Method of constant stimuli: Invalidity to the third power*

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A description of deficiencies in the method of constant stimuli, published by Levison and Restle (1968), was criticized as logically invalid by Sekuler and Erlebacher (1971), who then interpreted the findings as the result of a tendency to use available responses equally often. Sekuler and Erlebacher erroneously thought that the comparison adaptation-level (CAL) theory described the frame of reference for judgments. Correctly interpreted, the theory presents no logical difficulties. An experiment was performed to compare this frame-of-reference interpretation of CAL with the Sekuler-Erlebacher response-bias theory. The results agreed in detail with CAL theory and were in direct opposition to the response-bias interpretation. Thus, although the Sekuler-Erlebacher hypothesis is logically possible, it does not seem to be empirically true.

Levison and Restle (1968) recently published an experimental demonstration of the dangers of the respected method of constant stimuli in psychophysics, showing that the measured point of subjective equality (PSE) is spuriously close to the middle of the range of comparison stimuli (Co) used. We commented that, since E often chooses a narrow range of Co near where he expects to find the PSE and the method puts the PSE near the center of the range of Co, this method will give E any answer he expects. This, we claimed, is the worst sort of methodological error.

The particular experimental results were handled by the comparison adaptation-level (CAL) theory of Helson, in the Levison-Restle paper. Sekuler and Erlebacher (1971) have criticized this interpretation as illogical and have put forward an alternative interpretation, namely, that Ss attempt to use their available response alternatives equally often. Sekuler and Erlebacher's hypothesis agrees with ours as to the dangers of the method of constant stimuli, but differs as to interpretation.

In the original discussion of CAL theory, Helson, Michels, and Sturgeon (1954) said that the variable comparison stimulus, Co, is judged relative to CAL, a weighted geometric combination of the standard (Std), an average of all previous comparison stimuli, M(Co), and constant

factors. Sekuler and Erlebacher erroneously think that this is a "perceptual" theory and that the perceptions of the Std and Co stimuli are altered by previously presented stimuli. In fact, the CAL theory says that Std and Co have different roles; the standard combines with previous stimuli and background to form the CAL, and the current comparison stimulus is judged with respect to that frame of reference. Neither stimulus is altered in perception.

We have attempted to decide why Sekuler and Erlebacher drew the conclusions they did from our paper and, presumably, from Helson et al (1954). One problem is the use of the word "adaptation," which is currently employed in the sense of aftereffect experiments like dark adaptation, the effect of bright stimulation on later vision in the dark, or the kind of adaptation discussed by Rock (1966). It might be well if such effects were referred to as "aftereffects." Helson chose to use the term "adaptation level" for the mean value of the frame of reference. This terminological intersection is no doubt responsible for some of Sekuler and Erlebacher's confusion.

There is also a difference between the theories of information processing that underlie the two interpretations. The two physical stimuli, standard and comparison, plus fixed background, and the memories of past stimuli all join in producing a comparative judgment of Co relative to Std. In the Sekuler-Erlebacher interpretation, both Co and Std undergo alteration as a result of past stimuli, resulting in "perceived Std" and "perceived Co." These two perceptions are then compared, and the response corresponds directly to the outcome of that comparison (see Fig. 1). Our interpretation of CAL theory is that the background stimuli, memories of old stimuli, and the Std are

combined into a weighted geometric mean, the CAL. Then the Co stimulus is compared with that CAL, and response follows directly from the results of that comparison. This position is also shown in Fig. 1. It is perfectly true that the Sekuler-Erlebacher model cannot produce a shift in PSE, if we agree (as would seem reasonable) that both Std and Co would be altered equally. However, the CAL model, combined with its proper information-processing model, can and does predict such a shift in PSE.

This, of course, does not show that CAL theory is correct, nor does it refute the response-bias position put forward by Sekuler and Erlebacher. We have shown by logic that the CAL theory is a possible explanation of the shift of PSE toward the comparison stimuli, but we must do an experiment to decide whether CAL theory is the correct explanation.

The CAL theory and the response-frequency equalization (RFE) theory can be compared experimentally, because CAL theory says that PSE will move toward the mean of the Co stimuli, whereas the RFE theory, saying that the S tries to use both responses equally often, says that PSE should move toward the median of the distribution of the Co stimuli. Ss can be presented a distribution of Co stimuli having its mean on one side and its median on the other side of the standard, and one can determine which way the PSE moves. We report the results of such an experiment.

METHOD

Subjects

A total of 49 undergraduate students from introductory psychology courses at Indiana University served as Ss, 27 under Condition 1 and 22 under Condition 2.

Apparatus and Materials

Each stimulus was a white line oriented at 45 deg, projected on a screen approximately 130 x 130 cm, in a darkened room. The edges of the screen were barely visible but not pronounced. Up to four Ss could view the stimuli from a distance of 3 m. Lengths of standard and comparison stimuli used are shown in Table 1.

Stimuli were projected from a Kodak RA-150 random-access projector located outside the room. Responses were made on response boxes located in booths before each S. Selection of stimuli, timing, and collection and analysis of data were done by an IBM 1800 process-control computer.

Procedure

On each trial the S was first shown the standard slide for 2 sec, a dark field

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Table 1
Lengths of Standard (Std) and Comparison (Co)
Stimuli Used and Frequencies of
Co Stimuli Per Trial

Stimulus	Length (cm)	Frequency	
		Condi- tion 1	Condi- tion 2
Standard	18.73	-	-
Comparison	10.16	6	1
	12.70	1	0
	14.77	1	1
	16.83	1	3
	17.62	1	15
	18.73*	10	10
	19.37	15	1
	21.59	3	1
	22.54	1	1
	24.77	0	1
	27.15	1	6

*Same slide as the standard.

of PSE are necessarily small in this experiment, so that most of the effect should be shown on the responses to the comparison stimulus that is actually equal to the standard. For Condition 1, CAL theory says that PSE will be below the standard; hence, the comparison stimulus at the standard will be called "longer" more than half the time. For Condition 2, CAL theory says that PSE will be higher; hence, the comparison stimulus equal to the standard will be called "shorter" more than half the time. Predictions from the RFE theory are opposite.

In fact, these middle stimuli are called shorter than the standard more than half the time under both conditions, because of a sizable constant error. However, the proportion of "smaller" judgments should be less for Condition 1 than for Condition 2, according to CAL theory. The observed relative frequencies for the two groups were .293 and .490, respectively. This difference is highly significant [$t(47) = 3.59, p < .01$] in the direction predicted by CAL theory, and opposite to the direction predicted from the Sekuler-Erelebacher hypothesis.

The result is not limited to the particular comparison stimulus equal to the standard; the two distributions result in different psychometric functions displaced laterally, as is shown in Fig. 2.

The effect shown in Fig. 2 is very small; PSE for the two conditions are at approximately 18.7 vs 18.2 cm. However, this value agrees reasonably well with the results from the Levison-Restle experiment, in which the mean of past Co stimuli received a weight of $w_3 = .200$. In the present experiment the geometric means of the two distributions of Co stimuli were 17.39 and 19.10, respectively, forming a ratio of 1.0985. If the Levison-Restle parameter holds, then the ratio of PSEs should be

Fig. 1. Information processing model used by Sekuler and Erelebacher and the model intended by Levison and Restle as reflecting comparison adaptation-level theory.

followed for 2 sec, then a variable comparison stimulus was presented and remained in view for 2 sec. There was then a 3-sec interval before the standard stimulus was next shown. When the variable stimulus appeared, an amber ready light showed on the S's response panel, indicating that he should respond. This amber light was extinguished as soon as the S responded. Responses were accepted during presentation of the variable stimulus and for 2 sec after the variable stimulus disappeared.

Conditions 1 and 2 differed in the distribution of frequency with which the variable comparison stimuli were shown. The two distributions were designed to

place the mean on one side of the standard and the median on the other, and to have the same range. The two distributions were mirror images of one another, except for slight irregularities in the lengths of the lines used. The two distributions used are shown in Table 1. Each S was shown six random permutations of the distribution, and all responses were used in the analysis.

RESULTS

Our CAL theory says, in summary, that PSE will be moved toward the geometric mean of the comparison stimuli used, whereas Sekuler and Erelebacher's RFE theory should predict that PSE will be moved toward the median. Predicted shifts

Fig. 2. Psychometric functions relating probability that Co is judged longer than Std as a function of Co, for the two distributions of Co stimuli used. When the mean of the Co stimuli is below the standard (Condition 1) the PSE is relatively lower, and when the mean of the Co is above the standard (Condition 2), PSE is higher. Medians of the Co distribution are on the opposite side of the Std from the means.

$(1.0985)^{200} = 1.019$. The observed ratio of PSEs is $18.7/18.2 = 1.027$, so the effect is slightly larger than predicted on the basis of the old parameter. The new data would yield a value of $w_3 = .289$. This discrepancy may have arisen because the present experiment was done in what is believed to be a darker room and with the edges of the screen made less prominent. These two changes would reduce the effect of constant background stimuli and might enhance the effect of the distribution of Co stimuli employed. The results agree quite closely with the detailed predictions for the CAL theory.

DISCUSSION

If the erroneous interpretation of AL theory by Sekuler and Erlebachner were not so closely reasoned, and if the premises of their argument were not so widely believed, then the present paper might constitute "overkill." However, it appears common to think of AL theory as a theory of the distortion of perception. One reason may be that the predictions of AL theory arising from changes in the frame of reference are often the same as what would be predicted from satiation, lateral inhibition, negative or figural aftereffects, or other hypothetical processes that are thought to cause or to reflect distortions of perceptual appearance.

When large stimuli are introduced into a field, they lead to an increase in the AL, so that a given fixed test stimulus will be judged smaller. This is the basic mechanism in the frame-of-reference argument, and it does not imply that the appearance of any stimulus is modified. Any measure of apparent magnitude, depending as it must upon judgments of some kind, must depend upon the frame of reference.¹ The results of many experiments can also be given an entirely different interpretation, that stimuli are altered in appearance by the mere presence of other stimuli in the field. As suggested by Sekuler and Erlebachner (1971), such distortions would usually be the product of extended inspection and would be effective mainly when the inspection and test stimuli are very similar, whereas shifts in frame of reference may occur rapidly and will affect all test stimuli in about the same way. The fact that the word "adaptation" may be used in both theories does not make the two phenomena alike.

As for the theory that Ss tend to use

available responses with equal frequency, we do not find this hypothesis plausible in the face of the cooperativeness of our Ss and the fact that our instructions tell them to make correct comparative judgments. The present experiment shows that a tendency toward equal use of responses will not explain the shift of PSE toward the mean of the variable comparison stimuli used. This result throws such doubt upon the RFE hypothesis of Sekuler and Erlebachner (1971) that we feel that the burden of proof has shifted, and that they should now present direct and differential evidence in favor of their position and in opposition to the CAL interpretations.

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NOTE

1. Efforts to have the S describe his "true internal state" will, at best, lead him to change his frame of reference by changing the relative weights of various factors in the field, but cannot transcend the fundamental relativity of judgment.

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