*PSYCHOLOGICAL DISTANCE TO REWARD:
A HUMAN REPLICATION*

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Choice behavior in college students was examined in two experiments using the concurrent-chains procedure. In both experiments, the concurrent chains were presented on a microcomputer in the form of an air-defense game in which subjects used two radar systems to detect and subsequently destroy enemy aircraft. Access to one of two radar systems was controlled by a pair of independent concurrent variable-interval 60-s schedules with a 4-s changeover delay always in effect. In the terminal link, the appearance of an enemy aircraft was determined by a pair of differentially segmented fixed-time schedules (Experiment 1) or fixed-interval schedules (Experiment 2) of equal overall duration. In Experiment 1, the terminal-link duration was either 20 s or 40 s, and subjects preferred the unsegmented to the segmented intervals. In Experiment 2, the duration was either 10 s or 60 s, and the reinforcement contingencies required responding during the terminal link. Prior to the reinstatement of the initial link, subjects estimated the duration of the terminal-link schedule. Segmentation affected choice in the 60-s conditions but not in the 10-s ones. Preference for the unsegmented schedule was correlated with an overestimation of the durations for the segmented schedules. These results replicated those found in animal experiments and support the notion of increasing the psychological distance to reward by segmenting a time-based schedule of reinforcement.

Key words: preference, choice, segmentation, interval schedules, psychological distance, concurrent chains, computer game, humans

Based on the observation that multiple-component chains could hardly maintain responding in laboratory animals, Fantino (1969) hypothesized that breaking up a simple schedule of reinforcement into more than one component or segment, each correlated with a discriminative stimulus, increases the "psychological distance to reward" of that schedule. A direct implication of the psychological distance hypothesis is that a simple unsegmented schedule will be preferred to its segmented counterpart in a choice situation. For example, a simple fixed-interval (FI) schedule will be chosen more often than a chained FI FI schedule of equal overall duration to primary reinforcement.

To study preference between two schedules of reinforcement, a commonly employed technique is the concurrent-chains schedule (Autor, 1960, 1969; Herrnstein, 1961). Basically, this procedure consists of two phases, namely,

the choice phase and the outcome phase. During the choice phase, the subject is presented with two alternatives; the outcome of responding to either one is occasional access to a schedule of reinforcement. During the outcome phase, fulfilling the contingency requirement usually produces the primary reinforcer before the subject is returned to the choice phase. By calculating the relative proportion of responses allocated to the two alternatives during the choice phase, one can deduce how much an animal prefers one schedule over another.

The notion that segmentation of a schedule increases its psychological distance to reward, which in turn affects choice adversely, was first demonstrated by Duncan and Fantino (1972) using the concurrent-chains procedure. As predicted, subjects showed a strong preference for the simple schedule over the segmented one when the actual intervals to food were equal. In addition, such preference increased as the size of the overall interval became larger.

These findings were recently replicated by Leung (1987) and Leung and Winton (1985, 1986, 1988). Leung and Winton (1985) found that pigeons invariably favored a simple schedule over a segmented schedule. In addition, the adverse effect of segmentation on choice was extended to schedules of variable intervals. In

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separate experiments, Leung and Winton (1986, 1988) also showed that the magnitude of preference could be affected by the location of segmentation or the segmentation ratio. The generality of Duncan and Fantino's (1972) finding extends to response-independent time schedules of reinforcement (Leung & Winton, 1986; Wallace, 1973).

The evidence presented thus far tends to support Fantino's (1969) hypothesis that segmentation of a schedule increases the psychological distance to reward. However, the same effect has not yet been demonstrated in species other than pigeons. The present study is an attempt to replicate and extend previous findings on segmentation to human subjects. Two experiments were performed using the concurrent-chains paradigm. In addition, the second experiment assessed the relative psychological distance to reward by requiring subjects to estimate the duration of each of the terminal-link schedules. If a segmented interval schedule has a longer psychological distance to reward than its unsegmented counterpart, then subjects would be expected to overestimate the size of the segmented interval relative to that of the unsegmented one.

EXPERIMENT 1

The present experiment was similar to one of the experiments performed by Wallace (1973), who assessed choice between segmented and nonsegmented fixed-time (FT) schedules; however, we used human subjects. The terminal-link durations were either 20 s or 40 s. In order to maintain sufficient responding, the concurrent-chains procedure was simulated on a microcomputer in the form of an air-defense video game.

METHOD

Subjects

Twelve undergraduate college students (8 females and 4 males, mean age 19 years) responded to a recruitment announcement posted on the departmental notice board. They enrolled for an introductory psychology course in which each student was required to participate in one psychological experiment.

Apparatus

The video game was presented on an Apple-II+® (48K) microcomputer with a Taxan®

color monitor. A separate clock card was installed to provide an independent time source. Two keys on the keyboard were marked so that the A key was painted red and the L key was painted blue. These were the response keys. The software that controlled experimental events and data collection was written in BASIC.

Procedure

The concurrent-chains procedure was simulated in the form of an air-defense video game that required the subject to choose between two radar systems for detecting enemy aircraft. A schematic diagram of the procedure is presented in Figure 1. The initial link, represented by two circles, appeared on the left and right side of the monitor screen. Each circle, at the center of which the word "CHARGING" flashed, represented a radar system. Key-press responses, the left key for the left radar and the right key for the right radar, were required to determine which of the radar systems was operable. A changeover delay of 4 s always operated during the initial link (Herrnstein, 1961). Access to one of the two radars (terminal link) was arranged by two independent but identical variable-interval (VI) 60-s schedules whose intervals were determined by the Fleshler and Hoffman (1962) method. During the terminal link, only one radar was operative while the other vanished. Either a simple FT 2X s or a chain FT X s FI X s determined the minimum time required for the appearance of the enemy aircraft. At the end of the fixed time, a silhouette of a plane automatically appeared on the radar. The enemy aircraft had to be destroyed by pressing the space bar within 2 s (i.e., limited hold), otherwise it would vanish from the screen. A successful hit was signaled by an explosion of the plane accompanied by an appropriate sound effect. For every plane destroyed, the subject received 100 points, which were added to a counter shown on the center of the lower part of the monitor. In the case of the segmented terminal link, the first component was represented by the words "WARMING UP" flashing on the radar screen; the appearance of a grid coordinate on the radar screen signified the onset of the second component. The initial link was reinstated upon the destruction of the enemy plane or at the end of the limited hold.

Each subject was trained individually in a

laboratory room. In order to maintain responding, subjects were told that they were competing against 11 other students; upon completion of all sessions, a contestant who accumulated the highest score would be awarded a prize. To provide feedback, the cumulative score of each subject was plotted on a bar chart posted on the laboratory wall for everyone to see. At the first session, each subject was told about the objective of the game: The task was to detect as many enemy aircraft as possible using the two radars and to destroy them subsequently within the given period of time. All other instructions were presented on the monitor by the computer:

Our country is now at war with country X and we are being air raided. It is your responsibility to protect our airspace from invasion and to destroy any intruding aircraft upon discovery. For detecting enemy aircraft, you need to use radars and there are two available. Unfortunately, both radars require charging up after every use and therefore only one radar is available at a time. Since the charging time varies, you have to press a key to check whether charging has been completed, the left key for the left radar and the right key for the right radar. When one of the radars is found operative upon pressing the key, the other radar will become dark and inoperative. Please note that the two radars work differently. For one radar, a grid of coordinates will appear when ready and the radar will begin searching for aircraft immediately. The other radar needs a short while to warm up even when charging has been completed. However, it has a better range which ensures a more rapid detection of aircraft entering our air space. When either radar is operating, you don't have to do anything but to watch out closely for enemy planes on the screen. Once an aircraft is detected and locked on by the radar, you must fire a missile (by pressing the space bar) quickly before it disappears from the screen. For every aircraft shot down, you get 100 points added on to your score. You are only allowed to use the middle finger of your preferred hand for pressing keys through out the session. Are you ready? Timing begins now!

For the first session, subjects were given a 10-min trial run during which the terminal-link schedules were both FT 20 s. Actual training involved four conditions with terminal-link durations of 20 s or 40 s. In effect, there were two pairs of conditions each having the same duration but differing in terms of the position of the keys correlated with the simple and the

Fig. 1. A schematic diagram of the computer simulated concurrent-chains procedure in the form of a video air-defense game. The terminal link of Experiment 1 consisted of fixed-time schedules and that of Experiment 2 consisted of fixed-interval schedules.

segmented schedules. A daily training session lasted for about 1 hr, during which time all conditions would be presented once each for 14 min with a 1-min break before the next condition. However, the order of presentation varied every day to reduce any possible order effect. Table 1 shows these conditions and the order of presentation for all training sessions. In total, training was held for eight sessions, and the highest scorer received a box of chocolates for the first prize. At the end of training, each subject was interviewed on the strategies used and his or her conception of the schedules involved.

RESULTS AND DISCUSSION

For each condition, the choice proportion with respect to the simple FT schedule was calculated by dividing the number of initial-link responses by the total responses on both keys during that link. The reinforcement pro-

Table 1

The order of training conditions in each session of Experiment 1. Also shown are schedules in each condition and their correlated key positions in the terminal link.

Con- dition	Terminal-link schedule	Key position	Session							
			1	2	3	4	5	6	7	8
1	Simple FT 20 s	left	1	3	2	4	3	2	1	4
	Chain FT 10 s FT 10 s	right								
2	Chain FT 10 s FT 10 s	left	2	1	4	3	1	3	4	2
	Simple FT 20 s	right								
3	Simple FT 40 s	left	4	2	3	1	2	4	3	1
	Chain FT 20 s FT 20 s	right								
4	Chain FT 20 s FT 20 s	left	3	4	1	2	4	1	2	3
	Simple FT 40 s	right								

portion refers to the ratio of the reinforcement rate produced by responding on the FT key during the terminal link to the combined reinforcement rate from responding on both keys. Because the reinforcement proportions for all subjects differed little from .50, they are not presented here. All calculations were based on data obtained during the last two sessions of training.

Table 2 shows individual and group mean choice proportions with standard deviations for each condition. At the individual level, the choice proportions recorded were generally greater than .50; the highest preference was found in S4, whose choice proportions were close to or greater than .80. However, other subjects exhibited less preference for the simple (unsegmented) terminal link with choice proportions smaller than .60. In a few cases, preference was reversed favoring the segmented time. The greatest reversal occurred for S8 in Conditions 1 and 2 (choice proportions were .41 and .40, respectively) but S8's choice proportions favored the unsegmented terminal link in Conditions 3 and 4. These reversals could not be explained easily and could be due to key biases exhibited by individual subjects or to other extraneous variables. Preference for the unsegmented simple time schedule over the segmented one is evident from the mean choice proportion for each condition.

Whether the choice proportion for each condition differed from .50 was assessed statistically. To eliminate bias effects due to key preference, choice proportions from conditions of the same terminal-link durations were first

averaged for each subject and then group means were calculated. For the 20-s terminal link (Conditions 1 and 2), the mean average choice proportion was .58, which was significantly greater than .50, $t(11) = 2.88$, $p < .01$; for the 40-s terminal link (Conditions 3 and 4), the mean average choice proportion was .57, which was also significantly greater than .50, $t(11) = 3.00$, $p < .01$. The effect of the terminal-link duration on choice was assessed by comparing the two mean averages, but no significant difference was found, $t(11) = 0.33$, $p > .70$ for a two-tailed test.

Two conclusions can be drawn from these results. First, human subjects were very much like pigeons in that they preferred an unsegmented time interval over its segmented counterpart. That is to say, human choice behavior is also vulnerable to the segmentation effect that seemingly increased psychological distance to reward (Fantino, 1969). Second, for the terminal-link durations used, subjects did not seem sensitive to the different terminal-link durations. This is reflected at both the group and the individual level. As Table 2 shows, there was no consistent pattern in choice performance observed across conditions of different durations when both individual and group data were considered. Such results were not expected in light of previous findings that show a positive relationship between preference and the length of the terminal link. Perhaps human temporal discrimination differs from that of the pigeon. For example, for our subjects, 40 s may not have been much longer functionally than 20 s, whereas such a difference was more substantial to pigeons. Perhaps

future research with human subjects can introduce longer terminal links (e.g., 600 s) that may be useful in demonstrating the differential effect of schedule duration. Obviously, the researcher would have to overcome the problem of maintaining responding in human subjects when using longer terminal links.

EXPERIMENT 2

The psychological distance hypothesis (Duncan & Fantino, 1972; Fantino, 1969) suggests that dividing an interval schedule of reinforcement into two or more discriminable segments would have the effect of psychologically lengthening the distance to reward. One of the implications is that if segmentation increases the psychological distance to reward then an organism will not prefer the segmented schedule to its unsegmented counterpart. This was supported by choice data from Experiment 1 and previous studies with nonhuman subjects (Duncan & Fantino, 1972; Fantino, 1983; Leung, 1987; Leung & Winton, 1985, 1986, 1988).

Perhaps a more direct test of the hypothesis is to compare the subjective estimation of differentially segmented intervals by the organism. This approach is difficult with nonhuman subjects but is quite possible with human subjects who can be asked to estimate the length of a time interval and to report it verbally. The present experiment represented an attempt to correlate human choice responses with their verbal reports. As in Experiment 1, a concurrent-chains procedure was presented on a microcomputer in the form of an air-defense game. As before, subjects were informed that the highest score would win a prize. But on this occasion, subjects were told that points could be earned in two ways: (a) the number of enemy aircraft destroyed and (b) the accuracy in estimating the time interval required for detecting and destroying an enemy aircraft after a radar was selected. Because only a fixed amount of time was available for each condition in a session, it was to the advantage of the subject to make a fast and yet accurate estimate of the terminal-link duration.

It was hoped that the present experiment would help to clarify further the concept of psychological distance to reward by cross-verifying choice and verbal performances. If segmentation caused the distance to reward to

Table 2

The individual choice proportion for the simple FT schedule in each condition of Experiment 1. The group mean choice proportions and standard deviation for each condition are also shown.

Sub- ject	Terminal-link schedules			
	Chain FT 10 s FT 10 s versus simple FT 20 s		Chain FT 20 s FT 20 s versus simple FT 40 s	
	Simple left key (Condition 1)	Simple right key (Condition 2)	Simple left key (Condition 3)	Simple right key (Condition 4)
S1	.50	.50	.56	.52
S2	.66	.54	.63	.50
S3	.51	.48	.58	.58
S4	.78	.79	.75	.86
S5	.61	.62	.47	.71
S6	.56	.50	.54	.54
S7	.56	.50	.49	.55
S8	.41	.40	.56	.61
S9	.61	.65	.53	.55
S10	.67	.57	.59	.56
S11	.57	.59	.57	.48
S12	.82	.47	.55	.38
<i>M</i>	.61	.55	.57	.57
<i>SD</i>	.116	.103	.071	.120

increase psychologically, then the length of a segmented schedule would be estimated as longer than that of the unsegmented counterpart.

METHOD

Subjects and Apparatus

Fifteen undergraduate college students (4 males and 11 females, mean age 18.5 years) participated in the experiment in order to fulfill a requirement for an introductory psychology course. These students responded to a recruitment notice posted on the departmental notice board. The apparatus used was the same as in Experiment 1.

Procedure

The simulated defense game was exactly the same as in Experiment 1 except for three aspects. First, the FTs in the terminal link were replaced by FI schedules of reinforcement. Hence, responding was required to obtain the reinforcer. Second, terminal-link durations were 10 s and 60 s instead of 20 s and 40 s. Third, subjects had to estimate the durations between the onset of the radar and the ap-

Table 3

The order of training conditions in each session of Experiment 2. Also shown are schedules in each condition and their correlated key positions in the terminal link.

Con- dition	Terminal-link schedule	Key posi- tion	Session							
			1	2	3	4	5	6	7	8
1	FI 10 s	left	3	1	2	4	4	1	2	3
	Chain FI 5 s FI 5 s	right								
2	Chain FI 5 s FI 5 s	left	1	4	3	2	3	2	4	1
	FI 10 s	right								
3	FI 60 s	left	4	2	1	3	1	3	3	4
	Chain FI 30 s FI 30 s	right								
4	Chain FI 30 s FI 30 s	left	2	3	4	1	2	4	1	2
	FI 60 s	right								

pearance of a plane on the radar. For the segmented schedule, the warming up time was also included. The instructions to subjects were similar to those in Experiment 1 with appropriate adjustments made according to the changes implemented. There were also two pairs of conditions that were presented within the same daily session as in Experiment 1. Table 3 shows these conditions, the position of the keys, and the order of training in each session. Subjects were told that there were two ways to earn points in this game: (a) by destroying alien aircraft and (b) by estimating the time during which a radar was available. Once the reinforcer had been picked up (i.e., by downing a detected plane), instead of returning to the initial link, the subject was asked to key in his or her estimation of the time elapsed (in seconds). Only when an estimation had been made and the "RETURN" key hit would the choice phase be reinstated. Subjects were also told that points earned by estimation were related directly to the degree of accuracy and that 100 points would be awarded to an exact estimation, 90 points for a 10% deviation, and so on. No time limit was imposed on estimation, but subjects were told that, given the fixed period allocated for each game, spending too much time in estimation would unnecessarily reduce their chance for obtaining points from downing more enemy aircraft. Subjects were asked to remove their watches before entering the laboratory, and there was no clock nor timer of any kind in the room.

RESULTS AND DISCUSSION

Individual and group choice proportions (with regard to the simple schedule) with stan-

dard deviations are presented in Table 4. The individual and group estimated and obtained (in parentheses) time interval values with standard deviations are presented in the same table. One subject did not complete all the sessions; her data were dropped from analyses. All data were averaged over the last two sessions of training.

Unlike those observed in Experiment 1, choice results appeared to be affected by the size of the terminal-link duration. For the 10-s terminal link (Conditions 1 and 2), the choice proportion ($M = .51$) was not significantly greater than .50, $t(13) = 0.89$, $p > .10$. The indifference observed in these conditions was somewhat inconsistent with results found with pigeons (e.g., Duncan & Fantino, 1972) in that a small preference was observed even with a short terminal link. But there is no reason to assume that humans have a timing mechanism similar to pigeons. With pigeons, choice proportions under 10-s terminal-link conditions were barely greater than .50 when reinforcement proportions were taken into account (Duncan & Fantino, 1972). In contrast, results from the 60-s terminal link (Conditions 3 and 4) were more consistent with data obtained from pigeons. The mean average choice proportion (.58) was found to be significantly greater than .50, $t(13) = 3.4$, $p < .005$, indicating a preference for the simple FI schedule over its equivalent chain. However, pigeons exhibited extreme choice proportions under the same terminal-link duration of 60 s.

The time data provided further clues to the underlying processes of segmentation. Subjects were instructed to try their best to estimate the

Table 4

The individual and group mean choice proportions with standard deviations for each condition of Experiment 2. The estimated durations (in s) for the simple and the chained terminal-link schedule, group means, and standard deviations are also shown with the corresponding obtained durations (in s) in parentheses.

Sub- ject	Terminal-link schedules											
	Chained FI 5 s FI 5 s versus simple FI 10 s						Chained FI 30 s FI 30 s versus simple FI 60 s					
	Condition 1 (Simple schedule left key)			Condition 2 (Simple schedule right key)			Condition 3 (Simple schedule left key)			Condition 4 (Simple schedule right key)		
	Choice pro- portion	Simple interval (esti- mates)	Chained interval (esti- mates)	Choice pro- portion	Simple interval (esti- mates)	Chained interval (esti- mates)	Choice pro- portion	Simple interval (esti- mates)	Chained interval (esti- mates)	Choice pro- portion	Simple interval (esti- mates)	Chained interval (esti- mates)
S1	.56	10.0 (10.0)	12.0 (10.2)	.53	9.0 (10.2)	9.5 (10.7)	.61	57.0 (60.8)	78.0 (62.0)	.47	63.0 (64.2)	80.0 (65.5)
S2	.52	13.0 (10.0)	14.0 (10.0)	.52	12.0 (10.1)	12.0 (10.2)	.51	38.0 (61.3)	43.0 (62.0)	.52	41.0 (63.0)	52.0 (63.0)
S3	.40	9.0 (10.5)	8.0 (10.8)	.46	7.2 (10.5)	6.0 (10.5)	.50	55.0 (60.0)	56.0 (61.2)	.75	55.0 (60.8)	59.0 (62.0)
S4	.47	8.0 (11.0)	8.5 (11.5)	.53	6.9 (11.0)	7.5 (11.0)	.47	62.0 (62.0)	70.0 (65.3)	.60	67.0 (62.7)	77.0 (63.0)
S5	.51	11.0 (10.2)	12.5 (10.0)	.60	8.0 (10.3)	9.3 (10.1)	.50	47.0 (63.0)	50.0 (62.0)	.51	65.0 (62.7)	63.0 (62.9)
S6	.52	11.5 (10.1)	11.0 (10.4)	.42	13.0 (10.0)	12.0 (10.5)	.61	52.0 (60.3)	66.0 (60.5)	.53	59.0 (62.7)	64.0 (63.0)
S7	.47	7.0 (12.0)	7.0 (12.5)	.49	8.0 (10.0)	8.0 (10.2)	.45	62.0 (61.9)	58.0 (62.3)	.55	47.0 (61.0)	53.0 (61.5)
S8	.46	8.5 (10.0)	7.9 (10.6)	.47	10.5 (10.0)	9.6 (10.1)	.52	35.0 (64.7)	42.0 (66.0)	.52	46.0 (61.4)	59.0 (62.3)
S9	.54	15.0 (10.7)	14.0 (11.1)	.54	13.0 (10.5)	13.0 (10.8)	.73	70.0 (63.2)	88.0 (63.5)	.62	80.0 (64.0)	87.0 (66.7)
S10	.50	6.0 (10.0)	7.2 (10.2)	.56	6.0 (10.3)	7.4 (10.3)	.55	47.0 (61.5)	62.0 (61.0)	.58	58.0 (61.0)	65.0 (61.2)
S11	.55	9.0 (11.0)	9.8 (11.5)	.45	11.0 (11.0)	11.5 (10.9)	.54	61.0 (61.6)	67.0 (62.8)	.60	70.0 (64.3)	78.0 (64.0)
S12	.58	12.0 (10.0)	15.0 (10.3)	.52	12.0 (10.2)	12.0 (10.5)	.72	65.0 (62.4)	75.0 (64.1)	.62	54.0 (62.2)	61.0 (62.5)
S13	.40	10.0 (10.1)	9.7 (10.3)	.53	10.0 (10.0)	10.4 (10.4)	.43	44.0 (60.0)	44.0 (60.3)	.56	73.0 (60.2)	75.0 (60.5)
S14	.57	6.1 (10.2)	5.5 (10.0)	.57	7.7 (10.5)	8.6 (11.6)	.81	57.0 (66.0)	84.0 (67.0)	.80	55.0 (65.0)	79.0 (64.0)
<i>M</i>	.50	9.7 (10.4)	10.2 (10.7)	.51	9.6 (10.3)	9.8 (10.6)	.59	53.7 (62.1)	63.1 (62.9)	.57	59.5 (62.5)	68.0 (63.0)
<i>SD</i>	.058	2.4 (0.584)	5.1 (0.712)	.050	2.4 (0.341)	2.1 (0.416)	.090	10.3 (1.73)	15.1 (2.07)	.114	10.9 (1.49)	11.1 (1.65)

lengths of both simple and chained schedules in the terminal link, but accuracy was generally poor. Apart from a small number of cases, subjects tended to either over- or underestimate the time intervals, sometimes by a margin of as much as 20 s (e.g., S1 in Condition 4). The segmented schedule was reported to be longer than the unsegmented one only when the terminal link was 60 s. In the 60-s conditions, the group mean estimated duration of chained schedules (65.5 s) was sig-

nificantly longer than that of the simple schedule (56.6 s), $t(13) = 4.77$, $p < .005$; in the 10-s conditions, the simple ($M = 9.7$ s) and the chained schedules ($M = 10.0$ s) were not estimated to be significantly different from each other, $t(13) = 1.35$, $p > .1$. Although variations existed, data at the individual level also showed such a pattern. That is, when preference was shown for the simple schedule (Conditions 3 and 4), subjects also estimated the chain to be the longer of the two terminal-

link schedules. Hence, a preference shift toward the unsegmented schedule was correlated with an overestimation of the segmented schedule relative to the unsegmented one.

The time data support the psychological distance interpretation only when similar discrepancies could not be found with obtained intervals. Otherwise, the reported discrepancy between segmented and unsegmented intervals could be easily accounted for by the actual differences in duration. Hence the obtained durations for the simple and the chained schedules were also measured and analyzed. First, the obtained durations, compared with the estimated ones, showed much less variance. Second, the measured times were usually slightly greater than the intervals programmed. Third, the chained intervals in the terminal link were often longer than the simple intervals (see Table 4). To determine whether the estimated times in the 60-s conditions were the result of the actual durations, the mean average differences between the chained and the simple schedules from the two time measures were compared. A *t* test showed that the mean average difference of the estimated times (8.9 s) was significantly greater than that of the obtained durations (0.65 s), $t(13) = 4.45$, $p > .001$. In other words, the lengthening of perceived time to reinforcement under the chained schedule cannot be accounted for by the amount of time subjects spent in the terminal link. Together with the choice data, the present experiments show that segmentation tends to increase the psychological distance to reward.

A general description of absolute response rates in the terminal link is given here but no individual data will be presented. The rates observed under the shorter intervals were generally higher than those under the longer intervals. For the chained schedules, the first component rates tended to be slightly lower than the second component rates but the differences were small (compared to pigeons), especially in the 10-s conditions. Response rates under the simple schedules showed no systematic trend with respect to those under the chain. The mean average response rates (number of responses per minute) under the first and second components of the chain and the simple schedule were, for the 10-s conditions, 33.3, 35.6, and 27.8, respectively; for the 60-s conditions, they were 20.4, 26.2, and 25.1, re-

spectively. A few subjects tended to respond relatively slower than others; this contributed to the lengthening of the obtained intervals for the terminal-link schedules. However, a majority of the subjects exhibited reasonably high rates of responding, and the overall obtained intervals did not differ too much from the programmed ones.

Hence, choice and time data from Conditions 3 and 4 were consistent with Fantino's (1969) hypothesis of psychological distance to reward. Preference for the simple schedule provided indirect evidence for this interpretation. However, the strongest support came from the reported time data in which subjects tended to overestimate the segmented interval in relation to the unsegmented one. In other words, it seems that when a schedule of reinforcement has been segmented into two or more discriminable components, it has the effect of extending the psychological separation to reward. Perhaps one can also infer from the present 60-s conditions that the preference for the simple interval found in Experiment 1 was also due to the time distortion produced by segmenting a given time interval. This interpretation was supported by the interview conducted at the conclusion of Experiment 1.

GENERAL DISCUSSION

In the present study, human subjects were used to assess the effect of segmenting an interval schedule on choice performance and time perception. Previous research on segmentation investigated pigeons' choice behavior; we could only infer an increase in the psychological distance to reward from a shift of preference away from the segmented schedule. In the present Experiment 2, the lengths of the terminal-link schedules as perceived by the subjects were also collected (in the form of verbal reports) to determine the psychological distances of both segmented and unsegmented intervals. Results agree with Fantino's (1969) psychological distance hypothesis concerning segmentation. When subjects preferred an unsegmented schedule to its segmented counterpart, the estimated duration for the segmented schedule was often longer than that for the unsegmented schedule (Conditions 3 and 4 of Experiment 2). Although time data were not collected in Experiment 1, the preference shifts observed

were probably due to differences perceived between the segmented and unsegmented schedules.

However, one could argue that this finding might well be an artifact of instructional control; that is, the preference and the estimated time were due to the instructions rather than to segmentation. Instructions presented on the computer monitor screen informed subjects about the scheduled events during the terminal link. They were intended to bring subjects' behavior quickly under the control of scheduled contingencies and hence to reduce the number of training sessions to a minimum. The radar associated with the segmented alternative was described to the subject as consisting of a warm-up phase (first component) and an operational phase (second component). Hence the subject had to wait during the warm-up period, but this shortcoming was offset by the better pick-up range that helped to reduce the radar's detection time. Descriptions like these might have conveyed an impression of a crippled radar correlated with the segmented alternative. The preference shift away from the segmented terminal-link schedule could well be confounded by the seemingly biasing effect of the instructions.

However, the instructional control hypothesis was not borne out by our data. First, individual interviews with subjects at the conclusion of training did not reveal any systematic ill feelings toward the segmented alternative. Second, the choice data in Experiment 2 were inconsistent with an instructional control interpretation. Because both experiments used similar instructions, the biasing effects due to instructions, if any, should affect choice in all conditions no matter what the terminal-link duration. In Experiment 2, segmentation effects were found with the 60-s conditions but not with the 10-s conditions. Thus, preference for the simple schedule was probably not dependent on the instructions. Nevertheless, as has been demonstrated in past research (e.g., Matthews, Shimoff, Catania, & Sagvolden, 1977), verbal instructions may affect human behavior and may sometimes override schedule control. It is important for future investigations with human subjects to take this factor into consideration.

Leung and Winton (1988) pointed out that the initial component of a segmented chained

schedule could possess aversive properties as a result of its correlation with nonreinforcement. Such aversiveness might be the cause of the segmentation effect observed in both pigeons and humans. If that were the case, the initial component of the chain would be responsible for the increment of separation to reward. To test this possibility, future investigations should ask human subjects to estimate the lengths of both the first and second components of a chained schedule. Perhaps this type of molecular analysis may provide more insight into the processes underlying the segmentation effect.

When choice data were compared across humans and pigeons, three major differences were revealed. First, humans showed no preference in the condition with a short terminal-link duration (10 s). Previous studies with pigeons (Duncan & Fantino, 1972; Leung & Winton, 1985) found at least a small preference with short terminal links. Perhaps 10 s is functionally a relatively short time for humans in this procedure. But why short intervals should not show the segmentation effect remains a question for future investigation. The second difference in choice performances between humans and pigeons relates to the first: Choice proportions in humans, unlike pigeons (e.g., Leung & Winton, 1985), did not seem to increase with the terminal-link duration. In both Experiments 1 and 2, preference for the simple schedule in the 20-s, 40-s, and 60-s conditions did not differ across conditions. The values were about .58. On the other hand, preference found with pigeons could become extreme (in favor of the simple schedule) when the terminal-link durations were 40 s or longer (Duncan & Fantino, 1972; Leung & Winton, 1985, 1988). Third, a response requirement imposed in the terminal link did not affect choice in human subjects (cf. Neuringer, 1969). Other studies (Leung, 1987; Wallace, 1973) had found smaller preferences for the unsegmented schedule in the absence of a response requirement coinciding with the stimulus change between components.

Unfortunately, the present data offer no explanation for the discrepancies discussed above. Perhaps as a working hypothesis, there appear to be certain differences between humans and pigeons in temporal discrimination. However, such differences may be quantitative rather

than qualitative. In other words, pigeons may be more vulnerable to distortion than humans when discriminating between short interval schedules of reinforcement. Such a hypothesis can be verified empirically by using various terminal-link durations with human subjects.

To conclude, the present experiments replicate findings from research with pigeons (Duncan & Fantino, 1972; Leung, 1987; Leung & Winton, 1985, 1986). When the terminal-link duration was sufficiently long, human subjects also preferred an unsegmented schedule over its equivalent chain. Segmentation affected time perception as subjects perceived a chained interval schedule as longer than its simple counterpart. Together these results support the notion that segmentation of a schedule of reinforcement has the effect of lengthening its psychological distance to reward (Fantino, 1969). However many questions concerning the segmentation effect remain unanswered. For instance, the role played by each component of the chained schedule in distorting time perception per se remains unclear. Based on the present study, perhaps one fruitful approach would be to employ humans in this kind of experiment because researchers could utilize subjects' language capability to help assess the role of variables affecting choice. Finally, one major concern of the present line of research is to investigate the effect on choice of events occurring during the interreinforcement interval of a terminal-link schedule. Despite some concurrent-chains studies (e.g., Neuringer, 1969; Neuringer & Schneider, 1968; Schneider, 1972) that failed to find any effect, the present experiments, together with others (e.g., Fantino, 1968; Fantino & Duncan, 1972), suggest that the interreinforcement interval may not be the sole factor controlling choice behavior. A complete model of choice should take into consideration stimuli occurring during the interreinforcement interval.

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