Test of Bogartz's model on binary prediction by children

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Sixty-four nursery Ss and 64 kindergarten Ss predicted the next event in sequences that were either predominantly alternating or repeating. There were 100 trials in acquisition. For the 100 transfer trials, the type of sequence was switched for half of the Ss. Bogartz's model represented the essential features of the data. These findings support his theory, which emphasizes attention and short-term memory processes and assumes the learning of rules rather than probabilities. Furthermore, the results demonstrate that his theory can be extended to situations where children must change rules.

Bogartz (1966, 1967, 1969) has developed a theory and model for children's predictions of binary sequences. He assumes that attention and short-term memory processes determine the information available to children to make their trial-to-trial predictions, while a generator rule determines the response choice based on the information in the short-term store. It is assumed that the generator rule is acquired prior to or during the early trials of the experiment. Thus, Bogartz is proposing that children learn rules rather than probabilities in order to follow binary sequences.

The following is a brief summary of Bogartz's model. A more detailed and formal presentation of the model can be found elsewhere (Bogartz, 1969). Bogartz assumes that children's short-term memory store holds only the most recently passed trace. In the case of a binary situation, this could be the previous event, the previous response, or nothing. A response generator rule is then applied to the existing trace. As an example of how a child uses a generator rule, assume that the event sequence is an alternating one (or predominantly alternating) and that the child has acquired an alternation rule. If the child pays attention to the previous event and remembers it, he would predict the alternate event. If the child remembers the previous response, he would predict the alternate response. If he forgets both the previous event and response, he would guess. With a repetition sequence, a repetition rule would be used. Thus, the trace of a response or event would result in the prediction of the same, rather than the alternate, response or event on the next trial.

Bogartz has reported detailed fits of the model for prediction of single alternation sequences and also for tending to alternate and tending to repeat sequences. However, little is known about the application of the

model in situations where the

generator rule must change during the experiment or in situations that utilize preexisting rules of nursery children. The present paper reports on an application of Bogartz's model to data from a binary prediction situation with nursery and kindergarten children. The role of generator rules could be examined in two ways using these data. First, a transfer situation was used, making it necessary for the children to change their rule during the experiment. Second, sequences were employed that corresponded with suggested (Craig & Myers, 1963; Derks & Paclisanu, 1967) preexisting response tendencies of the nursery (repetition response tendency) and kindergarten (alternation response tendency) children. Thus, those children who were given a sequence corresponding with their existing

Table 1
Relative Frequency of 3-Tuples

	Group	Pred _I	Pred _G	Obs		Group	Pred _I	Pred _G	Obs
ccc	N ₁	.334	.315	.332	ccc	K ₁	.498	.512	.514
cce		.112	.125	.108	cce		.080	.083	.082
cec		.080	.080	.100	cec		.038	.031	.035
cee		.083	.096	.075	cee		.056	.066	.062
ecc		.117	.126	.110	ecc		.086	.085	.084
ece		.053	.050	.067	ece		.015	.014	.015
eec		.086	.096	.074	eec		.060	.067	.061
eee		.136	.114	.134	eee		.167	.143	.147
ccc	N ₁₁	.376	.362	.380	ccc	K ₁₁	.504	.555	.558
cce		.108	.125	.107	cce		.075	.082	.080
cec		.079	.082	.087	cec		.037	.033	.045
cee		.077	.086	.081	cee		.050	.061	.050
ecc		.112	.125	.108	ecc		.081	.082	.080
ece		.050	.043	.061	ece		.130	.012	.014
eec		.080	.086	.080	eec		.054	.061	.049
eee		.117	.090	.096	eee		.187	.114	.123
ccc	N ₉₁	.216	.158	.161	ccc	K ₉₁	.322	.289	.263
cce		.114	.124	.082	cce		.090	.094	.065
cec		.084	.097	.112	cec		.035	.031	.026
cee		.105	.124	.109	cee		.085	.094	.100
ecc		.117	.123	.086	ecc		.094	.091	.066
ece		.077	.096	.134	ece		.033	.030	.055
eec		.108	.123	.108	eec		.089	.091	.094
eee		.179	.157	.209	eee		.252	.279	.331
ccc	N ₉	.362	.334	.362	ccc	K ₉	.461	.409	.426
cce		.124	.139	.107	cce		.114	.142	.100
cec		.109	.117	.127	cec		.113	.142	.182
cee		.072	.079	.070	cee		.051	.049	.033
ecc		.129	.140	.114	ecc		.120	.142	.105
ece		.059	.058	.085	ece		.051	.049	.111
eec		.075	.080	.070	eec		.053	.049	.034
eee		.072	.054	.064	eee		.037	.017	.009
ccc	N ₉₉	.436	.391	.416	ccc	K ₉₉	.528	.473	.494
cce		.106	.132	.108	cce		.102	.134	.097
cec		.091	.103	.114	cec		.099	.134	.159
cee		.063	.073	.062	cee		.044	.038	.027
ecc		.112	.131	.107	ecc		.108	.134	.097
ece		.050	.044	.069	ece		.042	.038	.092
eec		.066	.073	.062	eec		.046	.038	.027
eee		.076	.052	.062	eee		.033	.011	.006
ccc	N ₁₉	.241	.151	.201	ccc	K ₁₉	.325	.282	.281
cce		.122	.132	.078	cce		.125	.148	.092
cec		.108	.132	.151	cec		.120	.148	.224
cee		.098	.116	.099	cee		.079	.078	.054
ecc		.126	.133	.082	ecc		.130	.148	.100
ece		.087	.116	.172	ece		.076	.078	.180
eec		.101	.116	.098	eec		.081	.078	.056
eee		.118	.102	.119	eee		.064	.041	.013

Table 2
Mean Number of Runs of Errors

Group	Pred _I	Pred _G	Obs	Group	Pred _I	Pred _G	Obs
N ₁	17.15	17.82	17.84	K ₁	10.30	10.04	10.06
N _{1,1}	16.47	16.99	17.00	K _{1,1}	9.60	9.60	9.62
N _{9,1}	19.71	22.19	22.06	K _{9,1}	12.96	12.47	12.62
N ₉	18.90	19.89	19.84	K ₉	17.24	19.25	21.62
N _{9,9}	16.32	17.67	17.69	K _{9,9}	15.10	17.28	18.81
N _{1,9}	21.44	25.19	25.31	K _{1,9}	20.70	22.71	27.75

response tendency would not have to learn a new generator rule during the early trials, while those children who were given a sequence that was opposite to their response tendency would have to learn a new generator rule. A detailed description of the methodology and summary statistics of the data have been reported elsewhere (Jones, 1970).

METHOD

The Ss were 64 nursery and 64 kindergarten children who were instructed to predict which of two red lights would come on for 200 trials by placing a white choice card in a slot under the predicted light. The Ss were tested one at a time and were told that this was a guessing game.

Sequences with repetition probabilities (probability of an event repeating itself) of .1 and .9 were chosen; the former results in an almost perfectly alternating pattern, while the latter involves extremely long runs of each event. The Ss were assigned randomly to one of eight experimental groups differing in repetition probability (π_1) for acquisition (Trials 1-100), π_1 for transfer (Trials 101-200), and for age. There were 16 Ss in each group, eight males and eight females. For the acquisition trials, π_1 was set at .1 for half the Ss at each age level (N₁ and K₁ groups) and .9 for the other half (N₉ and K₉ groups). For the transfer trials, π_1 was reversed for half of the Ss in each of the π_1 -age acquisition groups, resulting in four transfer π_1 groups at each age level: nonreversed N_{1,1} and K_{1,1}, nonreversed N_{9,9} and K_{9,9}, reversed N_{9,1} and K_{9,1}, and reversed N_{1,9} and K_{1,9}.

RESULTS AND DISCUSSION

The predicted values were obtained by two different methods. The first uses the average of individual parameter estimates for each S (Pred_I) to obtain the predicted values. The second uses one set of parameters for each group of Ss (Pred_G) to obtain the predicted values.

The values for the predicted (Pred_G) and observed mean correct responses in 20-trial blocks were presented in a previous paper (Jones, 1970). This statistical analysis was found to represent the essential features of all the groups. For acquisition, there were no differences

in terms of goodness of fit due to preexisting response tendencies. However, in the nonreversed transfer groups, the model fit closer for those groups whose sequence corresponded with their preexisting response tendencies. The model also tended to fit the data better for the nonreversed than for the reversed groups.

The remaining results for acquisition and transfer are presented in tabular form. Table 1 shows the relative frequency of the eight possible 3-tuples; Table 2 shows the mean number of runs of errors; Table 3 shows the mean values of the number of error runs; and Table 4 shows the mean values of the number of joint occurrences of two correct responses k trials apart. All of these results reveal a close fit of the model for both ages. However, the variability in the observed and predicted values is somewhat larger than that reported by Bogartz (1969) for Markov event sequences. When comparing the two

methods for computing the predicted means, it is evident that both methods give an adequate description of the results, although the fits are generally closer with the method of estimating the group parameter.

The best fits of the model were for those groups whose event sequence corresponded to their hypothesized preexisting response tendencies and for those groups who received the same event sequence in acquisition and transfer. Children in these groups did not have to learn a new rule in the beginning or during the course of the task. Therefore, the best fits occurred in situations where rule selection was not an important factor.

In summary, these findings support Bogartz's theory of information processing in children and demonstrate the generality of the theory to situations that necessitate flexibility in rule usage.

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Table 3
Mean Values of r_j , the Number of Error Runs of Length j

	Group	Pred _I	Pred _G	Obs	Group	Pred _I	Pred _G	Obs
r ₁	N ₁	8.50	8.23	10.28	K ₁	4.18	3.27	3.78
r ₂		3.94	4.43	3.41		2.14	2.20	2.38
r ₃		1.96	2.38	1.41		1.23	1.49	1.16
r ₄		1.05	1.28	.97		.77	1.00	1.12
r ₅		.59	.69	.44		.50	.68	.44
r ₁	N _{1,1}	8.42	8.38	9.00	K _{1,1}	4.11	3.41	4.44
r ₂		3.82	4.25	4.38		1.75	2.20	1.62
r ₃		1.88	2.15	1.56		1.00	1.42	1.31
r ₄		.97	1.09	.75		.66	.91	1.00
r ₅		.52	.55	.69		.46	.59	.19
r ₁	N _{9,1}	8.83	9.87	11.25	K _{9,1}	3.86	3.16	2.75
r ₂		4.58	5.48	3.94		2.64	2.36	1.81
r ₃		2.50	3.04	2.56		1.82	1.76	2.25
r ₄		1.43	1.69	1.62		1.27	1.32	1.62
r ₅		.84	.94	.88		.90	.98	1.31
r ₁	N ₉	11.44	11.93	12.81	K ₉	11.99	14.34	18.28
r ₂		4.15	4.78	4.19		3.27	3.66	2.88
r ₃		1.71	1.91	1.34		1.13	.93	.28
r ₄		.77	.77	.81		.46	.24	.12
r ₅		.38	.31	.34		.21	.06	.03
r ₁	N _{9,9}	9.74	10.40	11.50	K _{9,9}	10.56	13.50	16.12
r ₂		3.42	4.28	3.81		2.78	2.95	2.19
r ₃		1.49	1.76	1.12		.99	.65	.44
r ₄		.73	.72	.56		.42	.14	.00
r ₅		.38	.30	.25		.19	.03	.06
r ₁	N _{1,9}	11.32	13.55	15.50	K _{1,9}	12.58	14.97	22.31
r ₂		5.03	6.26	5.50		4.70	5.10	4.50
r ₃		2.41	2.89	2.38		1.91	1.74	.81
r ₄		1.21	1.34	.62		.82	.59	.06
r ₅		.63	.62	.31		.37	.20	.00

Table 4
Mean Values of C_k , the Number of Joint Occurrences of Two
Correct Responses k Trials Apart

	Group	Pred _I	Pred _G	Obs	Group	Pred _I	Pred _G	Obs
c_1	N_1	44.15	43.57	43.62	K_1	57.19	58.90	59.03
c_2		40.58	38.69	42.31		52.48	53.18	53.84
c_3		38.87	37.16	39.19		49.77	49.89	50.81
c_4		37.82	36.48	38.97		48.00	47.90	49.12
c_5		37.07	36.02	36.72		46.73	46.61	47.84
c_1	N_{11}	47.88	48.22	48.25	K_{11}	57.32	62.99	63.19
c_2		44.64	43.52	45.75		53.03	57.56	59.12
c_3		43.08	42.02	43.44		50.39	54.48	56.44
c_4		42.10	41.32	42.38		48.58	52.64	54.75
c_5		41.37	40.82	41.62		47.23	51.42	54.06
c_1	N_{91}	32.64	27.83	24.25	K_{91}	40.75	37.98	32.31
c_2		29.37	24.93	26.75		35.03	31.37	28.31
c_3		27.90	24.36	21.38		32.06	27.92	25.94
c_4		27.09	24.08	22.12		30.34	26.07	24.94
c_5		26.55	23.82	20.00		29.25	25.01	23.94
c_1	N_9	48.07	46.74	46.62	K_9	56.92	54.50	52.06
c_2		46.09	44.14	47.97		56.22	53.95	59.62
c_3		45.18	43.45	45.94		55.63	53.40	54.78
c_4		44.54	42.98	44.78		55.05	52.85	56.56
c_5		43.99	42.52	44.78		54.47	52.30	54.41
c_1	N_{99}	53.63	51.81	51.88	K_{99}	62.28	60.06	58.62
c_2		51.64	48.46	51.88		61.35	59.45	64.00
c_3		50.58	47.51	49.94		60.69	58.85	59.38
c_4		49.82	46.95	48.56		60.05	58.24	61.31
c_5		49.20	46.45	49.56		59.42	57.63	60.12
c_1	N_{19}	35.88	28.09	27.88	K_{19}	44.58	42.57	37.31
c_2		34.17	27.80	34.50		43.65	42.14	49.50
c_3		33.40	27.52	29.38		43.06	41.71	41.81
c_4		32.87	27.24	30.31		42.57	41.28	45.81
c_5		32.42	26.95	29.19		42.11	40.85	43.25

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