SPATIAL AND TEMPORAL RELATIONS IN CONDITIONED REINFORCEMENT AND OBSERVING BEHAVIOR

CRAIG A. BOWE AND JAMES A. DINSMOOR

INDIANA UNIVERSITY

In Experiment 1, depressing one perch produced stimuli indicating which of two keys, if pecked, could produce food (spatial information) and depressing the other perch produced stimuli indicating whether a variable-interval or an extinction schedule was operating (temporal information). The pigeons increased the time they spent depressing the perch that produced the temporal information but did not increase the time they spent depressing the perch that produced the spatial information. In Experiment 2, pigeons that were allowed to produce combined spatial and temporal information did not acquire the perch pressing any faster or maintain it at a higher level than pigeons allowed to produce only temporal information. Later, when perching produced only spatial information, the time spent depressing the perch eventually declined. The results are not those implied by the statement that information concerning biologically important events is reinforcing but are consistent with an interpretation in terms of the acquisition of reinforcing properties by a stimulus associated with a higher density of primary reinforcement.

Key words: spatial, temporal, discrimination, observing, information, conditioned reinforcement, key pecking, pigeons

For the past fifty years, most learning or behavior theorists have taken the position that the process by which a stimulus acquires the ability to reinforce behavior (conditioned reinforcement) is similar to or identical with the process by which it acquires the ability to elicit behavior occurring originally only in response to the unconditional stimulus with which it is paired (e.g., Hull, 1943; Mackintosh, 1974). Some writers have suggested that as an additional (Skinner, 1938) or alternative hypothesis (Keller & Schoenfeld, 1950), discriminative stimuli for operant behavior might similarly serve as conditioned reinforcers, but this formulation has lost much of its favor in recent years. To put the matter as simply as possible, the procedure for establishing a stimulus as a conditioned reinforcer has been most often thought to be the same as that for respondent conditioning.

However, difficulties in interpreting the acquisition and maintenance of observing responses within this framework (e.g., Prokasy, 1956; Wyckoff, 1959) have led a number of writers to suggest as an alternative formulation that "information" concerning future events of significance to the organism (e.g., food, shock) is the essential ingredient necessary to reinforce the behavior that brings it about. Although it was suggested by experiments on observing and is usually raised within that context, this "information hypothesis" is commonly thought to hold for a great variety of experimental settings. It is typically presented as a general hypothesis concerning the nature of conditioned reinforcement.

Despite the fact that in previous studies the information that was presumed to serve as the reinforcing agent has always been temporal in character, the hypothesis is usually worded quite broadly (e.g., Berlyne, 1960, p. 205; Bloomfield, 1972, p. 195; Hendry, 1969, p. 302; Lieberman, 1972, p. 342). One implication, then, or extension of the information hypothesis is that responses will be reinforced if they produce stimuli indicating which of two keys can currently produce food. In our first attempt to find empirical support for this prediction (Bowe & Dinsmoor, 1981), we used a

This report is based in part on a dissertation submitted by Craig A. Bowe to Indiana University in partial fulfillment of the requirements for a doctorate in psychology. We thank Leonard Green for his comments on an early version of this report. Reprints may be obtained from Craig A. Bowe, Central Institute for the Deaf, 818 South Euclid, St. Louis, Missouri 63110, or from James A. Dinsmoor, Department of Psychology, Indiana University, Bloomington, Indiana 47405.

procedure in which, by pecking the middle key, pigeons in the spatial information group produced stimuli indicating which of two side keys was currently "correct" (i.e., pecking might be reinforced). Whereas most of the birds in a comparable group that produced the more conventional temporal information about when pecking the side keys might be reinforced acquired substantial rates of pecking on the observing key, none of the birds in the spatial group did so.

In interpreting the results of our initial experiment (1981), we pointed to differences in the density of primary reinforcement correlated with the various stimuli as the critical parameter (see Autor, 1969; Browne & Dinsmoor, 1974; Herrnstein, 1964). The three stimuli encountered by the temporal information group were accompanied, respectively, by densities of zero, one half, and one delivery of the reinforcer per minute. As noted by Fantino (1977), the same parameter could, with equal readiness, also be described in terms of the relative delay to primary reinforcement associated with each of the stimuli, and this characterization has the additional advantage of providing a theoretical parallel with the interval between the conditional and the unconditional stimulus in respondent conditioning. But the stimuli that for the spatial information group specified which key was correct did not differ in their density or time to reinforcement from the uninformative, mixed-schedule stimulus. Regardless of which stimulus was present, the density remained at one half reinforcer per minute. Therefore, only the birds in the temporal information group had an opportunity to produce a stimulus associated with a higher density (or reduced delay) of reinforcement, and only such a stimulus could serve as a conditioned reinforcer.

It is possible that the procedure used by Bowe and Dinsmoor (1981) was not sufficiently sensitive. Pecking a key has a low operant level, and although pecking the observing key was initially reinforced with food, the response did not persist for a very long period of experimental time and did not provide substantial exposure to the food-based discrimination on the side keys. In fact, some birds did not form such discriminations. The present experiments employed operanda designed to produce greater periods of exposure to the discriminative stimuli and their associated con-

tingencies of reinforcement. Our intent in these experiments was to provide more sensitive tests of the proposition that the temporal information conveyed by stimuli differing in reinforcement density will support observing, whereas the spatial information conveyed by stimuli that indicate proper locus of responding but do not differ in reinforcement density will not support observing.

EXPERIMENT 1

In Experiment 1, depressions of one "perch" produced a stimulus display indicating which key might produce food (i.e., spatial information), and depression of another perch produced a stimulus display indicating which component of a mixed schedule was operating (i.e., temporal information). If spatial information is not reinforcing, then the birds should press only the temporal perch. On the other hand, if spatial information is reinforcing, then the birds should press both perches.

METHOD

Subjects

Three female White Carneaux pigeons 5 to 7 yr old were deprived of food until each reached about 75% of its free-feeding weight. The birds were maintained at that weight with supplementary feedings after experimental sessions. Water and grit were continuously available in the home cages. All three birds had served in a trace conditioning experiment before they were used in the present study.

Apparatus

A Lehigh Valley Model 1519 pigeon chamber that measured 35 cm across the front panel, 35 cm front-to-back, and 35 cm high was modified by the addition of two "perches." Each perch was a section of metal tubing 1.5 cm in diameter and 13.5 cm in length. The tubing was attached to the ends of two metal rods that protruded 3.8 cm from the front panel into the birds' working space. Each metal rod made contact with a pressure-activated switch on the other side of the panel. When a perch was depressed, this switch closed to operate electromechanical programming and recording equipment. The perches were placed side by side 2 cm apart, 2.3 cm from the floor, and 3 cm from the side wall closest to each.

Two white plastic keys were mounted behind circular openings on the front panel 8.5 cm from the ceiling and 12.7 cm apart (center-to-center). The keys could be transilluminated by Type 757 bulbs. The voltage supplied to the bulbs was regulated by variable resistors so that any one of four possible levels of illumination could appear on a key: (1) bright (24 V dc), (2) intermediate (20 V dc), (3) dim (12 V dc), or (4) dark (0 V). Besides appearing white and at various brightnesses, either of the two keys could also become green whenever other Type 757 bulbs that were mounted in green-jeweled housings behind the keys were supplied with 28 V dc.

A rectangular opening was centered in the front panel with its lower edge 9.8 cm above the floor. Whenever a reinforcer was earned, the opening provided the bird access for 3 sec to a raised food hopper containing mixed grain. Reinforcers were accompanied by the illumination of a Type 757 bulb operated at 28 V dc and located in the opening above the hopper. All other sources of illumination were extinguished during reinforcement.

Extraneous sounds were masked by continuous white noise from a speaker mounted to the left of the hopper opening and by noise from the chamber's ventilating fan. Throughout the sessions, except during reinforcement, a Type 757 bulb that was partially enclosed in a metal housing above the keys was supplied with 28 V dc to provide general illumination of the chamber. All experimental events were controlled and recorded by electromechanical equipment housed in a room adjoining the one in which the chamber was located.

Procedure

Pretraining. Both perches were present throughout pretraining, but their depression had no effect. Pecking the left key was shaped while the right key was covered by tape. Once a bird began to peck, it was allowed 30 reinforcers on a continuous reinforcement (CRF) schedule. During the next three sessions, each bird was successively shifted from the CRF schedule to a variable-interval (VI) 15-sec schedule, then to a VI 30-sec schedule, and finally to a VI 60-sec schedule. The birds were allowed 60 reinforcers during each of the first two of these sessions and 60 minutes of experimental time during the final session. All subsequent sessions were 60 min in length. The left

key was covered by tape on the fifth session, and each bird was allowed to peck the right key on the VI 60-sec schedule. Throughout all these sessions, the uncovered key was green.

For the sixth session both keys were uncovered. The location of the "correct" key alternated between left and right according to a variable-time (VT) 45-sec schedule. That is, during this and all subsequent sessions only one of the two keys was correct at any given moment, in the sense that only pecks on the correct key could produce food. Pecks on the incorrect key never produced food. Throughout this session the correct key was always green and the incorrect key was always dark, and a bird received reinforcers according to the VI 60-sec schedule when pecking the correct key. Spatial discrimination training continued in the same way in the seventh session but with one exception: The VI 60-sec schedule was not in operation throughout the session but alternated at variable intervals averaging 45 sec with an extinction schedule. During the extinction schedule no pecks were reinforced, even if they occurred on the correct key. This change set the stage for adding a temporal discrimination to the procedure. During the eighth session both keys were bright and the VI 60-sec schedule remained in force throughout the session. The birds received temporal discrimination training on the ninth and final session of pretraining, during which all four contingencies of primary reinforcement (i.e., left key correct and VI 60-sec operating, left key correct but extinction operating, right key correct and VI 60-sec operating, and right key correct but extinction operating) alternated as they had on the seventh session. Both keys were bright when the VI component was operating, and both keys were dim when the extinction component was operating. The four contingencies of primary reinforcement continued to alternate according to the independent VT schedules throughout the remainder of the experiment.

Temporal left/spatial right. After pretraining, the birds were allowed 30 sessions during which depressions of the left perch produced temporal information and depressions of the right perch produced spatial information. Temporal information and spatial information were conveyed by bright/dim stimulus displays and green/dark stimulus displays, respectively. For bright/dim displays both keys

became bright when the VI component was operating, and both keys became dim when the extinction component was operating. For green/dark displays the correct key was always green and the incorrect key was always dark. These stimulus displays appeared on the keys as long as a perch remained depressed; at other times, both keys were at the intermediate brightness (i.e., the stimulus correlated with the mixed schedule). Simultaneous depressions of both perches produced no stimulus displays and were not included in the data.

Temporal right/spatial left. During the final 30 sessions of the experiment, the roles of the two perches were reversed: Depressing the left perch produced the spatial information and depressing the right perch produced the temporal information. All other conditions in this part of the experiment were identical with those of the previous 30 sessions.

RESULTS AND DISCUSSION

Observing behavior was measured by calculating the percentage of time during each session that a bird depressed each perch. The resulting two measures were then separately averaged over each block of three sessions. To determine whether the temporal and the spatial information were being utilized by each bird, two kinds of discrimination index were calculated: a temporal discrimination index (TDI) and a spatial discrimination index (SDI). A TDI is calculated for each session block by dividing the number of pecks when the VI component was operating during a given kind of stimulus display by the total number of pecks during that kind of display. Thus, a TDI would be 1.0 if a bird pecked only when the VI component was operating during a given kind of stimulus display and would be about .5 if the bird did not discriminate which component of the mixed schedule was operating during that kind of display. An SDI is calculated for each session block by dividing the number of pecks on the correct key during a given kind of stimulus display by the total number of pecks during that kind of display. Thus, an SDI would be 1.0 if a bird pecked only the correct key during a given kind of stimulus display and would be about .5 if the bird did not discriminate which key was correct during that kind of display. A TDI and an SDI were calculated for each kind of stimulus display, so that there were

four indices of discriminative performance calculated for each bird: (1) a TDI while observing green/dark displays, (2) an SDI while observing green/dark displays, (3) a TDI while observing bright/dim displays, and (4) an SDI while observing bright/dim displays. Each of the four indices was averaged across all session blocks within a given part of the experiment.

Pretraining of the temporal discrimination and the spatial discrimination was successful for all birds. During the seventh session of pretraining, each bird achieved an SDI of .99, and during the ninth session, which was devoted to the temporal discrimination, the TDIs were .85, .90, and .81 for 10652, 1310, and 4007, respectively.

Figure 1 shows each bird's observing performance across all session blocks from Experiment 1. In the first part of the experiment, each bird increased the percentage of time it spent depressing the perch that produced temporal information and either maintained (at a low level) or decreased the percentage of time it spent depressing the perch that produced spatial information. In the second part of the experiment, after the functions of the two perches were interchanged, each bird increased the percentage of time it spent depressing the perch that produced temporal information and decreased the percentage of time it spent depressing the perch that produced spatial information, although in neither case did these reach levels attained before the reversal.

Table 1 shows the TDIs and SDIs for each bird in the two parts of Experiment 1. The SDIs of the birds while observing green/dark displays and the TDIs of the birds while observing bright/dim displays were generally high, indicating good spatial and temporal

Table 1
Discrimination indices for each bird in each part of Experiment 1.

	Bird	Green/ Dark		Bright/ Dim	
		SDI	TDI	SDI	TDI
Temporal Left/ Spatial Right	10652	.92	.31	.50	.95
	1310	.68	.40	.50	.97
	4007	.86	.57	.52	.95
Temporal Right/ Spatial Left	10652	.88	.44	.50	.96
	1310	.59	.44	.51	.96
	4007	.96	.41	.58	.92

Fig. 1. Mean percentage of session spent depressing perch that produced temporal information and perch that produced spatial information. Data are plotted separately for each of three birds. (Experiment 1)

discriminations, respectively. Bird 1310, however, did not discriminate very well spatially, especially in the second part of the experiment. None of the birds discriminated temporally while observing green/dark displays or discriminated spatially while observing bright/dim displays. The TDIs of the birds while observing green/dark displays were for the most part slightly below .5. This "reversed" temporal discrimination while observing green/dark displays can, perhaps, be attributed to selective observing of the bright/dim displays. Unsystematic observations by the first author of the present report suggested that all three birds kept the perch producing bright/dim displays depressed throughout most of the time when the VI component was operating, thus producing S+. However, when the extinction component was operating, so that depressing the bright/dim perch produced S-, the birds held that perch down only for very brief intervals. This corresponds to the pattern of behavior recorded by Dinsmoor, Browne, Lawrence, and Wasserman (1971) and by Dinsmoor, Mueller, Martin, and Bowe (1982). After releasing the bright/dim perch, the birds depressed the perch producing the green/dark displays and pecked the green (correct) key. Because these pecks occurred during the extinction component, they reduced the TDIs of the birds slightly below the chance level.

The total numbers of pecks to the stimuli associated with the mixed, the VI, and the extinction schedules, and with the correct and incorrect key locations during the first and last session blocks in each part of Experiment 1 are shown for each bird in Appendix 1. The amount of time spent in the presence of the stimulus correlated with the mixed schedule, the bright/dim stimulus displays, and the green/dark stimulus displays during the first and last session blocks in each part of Experiment 1 are shown in Appendix 2.

The results of Experiment 1 show that under conditions in which pigeons do acquire and maintain a response that produces information indicating when pecking may be reinforced, they do not acquire or maintain a response that produces information indicating which key to peck. Time increased only on the perch producing temporal information, because only in the presence of the bright/dim displays was there a stimulus accompanied by an increase in the density of primary reinforce-

ment (i.e., the bright keys). Thus, as predicted by the reinforcement-density (e.g., Browne & Dinsmoor, 1974) or delay-reduction (Fantino, 1977) analysis of observing, the birds of Experiment 1 observed temporal information but not spatial information.

EXPERIMENT 2

Bowe and Dinsmoor's (1981) experiment and the present Experiment 1 suggested that spatial information does not bring about the acquisition and maintenance of observing. But, does spatial information have any effect whatsoever on observing? More specifically, the first question addressed by Experiment 2 was whether birds that were allowed to produce a combination of spatial and temporal information would increase their rates of acquisition or their asymptotic levels of observing above those of birds that could produce only the temporal information. The second question addressed by Experiment 2 was whether an observing response, once established with temporal information, could be maintained by spatial information alone.

METHOD

Subjects and Apparatus

Eight female White Carneaux pigeons 5 to 7 yr old were deprived of food until each reached about 75% of its free-feeding weight. The birds were maintained at that weight with supplementary feedings after experimental sessions. Water and grit were continuously available in the home cages. Six of the birds had served in an autoshaping experiment with colors and dots as the stimuli. The other two (5844 and 1772) were experimentally naive.

The same apparatus was used in Experiment 2 as was used in Experiment 1.

Procedure

Pretraining. For all birds, pecking of the two keys was trained in seven successive daily sessions. During the first five sessions, tape covered one of the keys; pecks on the other key could produce food. When uncovered, a key was always at the intermediate brightness. Also, both perches were present throughout pretraining, but depressing them had no effect.

After pecking had been shaped on the right key and 30 reinforcers had been delivered on

a CRF schedule, each bird was successively shifted during the next three sessions to a VI 15-sec schedule, then to a VI 30-sec schedule, and finally to a VI 60-sec schedule. The birds were allowed 60 reinforcers during each of the first two of these sessions and 60 minutes of experimental time during the final session. All subsequent sessions in the experiment were 60 min in length. During the fifth session each bird was allowed to peck the left key, with reinforcers delivered according to the VI 60-sec schedule.

For the sixth session, both keys were uncovered, and a dual-state alternating device changing states according to a VT 45-sec schedule determined whether the left or right key was correct. Reinforcers were set up and could be produced according to the VI 60-sec schedule by pecks on the correct key. For the seventh and final session of pretraining, another dual-state alternating device changing states according to a second VT 45-sec schedule, independent of the first, determined whether the VI or extinction component of a mixed schedule was operating. Reinforcers were set up and delivered only when the VI-60 sec component was operating. Again, as in the preceding experiment, there were four contingencies of primary reinforcement, and these continued to alternate throughout each session for the remainder of the experiment.

Baseline. Following the pretraining, half of the birds from each condition had the left perch arbitrarily designated as effective and half had the right perch so designated. Depressions of the effective perch constituted that bird's observing response. The observing response produced stimulus displays in which the two keys changed from their intermediate brightness to some combination of bright, dim, and/or dark. As long as the effective perch remained depressed, the stimulus display continued to appear; at other times, both keys were at their intermediate brightness. Depressions of the ineffective perch had no effect and were not included in the data.

The three sessions after pretraining served as baseline sessions to measure the amount of time each bird spent depressing the effective perch when the stimulus displays conveyed no information. The displays produced by any given bird corresponded to those received by that same bird in the next part of the experiment, but these displays had no correlation

with any of the four contingencies of primary reinforcement.

Temporal vs. spatiotemporal information. For 30 sessions after the baseline determination, the birds in the Temporal Information/Spatiotemporal Information group received temporal information when they depressed the effective perch: If the VI component was operating, both keys became bright; if the extinction component was operating, both keys became dim. Birds in the Spatiotemporal Information/Temporal Information group received spatiotemporal information: If the VI component was operating, the correct key became bright; if the extinction component was operating, the correct key became dim; the incorrect key always became dark while these birds were observing.

Information switch. For 30 sessions after Temporal vs. Spatiotemporal Information, each group of birds was exposed to the procedure previously used for the other group. That is, the birds from the temporal-information condition received spatiotemporal information, and the birds from the spatiotemporal-information condition received temporal information.

Spatial information. For the 36 sessions after Information Switch, all birds were allowed to produce spatial information only. There were two conditions of spatial information: Bright and Bright/Dim. Half of the birds from each of the previous groups were assigned to each of these conditions. Whenever birds in the Spatial Information:Bright condition depressed the effective perch, the correct key became bright and the incorrect key

became dark. Whenever birds in the Spatial Information:Bright/Dim condition depressed the effective perch, the correct key became either bright or dim and the incorrect key became dark. There was no correlation, however, for any of these birds, between the bright or dim illumination of the key and the VI or extinction component of the schedule for delivery of the food.

RESULTS AND DISCUSSION

Table 2 shows the discriminative performances of the birds throughout Experiment 2. In general, inspection of Table 2 indicates that if either spatial information or temporal information was produced by a bird's observing response, the bird's pecking conformed to that information. During the three sessions of Baseline (no information) all the SDIs and TDIs were about .5. During observing of spatiotemporal information, both the SDIs and the TDIs for all birds except 5844 were fairly high even on the first session block, regardless of the order in which spatiotemporal information was observed. During observing of temporal information alone, the TDIs for all birds were fairly high and the SDIs were, of course, about .5 from the first to the last session blocks, regardless of the order in which temporal information was observed. And finally, during observing of spatial information alone the SDIs for all birds were fairly high and the TDIs for all birds were, of course, about .5.

Figure 2 shows the group means of time spent depressing the effective perch by the birds in the two conditions, Temporal Information followed by Spatiotemporal Informa-

Table 2

Spatial and temporal discrimination indices during Baseline and during first and last session blocks when birds were producing Spatiotemporal Information, Temporal Information, or Spatial Information.

Bird	Baseline SDI TDI		Spatiotemporal Information				Temporal Information				Spatial Information							
			First SDI TDI		Last SDI TDI		First SDI TDI		Last SDI TDI		Bright				Bright/Dim			
											First SDI TDI		Last SDI TDI		First SDI TDI		Last SDI TDI	
9227	.42	.48	.78	.77	.98	.98	.51	.98	.51	.96	.97	.53	.99	.45				
1294	.52	.41	.77	.79	.86	.88	.48	.99	.34	.97	.98	.44	.97	.32				
1844	.55	.56	.90	.87	.99	.98	.48	.99	.51	.95					.97	.50	.96	.49
5844	.44	.49	.49	.48	.97	.94	.52	.93	.50	.97					.96	.52	.90	.45
4781	.54	.43	.96	.94	.96	.97	.54	.82	.53	.97	.98	.53	.91	.48				
4107	.50	.49	.92	.91	.98	.97	.48	.82	.50	.95	.99	.55	.99	.47				
1083	.46	.40	.96	.97	.99	.99	.47	.80	.51	.98					.99	.44	.96	.53
1772	.48	.47	.90	.92	.97	.97	.49	.58	.50	.94					.96	.40	.95	.40

Fig. 2. Mean percentage of session spent observing during each block of three sessions in Experiment 2. Birds in the TI/STI group received only temporal information for 30 sessions, followed by spatiotemporal information for 30 sessions. Birds in the STI/TI group received the same two treatments in the reverse order. The initial points to the left represent the baseline performances for the two groups, with no information provided.

tion (circles) and Spatiotemporal Information followed by Temporal Information (squares), during the session blocks from Baseline, Temporal vs. Spatiotemporal Information, and Information Switch. Inspection of Figure 2 reveals: (1) The birds in the two conditions had similar baseline levels of depressing the effective perch. (2) The birds in the two conditions acquired the observing response and did so at nearly the same rates. (3) The birds in the

two conditions reached nearly the same asymptotes. If anything, the birds observing temporal information (circles) approached a higher asymptote than did those observing spatiotemporal information (squares). And (4) the birds in the two conditions maintained their observing responses at similar asymptotes when switched from observing temporal information to observing spatiotemporal information or vice versa. Table 3 shows the individual data for observing during Baseline, the first and last session blocks of Temporal vs. Spatiotemporal Information, and the first and last session blocks of Information Switch. Except for the one bird that failed to observe (1294), inspection of Table 3 leads to the same conclusions as did inspection of Figure 2.

Figure 3 shows the group means of time spent depressing the effective perch by the

Fig. 3. Mean percentage of session spent observing by birds receiving bright or bright and dim stimuli in Experiment 2 during the first and last session blocks of Spatial Information and during the preceding block, when temporal information was available.

Table 3

Mean percentage of session spent observing during Baseline and during first and last session blocks when birds were producing Spatiotemporal Information, Temporal Information, or Spatial Information.

Bird	Baseline	Spatiotemporal Information		Temporal Information		Spatial Information			
		First	Last	First	Last	Bright		Bright/Dim	
						First	Last	First	Last
9227	31	12	56	56	59	68	62		
1294	5	2	2	3	7	11	3		
1844	19	21	42	43	38			38	30
5844	18	12	35	48	44			21	8
4781	3	32	41	6	39	72	24		
4107	22	37	54	22	48	74	51		
1083	16	39	49	10	60			42	13
1772	5	29	40	2	27			33	18

birds in the two conditions, Spatial Information:Bright (horizontal stripes) and Spatial Information:Bright/Dim (vertical stripes), during the first and last session blocks of Spatial Information. For comparison, Figure 3 also shows the group means of time spent depressing the effective perch by the birds in the two conditions during the last session block of Information Switch (labeled "Preceding Session Block") in which temporal information was available to all the birds. Inspection of Figure 3 leads to two general conclusions: (1) Birds in both conditions decreased observing across the 36 sessions of Spatial Information, and (2) birds in the two conditions differed in the manner and extent that they decreased observing during Spatial Information. A comparison of the birds' behavior in the session block preceding Spatial Information with their behavior in Spatial Information shows that whereas birds in the Spatial Information:Bright/Dim condition substantially decreased the percentage of time that they depressed the effective perch, birds in the Spatial Information:Bright condition first increased the percentage of time that they depressed the effective perch and then decreased.

Inspection of the individual data in Table 3 supports in every case the first general conclusion drawn from inspection of Figure 3. That is, all birds decreased observing during Spatial Information. However, by the last session block of Spatial Information not every bird in the Spatial Information:Bright/Dim condition had greatly reduced its percentage of time depressing the effective perch (e.g., 1844). Furthermore, although each bird in the Spatial Information:Bright condition first increased and then decreased its percentage of time depressing the effective perch, the decrease during Spatial Information was small for 9227 and the remaining level high both for that bird and for 4107.

The total number of pecks to the stimuli associated with each schedule and with the correct and incorrect key locations during Baseline and the first and last session blocks of each condition are shown for each bird in Appendix 3. Similarly, the amount of time spent in the presence of each of the stimuli during the same session blocks is shown in Appendix 4.

The results of Experiment 2 are best explained by a conditioned-reinforcement in-

terpretation of observing in which spatial relations play no role, such as the reinforcement-density analysis (e.g., Browne & Dinsmoor, 1974) or Fantino's (1977) formulation in terms of the reduction in indicated time to primary reinforcement. When temporal information, either alone or in combination with spatial information, was produced by the observing response, a conditioned reinforcer—the bright key(s) correlated with the VI schedule—was thereby produced. Thus, whether the birds produced spatiotemporal information or temporal information only, they acquired and maintained the observing response. The fact that the addition of the stimulus conveying spatial information did not increase either the acquisition rates or the asymptotic levels of observing above those resulting from temporal information alone is due to the absence of any greater density of reinforcement when that stimulus was presented. In other words, the conditioned reinforcer was equally effective in either condition, because it was associated with the same relative advantage in reinforcement density. When temporal information could no longer be produced via an observing response, a conditioned reinforcer could no longer be produced. That is, during the Spatial Information sessions there was no stimulus associated with a greater reinforcement density than any other stimulus in the situation. Therefore, the birds failed to maintain their observing responses, despite the presence of spatial information.

Some of the results from the Spatial Information procedure may appear to contradict the above analysis. Specifically, some of the birds appeared to maintain observing responses that produced only spatial information. In fact, however, even the increases in observing and the relatively high levels maintained by two of the birds from the Spatial Information:Bright condition are compatible with Dinsmoor's selective observing hypothesis, a stimulus pairing interpretation (e.g., Dinsmoor, in press; Dinsmoor et al., 1971). To apply this hypothesis to Experiment 2, note first that during the 60 sessions preceding Spatial Information, the bright keys (S+) had for all birds become a conditioned reinforcer. Note also that during Spatial Information the birds from the Spatial Information:Bright condition (but not those from the Spatial Information:Bright/Dim condition) could

produce the bright keys at all times during the session, rather than only half of the time, as was the case during the preceding parts of the experiment. Therefore, during the first session block of Spatial Information, there was a substantial increase in the amount of time spent on the effective perch, because this produced the conditioned reinforcer more often than in previous session blocks. During the 36 sessions of Spatial Information, however, these birds decreased their observing, because the density of reinforcement associated with the bright keys was no longer any greater than that associated with an intermediate level of illumination. As might be expected after 60 sessions of training, the decrease in time spent observing was relatively slow.

The information hypothesis of observing does not seem to contribute to an analysis of the results from Experiment 2. In particular, the substantial declines in observing that were shown by birds from the Spatial Information: Bright/Dim condition contradict the hypothesis that spatial information is reinforcing. Even though such information was fully available and was effectively utilized by the birds from the Spatial Information: Bright/Dim condition, it was not sufficiently reinforcing to maintain a well established observing response. Furthermore, given that birds observing combined spatial and temporal information acquired observing responses at the same rates and maintained them at the same levels as birds observing only temporal information, it would appear that, at least under the conditions of the present experiment, spatial information adds nothing whatsoever to the effectiveness of the stimulus displays as conditioned reinforcers.

GENERAL DISCUSSION

The results of Experiments 1 and 2 join with those of other observing response experiments in demonstrating the reinforcing effect of stimuli correlated in time with primary reinforcement (i.e., temporal information). But the present results indicate that information about which of two keys must be pecked for food is not reinforcing for pigeons.

Experiment 1 indicated that, when tested under comparable conditions, pigeons observe temporal information but do not observe spa-

tial information. Experiment 2 indicated that the addition of spatial information to temporal information does not increase either the rate of acquisition or the asymptotic level of observing above that established by temporal information alone. Also, Experiment 2 indicated that spatial information alone cannot maintain observing, at least not at the level maintained by temporal information. The results of both experiments are best explained with an analysis of observing that posits that in a given situation organisms will acquire and maintain observing responses that produce a stimulus that accompanies a higher density of primary reinforcement.

Proponents of the information hypothesis (e.g., Bloomfield, 1972; Hendry, 1969; Lieberman, 1972; Schaub, 1969) have used the term "information" rather loosely in their interpretations of observing. If the word "information" refers to uncertainty reduction in general, as their usage seems to imply, then the present finding that spatial information does not maintain observing is not easily handled by this hypothesis.

A more important implication of the present findings is the basis that they provide for the functional distinction between a stimulus as discriminative and that same stimulus as reinforcing. Skinner (1938) first raised the issue of whether the operational distinction between a discriminative stimulus and a conditioned reinforcer was also a functional distinction. And although early experiments (e.g., Dinsmoor, 1950) seemed to support the functional identity of discriminative stimuli and conditioned reinforcers, later experiments (e.g., Dinsmoor & Clayton, 1966; Fantino, 1965; Stein, 1958; Wilson, Sherman, & Holman, 1981) are joined by the present experiments in demonstrating a functional distinction between a stimulus as discriminative and that same stimulus as reinforcing. That is, in the present experiments all the birds that were allowed to observe spatial information were shown to discriminate spatially, but none of these birds acquired or maintained observing responses that produced the stimuli for the spatial discriminations.

Although we have not been able to demonstrate any reinforcing effect of spatial information in our experiments to date and although this inability is compatible with the reinforcement density analysis of observing, it

remains possible that other assays might provide such a demonstration. Browne and Dinsmoor (1974) and Jenkins and Boakes (1973) found that pigeons will observe stimuli that signal response-independent food deliveries. Their situations involved only what we would term "temporal information," but it would be interesting to conduct a similar experiment in which food deliveries at one of two (or more) locations were signaled by the stimuli produced by an observing response. Note that in such an experiment the spatial information would answer the question, "Where do I go to eat food?", as opposed to information in our previous experiments that has answered the question, "Where do I go to produce food?" Another way to test the potential reinforcing effect of spatial information would be to increase the "amount" of spatial information over that in our previous work. This increase could be accomplished in two different ways: (1) by increasing the distance between the two food-producing response alternatives and (2) by increasing the number of food-producing response alternatives. The latter method is probably more appropriate, given the original definitions of the information concept in terms of uncertainty-reduction (e.g., Garner, 1974; Shannon & Weaver, 1949). However, in using either method it is important that reinforcement density be equal across the stimuli from the spatial information conditions, regardless of the subjects' behavior. Otherwise, temporal information will confound the tests for any reinforcing effects of spatial information.

REFERENCES

- Autor, S. M. The strength of conditioned reinforcers as a function of frequency and probability of reinforcement. In D. P. Hendry (Ed.), *Conditioned reinforcement*. Homewood, Ill.: Dorsey Press, 1969.
- Berlyne, D. E. *Conflict, arousal, and curiosity*. New York: McGraw-Hill, 1960.
- Bloomfield, T. M. Reinforcement schedules: Contingency or contiguity? In R. M. Gilbert & J. R. Millenson (Eds.), *Reinforcement: Behavioral analyses*. New York: Academic Press, 1972.
- Bowe, C. A., & Dinsmoor, J. A. Temporal vs. spatial information as a reinforcer of observing. *Bulletin of the Psychonomic Society*, 1981, 17, 33-36.
- Browne, M. P., & Dinsmoor, J. A. Wyckoff's observing response: Pigeons learn to observe stimuli for free food but not stimuli for extinction. *Learning and Motivation*, 1974, 5, 165-173.
- Dinsmoor, J. A. A quantitative comparison of the discriminative and reinforcing functions of a stimulus. *Journal of Experimental Psychology*, 1950, 40, 458-472.
- Dinsmoor, J. A. Observing and conditioned reinforcement. *Behavioral and Brain Sciences*, in press.
- Dinsmoor, J. A., Browne, M. P., Lawrence, C. E., & Wasserman, E. A. A new analysis of Wyckoff's observing response. *Proceedings of the 79th Annual Convention of the American Psychological Association*, 1971, 6, 679-680.
- Dinsmoor, J. A., & Clayton, M. H. A conditioned reinforcer maintained by temporal association with the termination of shock. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 547-552.
- Dinsmoor, J. A., Mueller, K. L., Martin, L. T., & Bowe, C. A. The acquisition of observing. *Journal of the Experimental Analysis of Behavior*, 1982, 38, 249-263.
- Fantino, E. Some data on the discriminative stimulus hypothesis of secondary reinforcement. *Psychological Record*, 1965, 15, 409-415.
- Fantino, E. Conditioned reinforcement: Choice and information. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior*. Englewood Cliffs, N.J.: Prentice-Hall, 1977.
- Garner, W. R. *The processing of information and structure*. Hillsdale, N.J.: Erlbaum, 1974.
- Hendry, D. P. Reinforcing value of information: Fixed-ratio schedules. In D. P. Hendry (Ed.), *Conditioned reinforcement*. Homewood, Ill.: Dorsey Press, 1969.
- Herrnstein, R. J. Secondary reinforcement and rate of primary reinforcement. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 27-36.
- Hull, C. L. *Principles of behavior*. New York: Appleton-Century, 1943.
- Jenkins, H. M., & Boakes, R. A. Observing stimulus sources that signal food or no food. *Journal of the Experimental Analysis of Behavior*, 1973, 20, 197-207.
- Keller, F. S., & Schoenfeld, W. N. *Principles of psychology*. New York: Appleton-Century-Crofts, 1950.
- Lieberman, D. A. Secondary reinforcement and information as determinants of observing behavior in monkeys (*Macaca mulatta*). *Learning and Motivation*, 1972, 3, 341-358.
- Mackintosh, N. J. *The psychology of animal learning*. New York: Academic Press, 1974.
- Prokasy, W. F. The acquisition of observing responses in the absence of differential external reinforcement. *Journal of Comparative and Physiological Psychology*, 1956, 49, 131-134.
- Schaub, R. E. Response-cue contingency and cue effectiveness. In D. P. Hendry (Ed.), *Conditioned reinforcement*. Homewood, Ill.: Dorsey Press, 1969.
- Shannon, C. E., & Weaver, W. *The mathematical theory of communication*. Urbana: University of Illinois Press, 1949.
- Skinner, B. F. *The behavior of organisms: An experimental analysis*. New York: Appleton-Century, 1938.
- Stein, L. Secondary reinforcement established with subcortical stimulation. *Science*, 1958, 127, 466-467.
- Wilson, C. L., Sherman, J. E., & Holman, E. W. Aversion to the reinforcer differentially affects condi-

tioned reinforcement and instrumental responding.
Journal of Experimental Psychology: Animal Behavior Processes, 1981, 7, 165-174.
Wyckoff, L. B. Toward a quantitative theory of secondary reinforcement. *Psychological Review*, 1959, 66, 68-78.

Received January 21, 1982
Final acceptance September 15, 1982

Appendix 1

Number of pecks to the stimuli associated with the mixed, VI, and extinction schedules and the correct and incorrect key locations during the first and last session blocks of Experiment 1.

Bird	Condition	Temporal Left/ Spatial Right		Temporal Right/ Spatial Left	
		First	Last	First	Last
10652	Mixed	2780	1420	2098	3049
	VI	2093	3006	717	2949
	Extinction	186	99	28	89
	Correct	307	291	1861	828
	Incorrect	56	27	165	63
1310	Mixed	4130	2679	3510	2942
	VI	1629	3660	2782	2501
	Extinction	135	102	97	132
	Correct	417	47	202	95
	Incorrect	90	25	116	57
4007	Mixed	4261	903	1846	1269
	VI	770	4028	731	2258
	Extinction	144	124	94	173
	Correct	138	107	4191	2508
	Incorrect	30	43	122	91

Appendix 2

Time in minutes spent in the presence of the stimulus associated with the mixed schedule, the bright/dim displays, and the green/dark displays during the first and last session blocks of Experiment 1.

Bird	Condition	Temporal Left/ Spatial Right		Temporal Right/ Spatial Left	
		First	Last	First	Last
10652	Mixed	95.02	89.22	100.01	92.56
	Bright/Dim	59.72	69.75	14.27	50.78
	Green/Dark	15.46	11.92	59.25	29.05
1310	Mixed	103.02	99.51	88.55	97.10
	Bright/Dim	43.29	66.21	50.88	60.19
	Green/Dark	26.72	9.17	31.86	15.81
4007	Mixed	148.93	67.87	70.84	58.41
	Bright/Dim	18.91	99.04	11.53	48.00
	Green/Dark	4.08	3.72	91.04	69.81

Appendix 3

Number of pecks to the stimuli associated with the mixed, VI, and extinction schedules and the correct and incorrect key locations during Baseline and the first and last session blocks of Temporal vs. Spatiotemporal Information, of Information Switch, and of Spatial Information in Experiment 2.

<i>Bird</i>	<i>Condition</i>	<i>Baseline</i>	<i>Spatiotemporal Information</i>		<i>Temporal Information</i>		<i>Spatial Information</i>	
			<i>First</i>	<i>Last</i>	<i>First</i>	<i>Last</i>	<i>First</i>	<i>Last</i>
9227	Mixed	4257	5180	1136	666	348	500	197
	VI	362	347	6099	5705	4667	2861	3081
	Extinction	391	106	128	88	176	2509	3810
	Correct	318	358	6129	2958	2480	5211	6840
	Incorrect	435	95	98	2835	2363	159	51
1294	Mixed	5961	7092	8183	8062	6117	8219	10151
	VI	43	49	60	303	378	370	55
	Extinction	61	13	8	4	13	479	115
	Correct	54	47	59	148	131	830	165
	Incorrect	150	15	9	159	260	19	5
1844	Mixed	2719	1215	642	367	1595	1918	3683
	VI	129	602	3027	2342	2388	1238	893
	Extinction	162	396	48	33	138	1228	915
	Correct	118	620	3039	1150	1291	2395	1724
	Incorrect	173	378	36	1225	1235	71	84
5844	Mixed	4005	3927	5084	6165	4657	6582	9587
	VI	218	163	3798	5289	4482	959	151
	Extinction	223	179	244	413	158	862	184
	Correct	197	171	3907	2985	2301	1764	304
	Incorrect	244	171	135	2717	2339	57	31
4781	Mixed	8011	7709	4620	5846	6785	1463	8650
	VI	93	3833	4592	58	5000	4288	1479
	Extinction	123	225	160	13	178	3860	1586
	Correct	117	3901	4579	37	2767	7985	2798
	Incorrect	99	157	173	34	2411	163	267
4107	Mixed	3540	2948	904	6003	1724	348	241
	VI	547	2287	5075	1348	5054	4700	2227
	Extinction	745	229	148	292	240	3867	2519
	Correct	568	2316	5138	794	2648	8535	4719
	Incorrect	724	200	85	846	2646	32	27
1083	Mixed	2282	4085	205	2874	868	190	5514
	VI	367	2414	3977	591	6304	1103	331
	Extinction	539	76	22	146	113	1402	293
	Correct	414	2397	3982	349	3274	2492	600
	Incorrect	492	93	17	388	3143	13	24
1772	Mixed	4060	4141	1926	4739	5451	3317	5656
	VI	95	1800	2584	46	2720	953	611
	Extinction	109	166	89	31	176	1408	898
	Correct	99	1771	2605	38	1439	2285	1433
	Incorrect	105	195	68	39	1457	76	76

Appendix 4

Time in minutes spent in the presence of the stimuli associated with the mixed, VI, and extinction schedules during Baseline, and the first and last session blocks of Temporal vs. Spatiotemporal Information, of Information Switch, and of Spatial Information in Experiment 2.

<i>Bird</i>	<i>Condition</i>	<i>Baseline</i>	<i>Spatiotemporal Information</i>		<i>Temporal Information</i>		<i>Spatial Information</i>	
			<i>First</i>	<i>Last</i>	<i>First</i>	<i>Last</i>	<i>First</i>	<i>Last</i>
9227	Mixed	118.83	151.95	75.96	75.59	70.48	55.60	65.15
	VI	27.18	12.29	69.30	71.64	70.52	63.91	50.63
	Extinction	26.57	8.28	25.51	25.55	30.46	56.04	57.87
1294	Mixed	164.96	172.58	171.04	167.94	158.87	154.37	166.76
	VI	4.43	1.64	1.49	3.71	9.02	7.84	1.87
	Extinction	4.10	1.27	1.34	1.09	3.87	10.94	2.80
1844	Mixed	140.73	136.68	101.59	100.12	108.25	107.46	121.25
	VI	16.31	24.33	54.15	57.54	46.46	34.51	24.88
	Extinction	15.97	12.90	20.11	16.96	19.46	31.70	25.99
5844	Mixed	145.64	151.96	114.09	90.59	97.22	137.47	157.75
	VI	13.82	10.00	39.08	62.90	62.67	18.26	6.68
	Extinction	17.58	11.26	21.83	19.36	13.89	17.59	7.52
4781	Mixed	172.62	116.73	102.10	166.52	105.92	47.72	132.30
	VI	2.00	43.97	59.96	4.77	57.29	67.68	19.83
	Extinction	2.53	11.79	10.87	5.23	9.27	58.03	21.24
4107	Mixed	136.73	108.40	78.41	137.76	89.40	45.79	85.44
	VI	18.79	40.97	66.44	20.43	62.65	69.55	41.94
	Extinction	20.58	23.19	27.33	18.01	21.26	58.76	45.96
1083	Mixed	150.45	105.29	89.70	154.44	69.80	99.55	151.40
	VI	11.06	45.80	62.01	10.11	75.63	31.36	10.69
	Extinction	15.45	22.87	22.80	6.20	27.65	39.91	11.00
1772	Mixed	167.94	121.97	102.55	168.75	126.80	117.02	142.36
	VI	4.83	36.66	50.54	2.12	38.47	22.65	12.69
	Extinction	3.76	13.71	18.36	1.71	7.87	33.95	17.89