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THE USE OF STRATEGIES IN TWO-CHOICE BEHAVIOR OF CHILDREN AND CHIMPANZEES[1]

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Adult chimpanzees and 3 groups of human children (ages 3.5, 5.1, and 10.8) were tested in a 2-choice situation consisting of a 50:50 probability series. Chimpanzees and the 2 older groups of children were tested with and without initial 100% training. Approximately half the Ss in each group received Short-Run (conditional probability .39) and the other half Long-Run (conditional probability .64) sequences. Initial training and series contingencies had their strongest effects on behavior of 10-yr.-old children. Chimpanzees and 3-yr.-old children showed a strong win-stay, lose-shift strategy. This strategy was weaker in 5-yr.-old children. Under Short-Run conditions 10-yr.-old children showed greater persistence with an unsuccessful choice than 5-yr.-old children. Results indicate that choice of strategy and effect of patterns of reinforcing events on strategy interact with maturational and species variables.

In two-choice situations of uncertain outcome recent work utilizing trial-by-trial analyses has revealed the presence of consistent response tendencies or "strategies" (cf. Goodnow & Pettigrew, 1955). Such tendencies may be a function of both ontogenetic (Cohen & Hansel, 1955; Crandall, Solomon, & Kellaway, 1961; Kessen & Kessen, 1961) and phylogenetic (Overall & Brown, 1959) factors and may vary with the pattern of stimulus or reinforcing events (Anderson, 1960).

The present research sought to determine the effect of stimulus patterns, i.e., the sequence of payoffs from two alternatives, on the kinds of strategies used by children and chimpanzees. Thus, we hoped to obtain a clearer picture of the relationship of stimulus patterns with maturational and species variables and of the role played by these factors in the production of strategies.

METHOD

Subjects and Apparatus

The following groups of *S*s were tested with modified versions of the Wisconsin General Test Apparatus: sophisticated chimpanzees (ranging in age from 11–40 yr.; all having previous extensive training on discrimination learning tasks; $N = 17$), 3-yr.-old children (mean CA = 3.5 yr., range 2.5–3.9 yr.; $N = 9$), 5-yr.-old children (mean CA = 5.1 yr., range 4.0–5.8 yr.; $N = 31$), and 10-yr.-old children (mean CA = 10.8, range 10–12.3 yr.; $N = 34$).

The children were from schools in the Orange Park, Florida area. One 5-yr.-old refused to be tested and three other 5-yr.-olds were dropped from the sample, each for a different reason: (*a*) One was suspected by both teacher and parent of being mentally retarded; (*b*) One was called out during a test session; (*c*) One chose the same position throughout testing.

Chimpanzees were tested with an apparatus similar to that described by Hayes, Thompson, and Hayes (1953). The apparatus for children consisted of a table 22½ in. x 37½ in. and 20½ in. high on which was mounted a sliding opaque screen and movable tray. Stimulus objects used with chimpanzee *S*s were identical square plaques, 4 in. x 4 in. x ¾ in., painted gray. These covered two foodwells 7½ in. apart. For the children the stimuli were black bottle tops 1⅜ in. in diameter and 1¼ in. high which covered two round pieces of compressed cotton, 1⅞ in. in diameter and 7½ in. apart. Grapes served as the incentive for the chimpanzees and candy for the children.

Procedure

All children were tested in a private or semi-private room at the school they attended. Generally, *E* was introduced to the class by the teacher, who told them *E* would play a "candy game" with each of them. After *E*'s introduction each *S* was brought to the testing room and seated in front of the apparatus. Following a minute of "small talk," *E* asked *S* if he liked chocolate chip candy. Then *S* was given one candy to eat and received the following instructions:

"This is a game in which you are to try to find

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this chocolate chip as many times as you can. I will hide it under either this object or that object (*E* demonstrates), but not both. You are allowed to look under only one object. That is a rule of the game. It is not fair if you pick up both objects, and if you do we will have to stop playing. When you find the chocolate chip you may keep it. Eat it or put it in this cup and save it until after mealtime. Remember it will always be under one of these objects."

After *E* took his place at the apparatus, he slowly dropped the opaque screen and said, "In order to hide the chocolate, I have to drop this screen. Okay?"

One procedural change was made for testing the youngest group. Preceding actual testing *E* showed *S* a single candy and placed his (*E*'s) hands behind his back (one candy in each hand) and presented his closed fists to *S*, asking him to find the candy. Following this one trial, instructions were given and testing was begun in the usual manner.

Stimulus presentation was the same for children and chimpanzees. After *E* baited a position with the opaque screen down, the screen was raised and the tray moved forward. The *S*'s task was to displace one stimulus object in order to obtain a reward. The noncorrection procedure was used for all *S*s. The interval between stimulus presentations was approximately 10–12 sec.

Experimental Design

The design was similar to that of Goodnow and Pettigrew (1955). For all but the 3-yr.-old children the experimental design was 2 × 2 factorial with two conditions of initial learning (100:00 or no training) and two kinds of probability series (Long-Run [LR] 50:50 or Short-Run [SR] 50:50) consisting of 70 trials. Three-year-olds did not receive 100:00 initial training.

Although each of the two stimulus events (reward under right or left object) occurred equally often during the probability series, a patterning effect was produced by varying the first-order conditional probability in the sequence of reinforcing events. Under the LR series the probability of reward for either side on trial *n* was .64, given that a reward occurred at that side on trial *n*-1. Under the SR series the comparable conditional probability was .39.

All *S*s were given five *pretraining* trials in which *E* baited both positions with reward. The *S*s were shifted from one training phase to another without a break. Each *S* experienced one of the following four training conditions: (*a*) Initial 100% training, consisting of continuous reinforcement at one position until a criterion of learning was attained (15 consecutive errorless trials), followed by the LR 50:50 series (*100% LR*). (*b*) Initial 100% training, followed by the SR 50:50 series (*100% SR*). (*c*) The LR 50:50 series without initial 100% training (*—LR*). (*d*) The SR 50:50 series without initial 100% training (*—SR*).

TABLE 1

FREQUENCY DISTRIBUTIONS OF SPONTANEOUS ALTERNATION RESPONSES DURING PRETRAINING

No. of Alternations	Group			
	Chimpanzees	Human *S*s		
		3-Yr.-Olds	5-Yr.-Olds	10-Yr.-Olds
0	2	8	4	5
1	2	1	1	4
2	5	0	0	8
3	5	0	2	10
4	3	0	7	6
5	0	0	17	1
Total	17	9	31	34

RESULTS

Pretraining

Table 1 presents the frequency distribution of spontaneous alternation responses for the five pretraining trials and the first training trial. These results show that whereas 3-yr.-olds initially tended to win-stay ($p < .01$, binomial test), 5-yr.-olds tended to win-shift ($\chi^2 = 38.45$, $df = 5$, $p < .01$). Response tendencies of 10-yr.-olds and chimpanzees showed no statistically significant trend during the pretraining phase.

Probability Series

The last 60 trials of the probability series were analyzed in terms of conditional response probabilities. The approach was to tabulate the proportion of choices (on trial *n*) of a previously (trial *n*-1) rewarded position (win-stay strategy) and the proportion of choices which shifted from a previously nonrewarded position (lose-shift strategy). It was expected that some *S*s (especially chimpanzees and young children) would show a preference for a single position which could be predicted on the basis of all training prior to the last 60 trials of the probability series. In order to determine the effect of this tendency, the actual location of position (right and left) was disregarded and instead positions were categorized as preferred (P) and nonpreferred (NP). Position preference was de-

TABLE 2

FREQUENCY OF CHOICES OF PREFERRED (P) AND NONPREFERRED (NP) POSITIONS FOLLOWING WIN OR LOSS, AND PROPORTION OF WIN-STAY AND LOSE-SHIFT RESPONSES

Condition	*N*	Choices on Trial *n* Grouped on Basis of Outcome on Trial *n*-1														
		Chose P						Chose NP						Total Choices		
		Won			Lost			Won			Lost					
		P	NP	%P	NP	P	%NP	NP	P	%NP	P	NP	%P	P	NP	%P
		Chimpanzees														
100% LR	5	86	24	78	55	7	89	48	24	67	52	4	93	169	131	56
100% SR	4	62	6	91	67	12	84	24	19	56	48	2	96	141	99	59
— LR	4	45	21	68	54	14	79	26	37	41	39	4	91	135	105	56
— SR	4	56	23	71	51	17	75	15	36	29	40	2	95	149	91	62
		3-Yr.-Olds														
— LR	4	61	10	86	44	9	83	56	24	70	32	4	89	126	114	53
— SR	5	63	19	77	71	14	84	35	31	53	58	9	87	166	134	55
		5-Yr.-Olds														
100% LR	9	124	64	66	83	39	68	65	56	54	86	23	79	305	235	56
100% SR	9	97	61	61	86	83	51	37	65	36	81	30	73	326	214	60
— LR	6	46	44	51	72	23	76	47	56	46	61	11	85	186	174	52
— SR	7	46	71	39	62	54	53	23	70	25	65	29	69	235	185	56
		10-Yr.-Olds														
100% LR	9	123	52	70	86	38	69	73	47	61	83	38	69	291	249	54
100% SR	9	89	53	63	60	84	42	77	53	59	59	65	48	285	255	53
— LR	8	53	60	47	84	42	66	56	82	41	68	35	66	245	235	51
— SR	8	44	79	36	46	71	39	47	76	38	49	68	42	240	240	50

Note.—Data for Trials 11–70 of 50:50 period.

termined by the algebraic summation of reinforcements and nonreinforcements previously received during pretraining, initial training (if any) and the first 10 trials of the probability series. This method was similar to that used by Spence (1937).

The frequency of P and NP choices following a win or a loss and the proportion of win-stay and lose-shift responses is given in Table 2 for all groups under all conditions.

Chimpanzees. As shown in Table 2, these animals had a strong tendency to win-stay, lose-shift with the P position in spite of the fact that the opposite strategy would have maximized success for the SR sequence. Table 2 also shows that there was a tendency to alternate away from the NP position regardless of success or failure. The effect was especially pronounced under the —SR condition. As expected on the basis of Spence's results (1937), the number of chimpanzees showing a predicted position preference was significant ($p < .02$) by a binomial test. Regardless of which position (P or NP) they chose animals receiving initial training had a significantly stronger tendency to win-stay than those not receiving such training (Mann-Whitney $U = 12$, $p < .05$).

Children. The data indicated that 3-yr.-olds were insensitive to the differential lengths of the run-sequence of reinforcing events. Table 2 shows that these *S*s had an extremely strong win-stay, lose-shift strategy. After the first 10 trials their primary reaction was to choose the side on which candy was last hidden.

That the 5-yr.-olds were sensitive to the run-sequence was indicated by a significantly greater proportion of win-stay responses with the NP position under the LR conditions than under the SR conditions ($U = 61$, $p < .05$). Although none of the other three measures significantly differentiated the groups, Table 2 shows that *S*s given either initial training or the LR series generally had the strongest win-stay tendency; moreover those *S*s receiving the LR series had the strongest tendency to shift following a loss.

Examination of Table 2 indicates that the 10-yr.-old group was the most sensitive to the experimental conditions and this observation is supported by the statistical analyses. The *S*s receiving initial training had a stronger win-stay strategy with both the P ($U = 38, p < .01$) and NP ($U = 86, p = .05$) positions than *S*s without initial training, whereas *S*s receiving the LR series had a stronger lose-shift strategy with both the P ($U = 23, p < .01$) and the NP ($U = 48$, $p < .01$) positions than *S*s receiving the SR series.

A tendency to alternate away from the NP position may be noted for human *S*s as it was for chimpanzees. The effect is most pronounced in 3- and 5-yr.-olds under the —SR condition. Position preference had practically no effect on the conditional response probabilities of the 10-yr.-old *S*s.

Disregarding position preference, the relation of age to strategies may be briefly summarized as follows: (*a*) The 3-yr.-olds had a significantly greater win-stay tendency than did 5-yr.-olds under the—LR ($U = 1.5, p < .05$) and—SR ($U = 2.5, p < .02$) conditions. Also, 3-yr.-olds had a significantly greater lose-shift tendency than 5-yr.-olds under the —SR ($U = 3.5$, $p < .05$) condition. (*b*) The 5-yr.-olds had a significantly greater lose-shift tendency than did 10-yr.-olds under the 100% SR ($U = 15, p < .05$) and —SR ($U = 11, p = .05$) conditions.

Discussion

Previous results, showing that strategies used in a two-choice task may be affected by the run-sequence of reinforcing events, have been replicated by this experiment using a variety of *S*s. The present study has also shown: (*a*) that the strategy *S* has depends on maturational and species factors and (*b*) that specific patterns of reinforcing events have differential effects on *S*'s strategy only when a particular stage of development has been reached. Furthermore, a start has been made toward a description of strategy development in humans. More specifically these results indicate the following: (*a*) Initial preference plays a role in determining the two-choice behavior of chimpanzees and young children. (*b*) Chimpanzees and 3-yr.-old children tend to choose a position where reward was last hidden. (*c*) Five-year-old children initially show a spontaneous alternation tendency. (*d*) In contrast with chimpanzees and 3-yr.-olds, 5- and 10-yr. olds are more likely to make decisions on the basis of the probable length of a run of reinforcing events, and thus anticipate reversals in the payoff from one or the other alternative. (*e*) Ten-year-olds show greater persistence with an unsuccessful choice than do 5-yr.-olds under conditions where such behavior maximizes the probability of reward.

Chimpanzees

The finding that the win-stay, lose-shift tendency is strong for sophisticated chimpanzees under conditions of uncertain outcome is consistent with Behar's (1961) data on sophisticated rhesus monkeys tested on an object-alternation task.

The effect of initial training was to increase the proportion of win-stay responses suggesting that without such training there is a greater tendency to win-shift or explore the stimulus situation (Harlow, 1950). This interpretation is consonant with Restle's (1958) and Levine's (1959) analyses of discrimination learning-set data in other nonhuman primates.

Three-Year-Old Children

The extremely strong win-stay, lose-shift tendency by these *S*s and their insensitivity to the differential lengths of the run-sequence of reinforcing events suggests a possible source of the differences found by

Messick and Solley (1957) between 3-yr.-olds and 5- and 8-yr. olds on a probability learning task. In their study *S*s at all age levels showed "probability-matching" behavior (the task was a card guessing game). However, when candy supplemented verbal approval younger children continued to probability-match whereas older children tended to maximize probability of reward. The present results suggest that the older child can react to the length of a run of reinforcing events and thereby adjust his behavior accordingly whereas the 3-yr.-old cannot. Thus, in principle at least, the older *S* is potentially able to achieve "optimal" performance. Whether he does or not depends on the kind of incentive used, as Messick and Solley have pointed out.

In contrast to the present results Kessen and Kessen (1961) found no consistent response tendencies in their 3-yr.-old *S*s. (The task was similar to that of Messick and Solley.) The different results may be accounted for by the different tasks and incentives. It seems reasonable to expect less apparently random behavior and more strategizing by a 3-yr.-old on a spatial discrimination task with a relatively strong incentive than on a successive color discrimination task involving no incentive except for task feed-back information.

Five-Year-Old Children

The strong alternation tendency in these *S*s indicates that they favor a change in response for its own sake. This same phenomenon was found in 6-yr.-old children by Cohen and Hansel (1955) and Gratch (1959) and Kessen and Kessen (1961). In view of the diversity of experimental situations in which this phenomenon has been found we may conclude that when *S*s at this age level are confronted with any kind of two-choice situation a strategy favoring change is quite pronounced. If this change is not forthcoming via the sequence of events, the *S*s often impose their own change.

Crandall et al. (1961) had no explanation for their finding that older children (15–17 yr.) predicted a more probable event significantly less often during the initial stages of a guessing game than did a younger group (6–8 yr.) which attained a value of .50. The present results, showing an increase in persistence with an unsuccessful choice as a function of age and initial response alternation at the 5-yr. level, might help to account for this phenomenon.

Ten-Year-Old Children

A comparison of 10-yr.-olds with college freshmen (Goodnow & Pettigrew, 1955) indicates that the training phases had a similar effect on both groups. The major source of difference between these two age groups appears to lie in the greater tendency of the older *S*s to repeat a previously unsuccessful choice.

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