Integration of conceptual information¹

Z. JOSEPH ULEHLA, LESLIE CANGES² AND FRANCES WACKWITZ³

UNIVERSITY OF DENVER

The integration of information model of Signal Detection Theory was tested in multiple observation conceptual discrimination tasks. Mean improvement in discriminability resulting from additional stimulus observations was consonant with theory when Ss produced a rating response after each stimulus observation, but fell short of theory when S judged the complete stimulus sets in a binary fashion.

Signal Detection Theory (SDT) provides a quantitative model for the integration of the information contained in multiple stimulus samples. If, on each trial, n independent samples are drawn from one of two stimulus alternatives, the resulting index of signal discriminability (d') is predicted to be $\sqrt{n}$ times the d' yielded by single samples (Green & Swets, 1966). In psychophysics, the validity of this prediction has received varying degrees of support (Green & Swets, 1966). This paper describes two experiments testing the integration model in a conceptual task—the discrimination of brief samples of English text.

EXPERIMENT I

Subjects

Six undergraduate students were employed as Ss.

Materials and Procedure

Two rather different magazines were used as the alternative stimulus sources. Magazine A is a "he-man" magazine, oriented to male readers and featuring adventure and sex. Magazine B is a "confessional" magazine, oriented toward female readers and featuring first-person accounts of romantic and family involvements. In total, 1200 two-word and 1200 four-word series of consecutive words were randomly selected from recent issues of each of the two magazines. The two-word and four-word series were each apportioned into the following stimulus conditions: (a) single-stimulus condition, with each item set consisting of a single word series; (b) double-stimulus condition, each item set consisting of a pair of same-source word series; (c) triple-stimulus condition, each item set consisting of three same-source word series. Each condition utilized 400 randomly ordered item sets, 200 from each magazine source. The materials for a condition were presented in 20 booklets of 20 item sets each; thus, in total, 120 booklets of conceptual discrimination items were presented.

Each S completed the 120 booklets of item sets in a randomly determined order over several self-paced experimental sessions. The S responded to each stimulus set by writing the first letter of the magazine he judged to be its source. In addition to a one dollar per hour base pay, Ss were paid one cent for each correct decision and fined one cent for each incorrect decision. S checked the accuracy of his work upon completing each booklet.

Results

Values of d' were computed for each stimulus condition for each S. The integration model of SDT predicts that the d' for doubles conditions should be $\sqrt{2}$ times the d' for singles conditions and that the d' for triples conditions should be $\sqrt{3}$ times the d' for singles conditions. As shown in Table 1, the mean d' s increase monotonically from single to double to triple conditions, but the increases fall far short of those predicted by the integration model.

EXPERIMENT II

Experiment 2 was suggested by preliminary findings⁴ of excellent integration of information in a perceptual task when S made a probabilistic judgment after each stimulus observation. It seemed possible that S may fail to make efficient use of the information contained in multiple stimulus observations when only one binary response is made to the entire set of stimulus observations, but S may be constrained to be more efficient when a relatively finely graded response is required after each stimulus observation of the set. Experiment 2 was conducted to test the same predictions tested in Experiment 1, but with a complex rating response required after each stimulus observation. In addition to the discrimination task of the previous experiment, an additional conceptual judgment task was included. This task required S to discriminate true statements from false statements adapted from multiple-choice elementary psychology test items designed for examinations in introductory psychology courses.

Subjects

Thirteen undergraduate students comprised the S sample. Seven performed in the magazine judgment task and six in the true-false discrimination task. All Ss used in the true-false task had completed an introductory course in psychology.

Table 1. Ratios Comparing d' in Double-Stimulus Conditions (d'_2) and Triple-Stimulus Conditions (d'_3) to the d' in the Single-Stimulus Conditions (d'_1) in Experiment I

Subject Number	Two Word Length		Four Word Length	
	d'_2/d'_1	d'_3/d'_1	d'_2/d'_1	d'_3/d'_1
1	1.31	1.41*	1.28*	1.58
2	0.98*	1.28*	1.16	1.22
3	0.85	1.04	1.29	1.37*
4	1.56	2.00	1.26*	1.39*
5	1.13*	0.95	1.37	1.56
6	0.92	1.43	0.92	1.21
Mean	1.13	1.35	1.21	1.39
SDT Predicts:				
	$\sqrt{2} = 1.414$	$\sqrt{3} = 1.732$	$\sqrt{2} = 1.414$	$\sqrt{3} = 1.732$

* Median

Table 2. Ratios Comparing d' in Double-Stimulus Conditions (d'_2) and Triple-Stimulus Conditions (d'_3) to the d' in the Single-Stimulus Conditions (d'_1) in Experiment II

Subject Number	True-False Items	
	d'_2/d'_1	d'_3/d'_1
1	1.69	2.69
2	1.33*	1.84*
3	1.31	1.66
4	1.47*	1.84*
5	1.50	1.75*
6	1.21	1.15
Mean	1.42	1.82
SDT Predicts:	$\sqrt{2} = 1.414$	$\sqrt{3} = 1.732$

Subject Number	Magazine Items			
	Two Word		Four Word	
	d'_2/d'_1	d'_3/d'_1	d'_2/d'_1	d'_3/d'_1
1	0.99	1.36	1.51	1.89
2	1.42	1.58*	1.35	1.75
3	1.21	1.38	1.38	1.59
4	1.30*	1.81	1.21	1.50
5	1.14	1.38	1.12	1.46
6	2.48	2.72	1.30*	1.51*
7	1.37	1.77	1.28	1.46
Mean	1.42	1.71	1.31	1.59
SDT Predicts:	$\sqrt{2} = 1.414$	$\sqrt{3} = 1.732$	$\sqrt{2} = 1.414$	$\sqrt{3} = 1.732$

* Median

Materials and Procedure

The two-word and four-word three-item sets employed in the triple-stimulus condition of Experiment 1 constituted the materials for the magazine discrimination task. For the true-false discrimination condition, three-item sets (200 true, 200 false) were combined in a random order.

The seven Ss assigned the magazine judgment task performed in both the two-word and four-word conditions. In addition to judging the source (or truth value) of the stimulus items, S produced certainty ratings which ranged from 50% to 100% in steps of 10%. The S was instructed that accurate use of the certainty ratings would result in 50% of the judgments rated 50% proving correct, 60% of the judgments rated 60% proving correct, etc.

The S responded to each triplet as follows. Using cardboard to screen subsequent stimuli, S initially observed only the first member of the triplet. On the basis of this observation, S judged the source (or truth-value) of the stimulus item and expressed, in a percent, his certainty that this judgment would prove correct. The S then exposed the second stimulus item and produced a second stimulus judgment and certainty rating with both stimulus items in view. The S had been instructed to consider both stimulus items when making his second stimulus judgment and certainty rating. Similarly, S produced a third judgment and certainty rating on the basis of all three stimulus items comprising the triplet.

In addition to a base pay of one dollar per hour, S

received 1/3 cent for each correct stimulus judgment and was fined 1/3 cent for each incorrect stimulus judgment. A second bonus related to accuracy of S's certainty rating; after all items were completed, the actual percentage correct was computed over judgments assigned each certainty rating. The S was paid one dollar for each instance in which the percentage correct was within 10% of the nominal percent.

Results

Three sets of d' values were computed for each type of stimulus material. The first set included a d' for each S based on his judgments of the initial stimulus item of each triplet. The second set pertained to judgments of the first two stimuli of each triplet, and the third set pertained to judgments of entire triplets. Certainty ratings were ignored in the computation of d' s. In theory, for each S the d' values of the second and third sets should be $\sqrt{2}$ and $\sqrt{3}$ times the d' of the first set, respectively. As shown in Table 2, the means over Ss of the ratios of d' values were generally close to the theoretical predictions. The extremely close fit of some of the mean ratios to theory may be fortuitous, given the substantial inter-S variability.

DISCUSSION

Only Experiment 2 yielded a mean improvement in d' with additional stimuli that was consonant with the integration model of SDT. The failure to obtain the predicted improvement in Experiment 1 may be due to a lack of concentrated effort to use all of the available information when S has only to make one binary discrimination response to the entire set of two or three stimuli. In Experiment 2, S observed the stimuli of a set sequentially, made a discrimination judgment after each stimulus observation, and expressed his certainty that his discrimination judgment would prove to be correct. With the complex judgments required in Experiment 2, mean integration of information conformed fairly closely to the $\sqrt{n}$ prediction of SDT. Somewhat similar results have been obtained in an auditory detection task. Swets & Birdsall (1967) found that requiring certainty ratings from S led to efficient integration of information, but responding after each stimulus observation yielded no better integration than responding once per trial. In both psychophysics and conceptual discrimination, the integration model appears tenable when relatively complex responses are demanded of S.

References

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- Swets, J. A., & Birdsall, T. G. Deferred decision in human signal detection: A preliminary experiment. *Percept. & Psychophys.*, 1967, 2, 15-28.

Notes

1. This research was supported by the National Science Foundation Grant GB-3081. Thanks are due to Drs. Kenneth B. Little and Donald Stilson for valuable suggestions and to Terry C. Weyl for assistance in data analysis.
2. Now at the University of Colorado.
3. Now at the University of Illinois.
4. Cameron R. Peterson, personal communication, 1966.