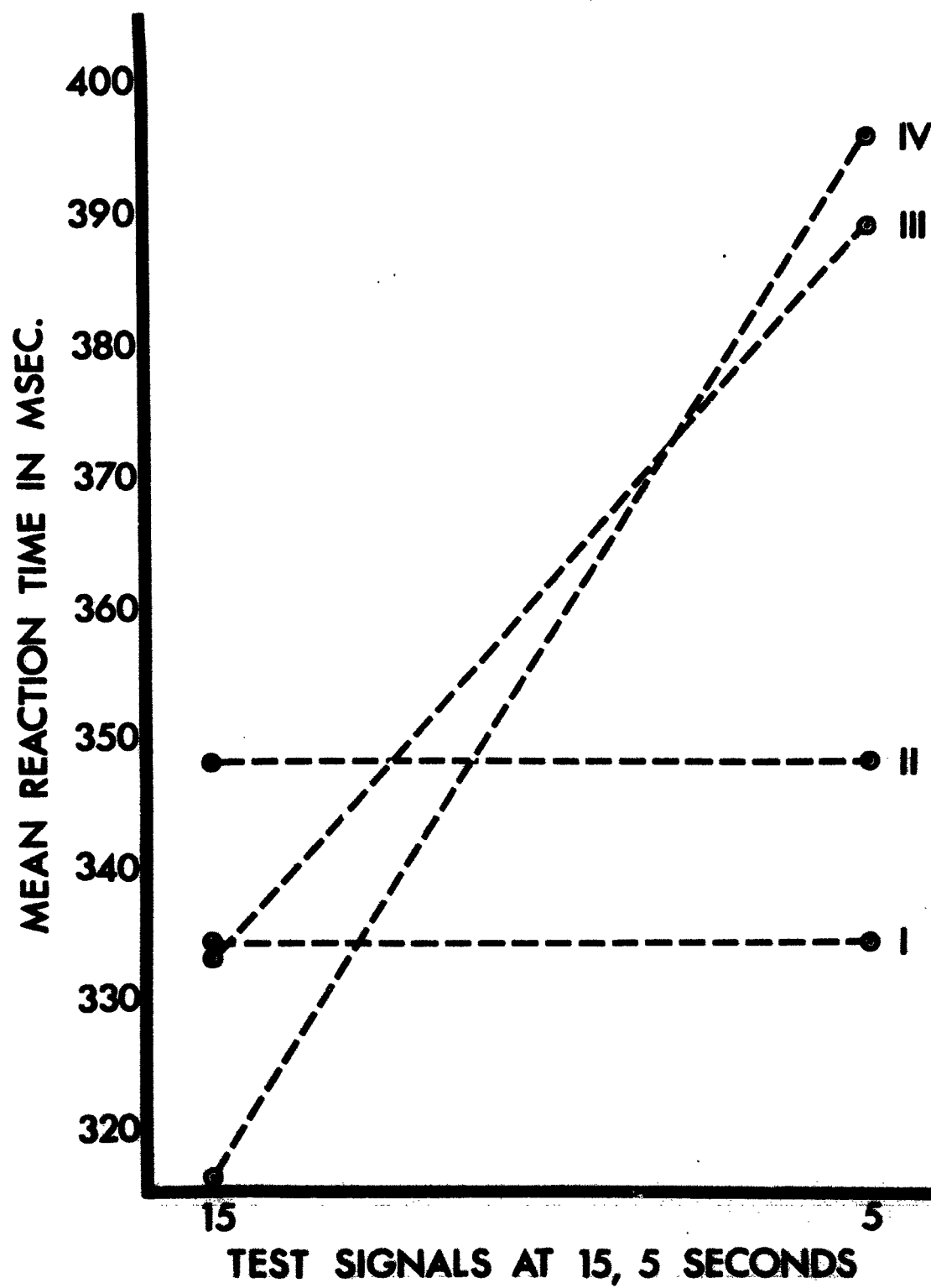
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FOOTNOTE

1. This work was performed under contract Nonr-3634 (01) between the Physiological Psychology Branch, Office of Naval Research, and Kansas State University. EDT is now at the University of California at Davis.

Fig. 1. Mean response latencies on 15 and 5 sec. test trials following adaptation series with different statistical structures. Group I received a rectangular distribution of 5, 10, 15, 20 and 25 sec. presentation intervals; Group II a randomly-ordered normal distribution; Group III a non-randomly ordered normal distribution; and Group IV an invariant program of 15 sec. presentation intervals.



Technical Report No. 30

Constancy¹

Harry Helson

Kansas State University

1. This report describes an experiment performed under contract Nonr-3634 (01) between Kansas State University and the Physiological Psychology Branch, Office of Naval Research. It is part of a project entitled "The Evolution of Perceptual Frames of Reference."

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May 1965

Constancy

Harry Helson

Kansas State University

It is a well-known fact of everyday experience that such characteristics of objects as their color, form, and size tend to remain invariant under changing conditions of stimulation. Thus a white sheet of paper looks white in bright sunlight and in deep shadow, a coin still appears round when it is turned out of the frontal-parallel plane and its image on the retina is elliptical, and a man appears the same height at 20 feet distance as he does at 10 feet, although the retinal image is reduced to one-half in linear dimensions in the former case. The constancy of object properties is not limited to visual perceptions but is found also in other sense modalities, e.g., an orchestra sounds equally loud in all parts of an auditorium that has good acoustic properties, and different temperatures feel "right" or comfortable within wide limits. If the brightness of objects were solely determined by the amount of light they send to the eyes, then a piece of chalk on an overcast day would appear as dark as a lump of coal on a sunny day and, in the course of one day, the same objects would take on all lightnesses between white and black. It is evident that objects as perceived tend to remain fairly stable in contrast to the changing conditions of stimulation. The fundamental nature of visual constancy was noted by Helmholtz (1924) and Hering (1920) who saw that it posed important problems for physiological optics. We now know that perceptual constancy has even greater importance in that it is part of the broader problem of biological adjustment and survival.

That perceptual constancy has its origins in basic mechanisms and is not wholly a product of memory or intellectual inferences about the way things ought to look is proved by experiments with very young children and adults. The results with children of different ages, while conflicting, show that they do not perceive the colors, shapes, and sizes of objects merely in accordance with the images projected on the retina, but rather in accordance with the invariant properties of the objects (Woodworth and Schlosberg, 1954, Chs. 14, 15, and 16). Experiments with animals below man are decisive. Fishes taught to get food in troughs painted a certain color continued to choose the same troughs even when the intensity

and color of the illumination was changed radically (Burkamp, 1923). Hens taught to discriminate white rice grains from yellow in daylight illumination continued to pick the 'white' grains in strongly colored yellow light (Katz and Révész, 1921). Finally, chimpanzees that chose food from containers having high or low reflectance (white or black) under normal conditions of illumination also chose the same containers when they were illuminated, so that the amounts of light reflected from them were reversed, i.e., that reflected from the containers with high reflectance was actually less than that from the containers with low reflectance (Köhler, 1915).

Much mystery has surrounded the ability of organisms to respond to invariant properties of objects, but a consideration of certain facts enables us to bring phenomena of perceptual constancy within the framework of well-known physiological and psychological processes thus relating them to the wider realm of biological adaptations. These facts may be summarized in a number of principles having general applicability (Helson, 1964). The first of these principles is that organisms adjust their level of response to the level of stimulation: if the average level of stimulation is high, as in bright sunlight, the eyes rapidly adapt to the high energies reaching the retina and thereby reduce the net effectiveness of the bright light; conversely, if the level of illumination is low, adaptation quickly makes the eyes more sensitive to incoming stimulation through regeneration of photopigments and also by the much faster action of less well-understood neural amplification mechanisms, thereby increasing its effectiveness. The role of adaptation in constancy, while recognized, was not sufficiently appreciated by 19th Century workers in visual science, because they thought only in terms of what Walls (1960) has called the "cold molasses" kinetics of photopigment concentration which could only account for the slow, insensitive sorts of adaptation. Recent work (e.g., by Schouten and Ornstein, 1939) has demonstrated there is a rapid, almost instantaneous, adjustment of visual processes to take care of sudden changes in stimulation, and there are mechanisms in other sense modalities for rapid adjustments to changed stimulation to bring the organism into equilibrium with the environment.

The second principle at work to preserve constant properties of objects is that organisms respond to ratios of stimulation as well as to absolute amounts of energy. When the general illumination is raised or lowered, the relative amounts of light coming from different objects to the eyes remain the same: white objects still reflect about 30 times as much light as black objects and hence the former look white and the latter look black in both bright and dim illumination. Contrast effects, whether simultaneous or successive, which depend upon ratios rather than absolute amounts of stimulation, are largely responsible for the stability of the visual world.

A third, often overlooked, principle operative in the perception of object properties is paradoxical from the point

of view of the concept of constancy. Constancy is hardly ever perfect. It is always approximate and partial. It is more proper to speak of "approximation" to constancy of "compensation" rather than in terms that imply unchangeable perceptions in the face of all changes in physical input to sense organs. Let us suppose for a moment that constancy were perfect. Then we would not recognize bright from dim illumination, objects at a distance would appear as large as close by, and we would feel no different on a cold day from the way we feel on a warm day. It does have biological utility to perceive changes in general illumination and in size and form of objects and to discriminate far from near sources of sound. Actually, there is never perfect constancy but only what Thouless (1931) called perceptual "regression to the real" object. To be sure, a white sheet of paper looks white in low illumination, but it is a dimmer white than in bright light and hence gives an indication of the lower amount of light it sends to the eyes: similarly, a man at 20 feet is perceived to be almost as tall as he does at 10 feet, but he is seen in a perspective that places him at a greater distance and so is a somewhat different perceptual object. Thus we have constancy with change, the one giving information about invariant objects properties, the other giving information about changes in the relations of objects to the organism. Technically, the facts reduce to this: while some dimensions of perception remain constant with changing stimulation, others do not, with the result that we are able to recognize objects as the same in altered environments.

Perceptual constancy has a parallel in the concept of homeostasis (Cannon, 1939) according to which physiological mechanisms act to preserve 'normal' values of certain critical constants such as 98.6° F body temperature, pH of 7.40 acid-base equilibrium of the blood, normal blood-sugar level, etc. The range over which objects are perceived as 'normal' or the same is, however, much greater than the range over which physiological constants may change while maintaining a normal state of health. However, it should be remembered that much of the constancy found in behavior depends upon the action of homeostatic mechanisms, e.g., ability to withstand fairly large changes in external temperature and reduced oxygen supply at high elevations.

While the discussion of constancy to this point has made it seem like a fairly simple, univocal phenomenon, it is by no means so when all the facts are considered. Constancy may be reduced and even made to disappear both by altering the field conditions under which objects are seen and by instruction to observers to adopt various attitudes in judging attributes of objects. Thus if one looks through a long, narrow black tube at objects, their color, size, and shape are seen in accordance with the properties of the retinal image, and there is little or no 'constancy'. If observers are asked to judge actual physical size, as against apparent size, then the perceived size increases with distance

(super-constancy or over-compensation). If, on the other hand, observers are asked to judge analytically, or in accordance with 'apparent size in perspective', then perceived size decreases with distance (Carlson, 1960). For some purposes one attitude is better than another: the painter must view a scene analytically and depict objects neither as they are physically, nor as they are perceived naturally, nor entirely as they are seen analytically but somewhere between these appearances in order that his picture may have some likeness to the object as perceived.

Studies purporting to show correlations between degree of perceptual constancy and intelligence or self-esteem (Coopersmith, 1964) and psychotic states (Weckowicz, 1964) may only be measuring the degree to which observers can adopt an objective or analytical attitude as against the natural way of looking at things and hence should not be interpreted as direct correlations between the mode of perception and complex personality traits or states. Similarly, cross-comparisons between children and adults, sub-human and human subjects, and sub-cultures and our culture with respect to the degree of constancy should be interpreted with caution in view of the large part played by field conditions and attitudes on perceptual constancy. The complex nature and the many factors determining how objects will be perceived, i.e., whether constancy, super-constancy, or no constancy is found, attests the many resources organisms have at their command for responding adequately to objects under the changing conditions of the external world.

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Technical Report No. 31

Anchor Effects in Pitch Localization¹

Eugene D. Rubin, Mark E. Ware, and Harry Helson

Kansas State University

1. This report describes an experiment performed under contract Nonr-3634(01) between Kansas State University and the Physiological Psychology Branch, Office of Naval Research. It is part of a project entitled "The Evolution of Perceptual Frames of Reference."

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May, 1965

Anchor Effects in Pitch Localization

Eugene D. Rubin, Mark E. Ware, and Harry Helson

Kansas State University

Evidence that high pitches are localized higher in space than low pitches was first presented by Pratt (1930) who stated that ". . . prior to any associative addition there exists in every tone an intrinsic spatial character which leads directly to the recognition of differences in height . . . along the pitch continuum." Since his pitches were an octave apart, and there were no inversions in the ordering of the tones, the evidence was very strong especially since the octave in which a tone lies is often confused with other octaves.

It was not until nearly thirty years later that Pedley and Harper attempted to settle whether pitches are associated with a particular height in space or are subject to series effects, i.e., are localized absolutely or relative to other pitches. To test if position in a pitch series would affect perceived height, these workers presented Os with three series of seven pitches in each of which two were the same, viz., 900 and 1400. In one series they were the top members, in the second, they were the middle members, and in the third, they were the lowest members. The results were clear: when at the top of the series, the two pitches were localized a little above 5 on a 1-7 scale; when in the middle, they were localized about four; and at the bottom of the series, they were localized a little over three. In this study we seek to determine if localization in space of pitches is subject to anchor as well as context effects, as predicted from adaptation-level theory. We hypothesized a low anchor should raise and a high anchor should lower perceived height of series tones as compared with their positions when no anchor is employed. Two experiments were performed and will be reported to show that apparently minor differences in conditions may affect the results in this area of investigation.

Experiment I

Subjects: The Ss were ten undergraduate men and women selected from Introductory Psychology courses at Kansas State University.

Apparatus: The study was conducted in a small room, 8' x 13' x 13'. An audio frequency oscillator connected in series

with an interval timer provided the series and anchor tones. The output of the oscillator was fed to two speakers connected in phase and mounted behind a black cloth screen three feet wide, reaching from the floor to the ceiling one ft. in front of the wall. On the screen was a white vertical strip 4 in. wide, marked with the numbers 1 through 7 at one ft. intervals from bottom to top; the number 1 was located at 1 ft. from the floor. In addition, the scale was marked at 3" intervals between the numbers to aid Ss in making more accurate estimates of the positions of the tones. The speakers were placed behind numbers 1 and 7, and wires were led to positions where speakers would have to be if there were seven rather than two speakers behind the screen.

Procedure: There were three conditions: (1) in the control (C) condition, only the five series stimuli consisting of 250, 375, 562, 844, and 1265 cps were presented; (2) in the high anchor (HA) condition, a tone of 2000 cps was presented before each of the series stimuli; and (3) in the low anchor (LA) condition, a tone of 80 cps preceded the series stimuli. The C condition was always presented first, followed by either the HA or LA conditions, counter-balanced across Ss. Each S observed in all conditions.

Each S sat in a chair facing the screen at a distance of 10 ft. from the screen, with head level with number 4 on the scale. Ss were provided with pencil and answer sheet on which they recorded their judgments.

All tones were equated for loudness according to equal loudness contours for pitch as given in Chapanis, Garner, and Morgan. Each tone was presented for 1.5 sec. with a 5 sec. rest period between tones and a 1 min. rest period between conditions. In the HA and LA conditions, there was a 3 sec. interval between the anchor and the series tones, with the anchor always presented first.

Ss were told there were seven small speakers behind the screen, one behind each of the numbers, and that several tones would be presented randomly through these speakers. Ss were asked to record the number posted in front of the speaker from which each tone came. If the tone seemed to be between numbers on the scale, they were to record exactly where it seemed to come (e.g. 4 1/2, 6 1/4, etc.). In the anchor conditions, Ss were told they would hear a tone immediately followed by another, but they were to record their judgment of the second tone only. A ready signal was given before each tone, and before the sequence of two tones in the anchor conditions.

Each S made practice judgments until he felt confident that he could locate the position of the tones on the scale. The five tones were then presented randomly five times making 25 reports by each S in each of the conditions. The data therefore were based on a total of 750 observations (10 Ss x 25 judgments x 3 conditions).

Results: The results were combined and averaged for each condition. In the HA condition, the anchor had a clear effect upon the series tones; all tones were localized below

the control localizations when no anchor was employed. The LA condition, however, appeared to have had no effect on the series tones as the LA and C curves crossed four times.

An analysis of variance showed that there was a significant difference between stimuli, $F (df 4, 36) = 20.31, p < .01$, and between conditions, $F (df 2, 18) = 1.47, p < .05$. The significant difference between stimuli shows that the stimuli were judged as being at different heights on the scale: as the tones increased in pitch, they were judged higher on the scale. The significant effects between conditions show that the anchors did affect the series tones, but this must be ascribed to the HA condition in view of its clear separation from the control condition and not to the LA condition. The difference between the mean of the C condition and the mean of the HA condition was .615, $F (df 1, 18) = 15.846, p < .01$. The high anchor pushed the judgments of the series tones down an average of about 7.4 in. on the scale. The difference between means of the C and LA conditions was .053 (not significant). The LA pushed the series tones up an average of only a little over 0.5 in. on the scale. The significant interaction between stimuli and conditions shows that the stimuli were differentially effected by the anchors in accordance with the usual repulsion effects of anchors.

Discussion: The analysis of variance supported the prediction that the high anchor would lower judgments of vertical location, but did not support the prediction that the low anchor would raise the judgments. The ineffectiveness of the low anchor upon the series members must be attributed to a number of factors. It appears that the low anchor, far below the series stimuli, was perceived as being somewhat unrelated to them. Another reason why LA was ineffective may have been that the equal loudness curves, used in calibrating the stimuli, were not appropriate for the experimental room, thus creating inequalities in the loudness of the tones.

A second experiment was therefore performed in view of the clear-cut anchor effect of the HA condition, not only to verify the initial hypotheses of this study, but also to gain an understanding, if possible, of why the LA failed to yield significant effects.

Experiment II

Subjects: Twelve undergraduate women were recruited from Introductory Psychology classes during the summer session at Kansas State University

Apparatus: A larger room (17' x 13' x 13') was used for the second experiment. All other apparatus was identical with that of Experiment I, except for three changes. An electronic switch was introduced into the circuit to eliminate clicks which may occur at the onset and offset of the tones. It was found that some Ss reported that these clicks appeared to shift the location of the tones. Two oscillators were used; one for the series tones and one for the anchor tones

along with two attenuator pads for equating loudness. The wires that led to supposed oscillators behind the seven numbers on the scale were also removed.

Procedure: Several important changes were introduced in the procedure of Experiment II. The series of tones was the same as in Experiment I, except that the LA was moved up from 80 to 158 cps, making the LA the same distance on a geometric scale as far below the lowest tone of the series as the HA was above the highest tone of the series.

Each S still served across all conditions, but in this case, all conditions were counterbalanced across all Ss. But in this experiment each S observed under only one condition per day, the three conditions, C, HA, and LA being given on successive days.

The presentation order of the tones was a 5 x 5 Latin square presented two times in succession. Each tone was therefore judged ten times under each of the three conditions. The data are therefore based on a total of 1800 observations (12 Ss x 5 tones x 10 observations x 3 conditions).

A short pilot study was run in order to equalize the loudness of the tones in the new room where the second study was conducted. All tones were equated in loudness to the middle tone (562 cps) using the method of limits.

The instructions emphasized the fact that this was purely a judgmental task, and that there were no right or wrong answers. The Ss were encouraged to use the entire scale and, if they wished, to use numbers above or below the scale (numbers greater than 7 or less than 1). Ss were only told that the speakers were behind the screen to counteract any preconceived ideas as to where the tones came from. The Ss were also instructed to make verbal reports of the locations of the tones. It was emphasized that the Ss were to keep their heads steady and turned toward the scale while the tones were being presented.

Results: The data of this experiment are graphically illustrated in Fig. 1. In this experiment, the low as well as the high anchor had significant effects on localization of the series tones. The conditions were found to be significantly different in the analysis of variance, $F(df\ 2, 100) = 58.35$, $P < .01$, and, in the same analysis corrected for residual effects, $F(df\ 2, 4) = 11.984$, $P < .025$. Multiple comparisons indicated that both LA vs. C and HA vs. C were significantly different.

Once again, the tones were judged as being at significantly different places on the scale, $F(df\ 4, 100) = 255.30$, $P < .01$. Particular sequence, practice effect (P), and all interactions were statistically not significant. The adjusted residual effects were also not significant.

When the tone component (T) and the tones x conditions (T x C) interaction were analyzed, there was a significant linear tone component, $F(df\ 1, 124) = 756.91$, $P < .01$ and a significant T x C linear component, $F(df\ 2, 124) = 3.32$, $P < .05$, indicating that, while all three curves were stat-

istically linear, the slopes of the curves were significantly different. All other components were not significant.

Discussion: The results support the original hypotheses that anchors would shift the judgments of the vertical location of pitch. Both high and low anchors shifted localization of pitches significantly. Furthermore, the hypothesis that contrast effects would occur with both the HA and LA was borne out statistically. From Fig. 1, it can be seen that the tones which were affected most by each anchor were those closest to the anchor, as has been found with lifted weights and in vision.

The second study has shown that judgments of height of pitches are affected by factors which, if not controlled, can hide anchoring effects. Such factors as room size, reverberation times, absorbent qualities of the walls, background noise, which may mask certain tones, unequal loudness, insufficient number of observations, and instructional set may affect the judgment process. For example, a pilot study was run for the second experiment in a special sound absorbent and shielded room. It was hoped that this would reduce any background noise which might influence judgments. But it turned out that the sound absorbent tile appeared to have reduced the effect of the higher tones, especially the high anchor, which was previously effective in the room used in the first study.

Summary and Conclusions

Typical anchor effects were found in pitch localization: an anchor below the series pitches displaced them upward, and an anchor above the series pitches displaced them downward with the maximum shifts occurring in series stimuli nearest the anchors in accordance with the usual anchor effects. It thus appears that pitch, supposedly a metathetic dimension, yields effects similar to loudness, a prothetic dimension, so far as localization is concerned. While it may be claimed that "height" is not a metathetic dimension, Christman showed that satiating tones lower in pitch cause an upward displacement in perceived pitch, and higher satiating tones cause a downward displacement in perceived pitch. Whether the anchor effects found in this study result from apparent position of the anchors relative to that of the series tones or from their effects on the pitch of the series tones, or both, can only be answered by further experimentation. It thus appears that no distinction can be made between so-called metathetic and prothetic continua, so far as series and anchor effects in perception of pitch and apparent position in space are concerned. Furthermore, series and anchor effects appear to be the same with respect to pitch as they are in perception of loudness, brightness, and tactile-kinesthetic qualities.

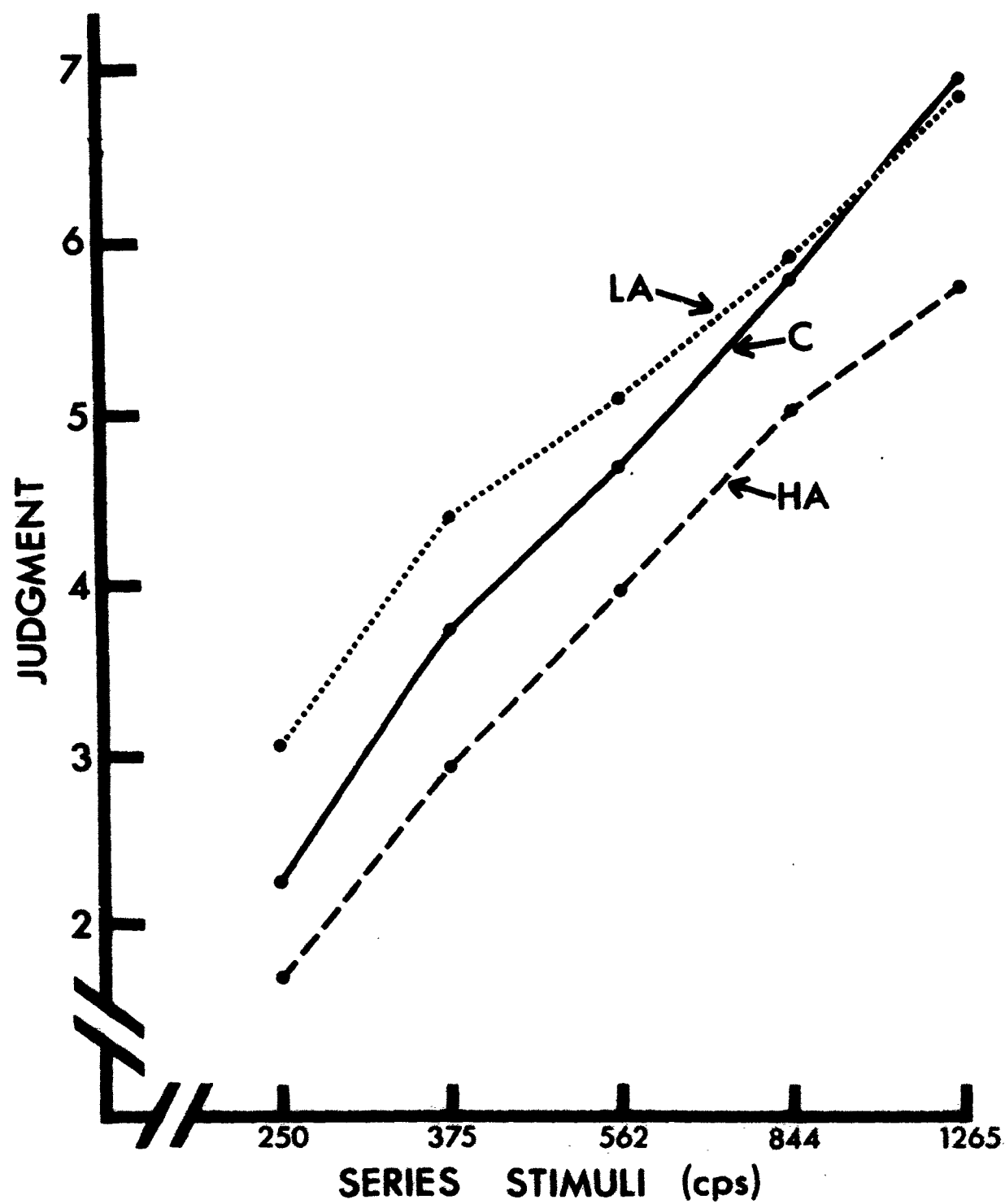
FOOTNOTES

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FIGURE LEGEND

Fig. 1. Judgments of Heights of Tones as a Function of Anchor Below (LA) and Above (HA) the Series Tones. In the Control (C) the Series Tones were Judged Without Anchor Tone.



Technical Report No. 32

The effect of variation in specific stimuli
on memory for their superordinates¹

William Bevan, Kansas State University, William F. Dukes,
University of California (Davis), and Lloyd L. Avant,
Kansas State University

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The effect of variation in specific stimuli
on memory for their superordinates*

William Bevan, Kansas State University, William F. Dukes,
University of California (Davis), and Lloyd L. Avant,
Kansas State University

One of the widely accepted notions regarding human behavior concerns the relationship between repetition--practice, exercise, frequency--and retention. Summarized by the cliché, "Practice makes perfect," the general idea was given scientific status by such pioneers as Ebbinghaus and Thorndike. Its validity has, of course, not gone unquestioned. Early challengers include, among others, Gottschaldt¹ with his data on the recognition of hidden forms, Dunlap² in his demonstration involving "negative practice," and, on the basis of results from drawing lines while blindfolded, even Thorndike³ himself. More recently, the generalization has been under attack by the protagonists in the one-trial learning controversy.⁴

Dunlap focussed on the question of what is repeated, Gottschaldt on where it is repeated (the question of context), and Thorndike on how it is repeated. During the past 40 years numbers of investigators have explored various aspects of these not-independent questions, especially those treating the effects of changed context at the time of recall. Few, if any, investigations have sought to determine the effects on memory of varying, in successive presentations, the "what-is-repeated." Essentially a problem in memory for classes, the question in its simplest form is: Will one be better able to recall x if he has been exposed to the sequence x_a, x_a or x_b, x_b , rather than to the sequence x_a, x_b ? Will he recall x better if presented x , twice as an aspect of ax or bx , than if he experienced ax and bx each once? Some of the literature on the effects of varied experience--e.g., that treating early environment and later learning⁵ and the evolution of concepts⁶--suggest that varied presentations may be facilitating. The reports of⁷ detrimental effects of contextual change at the time of recall, as well as inferences from some of the work on variability of stimulus compounds⁸, might, on the other hand, lead to the opposite conclusion.

In an effort to provide some answers to the questions

raised above, three separate experiments were performed. The first two, "qualitative" in the sense of asking "yes" or "no" about the effects of varied experience, differ primarily in the type of stimuli used, pictures in the first instance, words in the second. The third experiment, essentially quantitative in nature, and extending the rationale of the first two, explores the effects of different degrees of variation.

Experiment I

Method. (1) Materials. From pictures of two different specimens of 20 easily recognizable and identifiable objects (e.g., a red apple was arbitrarily designated specimen A, a yellow one, specimen B; a man's shoe, A, a woman's shoe, B, etc.), colored slides were prepared, the within-pair sizes of the pictured objects being approximately equal. The slides were assembled into four series, each containing two instances of every object as follows:

- Series 1: Slides 1-20: all A-specimens
Slides 21-40: A specimens repeated for one half of the slides, B's presented for the other half.
- Series 2: Slides 1-20: all A-specimens
Slides 21-40: B specimens of the objects presented as A in slides 21-40 of Series 1 and vice versa.
- Series 3: Slides 1-20: all B specimens
Slides 21-40: B specimens repeated for one half of the slides, A presented for the other half.
- Series 4: Slides 1-20: all B specimens
Slides 21-40: A specimens of the objects presented as B objects in slides 21-40 of Series 30 and vice versa.

Within each set the order of presentation of repeated and different specimens was balanced: RDDRDDR or vice versa. No sequences or reversed sequences of objects were duplicated from first to second half of the series, and no object appeared in a highly favored or unfavored position for both presentations.

(2) Procedure. Slides were presented to Ss in groups by means of a Kodak Carousel 35mm projector with 2 sec. exposures and 2 sec. intervals between slides. The only directions given Ss before presenting the slides were to alert them to the fact that they were to participate in a psychological experiment during which they would see, in rapid succession, pictures of common objects on the screen before them, and to request that they not make comments, laugh, or take notes while the slides were being shown.

After the showing of the slides each S was given a sheet of paper on which he was asked to write the names--

single words, common nouns--of all objects he could recall having seen. One and one-half minutes were allowed for recall.

(3) Subjects. Records were obtained in the classroom from four groups of Ss, members of undergraduate psychology and education classes at Kansas State University, one group for each of the series described above. In all, 125 Ss participated; but to facilitate treatment of the data, records of Ss were randomly excluded until the N for each group was equal to that of the smallest (26). The number of male and female Ss per group was approximately equal.

Results. Although the objects were selected in part on the basis of ease of identification and uniformity of identifying label ("apple," "piano," etc.), some leeway was allowed in determining the acceptability of a response--e.g. either "purse" or "handbag" was acceptable. The number of items recalled by individual subjects ranged from eight to 16 out of the 20 possible, the mean being 11.31.

For each subject a difference score was obtained by subtracting the number of duplicated items recalled from the number of varied items recalled--(EAB-EAA) or (EAB-EBB). These difference scores ranged from -5 to 8, their overall mean being 1.27. Because of the particular design employed--each subject was his own control for the variety-repetition portion--the usual measure of the major intervals was not available. The difference scores were consequently subjected to a modified analysis of variance in which the mean difference for all groups was compared to zero, the expected mean difference under the null hypothesis. In this analysis, variety was a highly significant source of variance-- $F(1,104) = 35.6$, $p < .01$ --indicating the superiority in memory for this type of varied presentation over sheer repetition.

Experiment II

Method. (1) Materials. Instead of pictures, 20 different common nouns are used as stimulus-objects. Variety was achieved by having different modifiers or specifying words--e.g., "pine tree," "oak tree," "sunny weather," "rainy weather," etc. Four series were constituted in the manner described for Experiment I.

(2) Procedure. The directions to Ss and the presentation of the slides paralleled those in the preceding experiment except that 3 sec. exposures were used with no between-slide interval other than the brief, uniform period involved in the machine's automatic operation. After all the slides had been shown, Ss were asked only to write down all the second words, i.e. the nouns, that they could remember in 1 1/2 min.

(3) Subjects. Ss were members of undergraduate psychology and education classes at the University of California, Davis. As before, records were selected randomly from the largest groups until all four were equal in size (23).

Results In scoring, no deviations other than plurals were accepted. The number of words recalled by individual subjects varied from 5 to 14, the mean being 9.11. Difference scores (Σ varied - Σ duplicated words recalled) ranged from -5 to 6, with a mean of .54. When the variance was analyzed in the manner indicated above, variety again was a significant source, $F(1,92) = 6.29$, $p < .05$.

Experiment III

Because of the positive effects of variety on memory, the following experiment was performed to explore beyond the either-or question by introducing different degrees of variation.

Method. (1) Materials. The pictures used in Experiment I were supplemented by adding two more specimens (C and D) to each of the 20 categories. The slides were assembled into five series of 80 each as follows:

- AAAA - Each A specimen presented four times in complete, randomized sets of 20.
- AAAB - Each B specimen presented once for every three presentations of the A specimens; order of presentation randomized in sets of 20.
- AABE - Each B specimen presented twice for every two presentations of the A specimens. Order randomized in sets of 20.
- AABC - Each A specimen presented twice, B once, and C once. Order randomized in sets of 20.
- AECD - Four complete randomized sets of 20, one composed of A specimens, one of B specimens, etc.

(2) Procedure. The main procedural routine was the same as that in Experiment I, except that 3 min. were allowed for recall. In addition, without prior announcement, retention was tested, depending on class scheduling, two to four days after presenting the slides and again after a three-week period.

(3) Subjects. Ss were freshmen, members of English Composition classes at Kansas State University. As before, testing was done in the classroom, separate classes being used for each of the five series outlines above. Because of the difficulty in obtaining a constant male to female ratio and in order to avoid possible variability in results due to sex, only male records were used, the total N being 48 (9, 9, 5, 10 and 15 for the five groups).

Results. S's score was simply the number of generic stimuli recalled. The mean recall scores for each of the five groups under each of the three recall conditions--immediate, two-four day delay, and three-week delay--are shown graphically in Fig. 1. An overall analysis of variance, as well as three one-way analyses for the three recall conditions, was performed. The summaries of these analyses are presented in Tables I and II. These results indicate quite

clearly that success in recall, both immediate and long term, is positively related to the degree of variety among the specimens representing each class of stimulus object.

Discussion

The data from each of the experiments indicate that memory for generic stimuli may be enhanced by varying, in successive presentations, the specimens representing them. S is, for example, more likely to recall "shoe" if he is shown one picture of a woman's ballet shoe and another of a man's oxford, than if he is shown either twice. Similarly, the likelihood of recalling the word "weather" is greater if shown the words "sunny weather" and "rainy weather" than if shown either pair two times. These results may be contrasted with the disruptive effects generally reported in experiments where variation is introduced at the time of recall rather than during training. The two sets of findings are, of course, not necessarily contradictory, since the effect of any change would undoubtedly be a function both of its nature and of the time at which it is introduced. As in the case of the formally similar transfer problem, determining the types of situations--here the dimensions to be varied--which have generally positive, zero, or negative effects on retention is a further empirical problem.

One might also expect, as the results of Experiment III demonstrate, different effects from different degrees of variation among the specimens used. Increasing the degree of variation here proved to be essentially facilitating: Fig. 1 depicts the improvement in recall with diversity; the analysis indicates the significance of this relationship-- F series (4,43) = 12.30, $p < .01$. Although Fig. 1 suggests the relationship between specimen variety and success in recall to be monotonic for the range examined, this cannot be confidently asserted since the values on the abscissa are not known to constitute an interval scale. Nor would such a relationship be expected to hold indefinitely as degree of variety became greater. A possible depressing effect from a small degree of variation, manifest in both immediate and three-week recall data, is suggested by the slightly lower recall scores with the introduction of one degree of variation in four repetitions (AAAA to AAAB). If this minimum initial drop in an otherwise increasing function is a real effect, it is not at all novel, having been observed in several other relationships in psychology.¹⁰

A further question concerns the manner in which the effects of varied repetition on memory operate over time. Since the same subjects were used under each recall condition, there is some contamination in the results from the delayed situations. However, since the contamination would tend to work against the effect, by minimizing temporal differences, it is, for our present purposes, of little consequence. As indicated in Fig. 1 and validated by the analysis, several

temporal effects are observed in the data. First, there is the usual loss with the passage of time, immediate recall being considerably superior to the other two conditions-- $F(1,86) = 137.21, p < .01$. Second, the greatest loss, as in traditional curves of forgetting, occurs early. The difference between recall under the delayed conditions, although significant, is less marked than that between the immediate and delayed-- F of 6.94 vs 137.21. Third and most important, the primary effect becomes more pronounced with time, the greatest loss over time occurring with the less varied presentations: F interaction $(8,86) = 4.80, p < .01$.

In attempting to explain these overall findings--the positive effect of variety on memory for generic stimuli--one might equally well invoke an associationistic or a motivational hypothesis. By the former, the increased number of associations with x (a, b, etc.) would enhance its probability of recall because recalling any one of the several items may lead to its recall as opposed to the limited condition of the single associate. The motivational type of hypothesis would, on the other hand, make the advantage stem from heightened interest or attention as the aspects vary. The two, of course, are not mutually exclusive. The degree to which each may operate in producing this effect might be determined, or at least explored, in further empirical investigations.

Summary

Three experiments involving a total of 251 subjects, examined the relationship between the recall of generic stimuli and the number of individual specimens used to represent such stimuli. The first two compared immediate recall after two different specimens had been presented with recall after the repeated presentation of a single specimen. In the first experiment the stimuli were colored photographs of common objects; in the second, common nouns with frequently associated adjectives. In both instances, more generic stimuli were named when two different specimens represented the stimulus than when a single specimen was repeated. The third experiment was a more elaborate one in which each generic stimulus was represented by from one to four specimens. Success in recall was positively related to the number of specimens presented. Furthermore, this difference in performance was enhanced with the passage of time. Memory loss after two or four days and after three weeks was greatest for the condition involving the repetition of the single specimen and decreased as the number of specimens used was increased.

FOOTNOTES

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TABLE I
Summary of an Overall Analysis of Variance
of the Data of Experiment III

Source	df	SS	MS	F	P
Series (AAAA, AAAB, etc.)	4	635.60	158.90	12.30	< .01
Linear	(1)	570.64	570.64	44.17	< .01
Non-linear	(3)	64.96	21.65	1.68	
<u>Ss</u> within series	43	555.56	12.92		
Recall	2	346.06	173.03	72.07	< .01
(2-4 day) vs (3-week)	(1)	16.67	16.67	6.94	< .01
Immediate vs. delayed (both conditions combined)	(1)	329.39	329.39	137.21	< .01
Series X Recall	8	92.15	11.52	4.80	< .01
Linear	(2)	58.85	29.42	12.26	< .01
Non-linear	(6)	33.30	5.55	2.31	< .01
(<u>Ss</u> within Series) X Recall	86	206.46	2.4		
Total	143	1835.83			

TABLE II
Summaries of Analyses of Variance
Under Three Conditions of Recall for Experiment III

Immediate Recall					
Source	df	SS	MS	F	P
Between Groups	4	73.03	18.26	4.77	<.01
Linear	(1)	65.70	65.70	17.18	<.01
Non-linear	(3)	7.33	2.44	--	
Within Groups	43	164.45	3.82		
Total	47	237.48			
2-4 Day Recall					
Source	df	SS	MS	F	P
Between Groups	4	356.99	89.25	11.98	<.01
Linear	(1)	310.34	310.34	41.66	<.01
Non-linear	(3)	46.65	15.55	2.09	
Within Groups	43	320.32	7.45		
Total	47	677.31			
3-Week Recall					
Source	df	SS	MS	F	P
Between Groups	4	297.73	74.43	11.54	<.01
Linear	(1)	239.31	239.31	37.12	<.01
Non-linear	(3)	58.42	19.47	3.02	<.01
Within Groups	43	277.24	6.45		
Total	47	574.97			

Legend for Figure 1.

Recall of generic stimuli as a function of the number of specimens representing each generic stimulus: AAAA, four presentations of a single specimen for each generic stimulus; AAAB, three presentations of one and one presentation of a second specimen; AABB, two presentations of two specimens; AABC, two presentations of one specimen and one presentation of two other specimens; ABCD, one presentation of four different specimens.

