An application of a three-state all-or-none model to human eyelid conditioning data¹

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Abstract

The Bower-Theios three-state model was applied to eight sets of human eyelid conditioning data. In all instances, the prediction of stationarity in the intermediate state was not sustained. Earlier support of the model was concluded to have resulted from a bias in the method of testing for stationarity. Problems in the use of human conditioning data to test the model were discussed.

Introduction

Bower & Theios (1964) show that a three-state, two-element pattern model provides an adequate description of some data from human eyelid conditioning. The model describes learning as a change from an initial state with P (response probability) = 0 to an intermediate state with $P = k$, a constant during that state, to the absorbing state where $p = 1$. Successive trials in the intermediate state, which is the concern of this paper, constitute a sequence of Bernoulli trials to which all binomial statistics can be applied. Although its entire length cannot be determined from a sequence of trials, all trials separating the first CR from the last failure to make a CR before P becomes unity are included in the intermediate state. Trial-by-trial P s separating the first CR and the last failure to make a CR will be referred to as the "intermediate state function," or as the "ISF."

Bower & Theios (1964) obtained an ISF by lining up the data of all Ss who met criterion at the trial which followed the first CR. P , in blocks of three trials, was plotted following the first CR, with individual Ss dropped from the ISF as they met the criterion for complete learning. The ISF exhibited stationarity: i.e., P remained constant over trial blocks.

As noted elsewhere (Suppes & Ginsberg, 1963; Prokasy, 1964) an ISF obtained with a decreasing N over trials may exhibit stationarity when, in fact, there are increments in P . In this paper, ISFs from human eyelid conditioning are presented in which this bias does not exist.

Procedure

Eight sets of data were employed. Set A was obtained from I. Gormezano, and is composed of data taken from several studies with Ss given the same treatment combinations. Set B was obtained from W. Runquist². Sets C and D were obtained from Prokasy (in press). Sets E through H were gathered with C. Allen in the Penn State laboratory. Sets G and H were obtained with Ss run under the masking procedure described by Spence, Homzie, & Rutledge (1964).

ISFs were obtained only from those Ss in each set who met a learning criterion of 10 consecutive trials and who had at least 20 trials separating the first CR and criterion. Thus, ISFs of 20 trials in length were employed, with the same Ss contributing to each point. Both forward and backward ISFs were obtained from each set of data. The forward ISF had as its initial trial the trial which followed the first CR, while the backward ISF had as its terminal trial the trial which preceded the last failure to make a CR before criterion. Due to a limitation imposed by the number of trials, the ISF was only 12 trials long for set A.

Results

Forward and backward ISFs are presented in Table I, together with information descriptive of the studies from which the data were obtained. The significant value of χ^2 in all sets of data shows, by a median test, that the backward ISF is higher than the forward ISF. Moreover, increases in P over trials were observed in a number of instances, as indicated by the significant rank-order correlations between probability and ordinal-trial position. In neither instance, according to the model, should the null-hypothesis be rejected; hence, no set of data supports the model.

Discussion

It is unlikely that the discrepancy between these results and those reported by Bower & Theios can be attributed solely to experimental conditions peculiar to these data. First, data set A came from the sample which Bower & Theios used to support the model originally. Second, in only two sets (E & F) is it possible to reject the hypothesis of stationarity when the ISF is plotted as a forward, decreasing- N function. Thus, P increases during the intermediate state, but the forward, decreasing- N ISF is relatively insensitive to these increases. It can be concluded that the Bower-Theios model does not provide an adequate description of human eyelid conditioning data.

This failure of the model should not be surprising in view of the fact that its boundary conditions were not met. The model can be applied appropriately only to data with an initial state P of zero and a terminal state P of unity. With the original data employed by Bower & Theios it was not possible to obtain reliable estimates of initial state P s, while the median P following the criterion run in the subset of those data constituting present Set A was .91. A similar result obtained with the remaining sets, the medians varying from .67 to .93. Moreover, mean initial state P s in Sets E through H were found to vary from .10 to .25.

Table I
Forward and Backward ISFs from Eight Sets of Human Eyelid Conditioning Data^a

	Set	ISF	Ordinal Trial Position																				Rho	χ^2
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
A	(69,17,70	F	647	647	529	412	588	529	882	471	647	647	706	706									.441	6.0*
	.50,20,200)	B	588	647	588	706	706	765	941	765	941	941	824	765									.804*	
B	(59,33,500	F	455	424	485	303	273	485	333	394	515	303	394	424	546	394	636	485	424	455	455	455	.270	25.6*
	.50,20,80)	B	667	667	606	697	667	697	758	697	758	515	788	546	606	849	727	667	879	818	939	818	.554*	
C	(76,33,295	F	455	394	455	424	546	636	485	455	636	636	576	485	364	636	515	636	667	606	606	515	.492*	14.4*
	.45,8,175)	B	515	606	788	727	758	606	636	727	697	818	788	758	788	818	788	758	818	727	636	818	.504*	
D	(75,39,295	F	308	462	308	436	436	410	436	462	462	564	436	539	513	410	410	590	513	513	410	462	.472*	25.6*
	.45,4,175)	B	615	615	564	667	564	692	692	641	615	692	667	641	821	692	641	821	744	795	795	667	.554*	
E	(60,40,300	F	200	200	375	350	400	275	325	275	275	175	350	375	400	400	250	450	425	325	250	350	.289	40.0*
	.50,12,200)	B	575	625	750	550	625	575	775	575	675	875	625	725	700	550	725	725	600	700	825	775	.394	
F	(60,36,300	F	222	167	361	250	222	222	306	278	194	417	417	361	333	361	250	444	361	222	389	389	.536*	40.0*
	.50,12,100)	B	667	694	583	583	750	556	667	722	806	611	611	750	722	694	694	694	722	750	917	778	.574	
G	(60,29,300	F	517	310	345	517	379	310	379	448	379	483	552	345	517	276	241	310	241	414	483	586	-.020	19.6*
	.50,12,200)	B	586	586	586	759	759	655	414	655	621	586	690	517	690	793	552	759	552	621	655	690	.136	
H	(60,21,300)	F	191	286	238	238	381	381	238	286	286	191	476	381	381	286	381	429	619	524	381	571	.698*	17.6*
	.50,12,100)	B	667	524	524	524	381	429	571	571	524	619	619	476	667	571	667	667	667	762	714		.695*	

a. Numbers in parentheses refer, in order, to: number of Ss in the set, number of Ss meeting criteria described in the text, number of conditioning trials, interstimulus interval (sec.), intertrial interval (sec.), and UCS intensity in mm mercury. Decimals are omitted from response probabilities. See test for explanation of rho and χ^2 .

* $p < .05$.

Recognizing these limitations, Theios and Brelsford (Brelsford, 1965; Theios & Brelsford, 1965a, b) have developed a Markov model in which the initial and terminal state Ps do not have to be, respectively, zero and unity. While the newer model may be able to account for human eyelid conditioning, the data presently available do not provide a satisfactory vehicle for testing it. First, we do not have any data with reliable initial and terminal state Ps for individual Ss. Second, in those studies where reliable estimates of terminal state Ps are possible (e.g., Prokasy, in press), there are extensive individual differences. Finally, the latency distributions of individual Ss are frequently incomplete; i.e., the distribution of latencies is curtailed by UCS occurrence (Prokasy, in press). This necessarily results in an underestimate of S's response probability. It should be noted, too, that these distributions shift forward during conditioning, so that rises in P during the intermediate state are, at least in part, an artifact of this shift. Together, these two facts complicate parameter estimation and tests involving, particularly, sequential statistics.

References

Bower, G. H., & Theios, J. A learning model for discrete performance levels. In R. C. Atkinson (Ed.), *Studies in mathematical psychology*. Stanford: Stanford University Press, 1964.

Brelsford, J. W., Jr. Experimental manipulation of state occupancy in a Markov model for avoidance conditioning. Report No. 7, Conditioning Research Laboratory, University of Texas, 1965.

Prokasy, W. F. Stimulus fluctuation, reactive inhibition and time between trials in classical eyelid conditioning. *J. exp. Psychol.*, in press.

Prokasy, W. F. Pattern models, sampling theory, $D[A(1 - 10^{-10})]$... and some conditioning data. Paper read at Psychonomic Society Meeting, Niagara Falls, Ontario, Canada, 1964.

Spence, K. W., Homzie, M. J., & Rutledge, E. F. Extinction of the human eyelid CR as a function of the discriminability of the change from acquisition to extinction. *J. exp. Psychol.*, 1964, 67, 545-552.

Suppes, P., & Ginsberg, R. A fundamental property of all-or-none models, binomial distribution of responses prior to conditioning, with application to concept formation in children. *Psychol. Rev.*, 1963, 70, 139-161.

Theios, J., & Brelsford, J. W., Jr. Eyelid conditioning in the rabbit as a Markov process. Paper read at the Midwestern Psychological Association Meeting, Chicago, Illinois, 1965a.

Theios, J., & Brelsford, J. W., Jr. A Markov model for classical conditioning: application to eye-blink conditioning in rabbits. Report No. 9, Conditioning Research Laboratory, University of Texas, 1965b.

Notes

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