Value transfer in a simultaneous discrimination by pigeons: The value of the S⁺ is not specific to the simultaneous discrimination context

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During simultaneous discrimination training, there is evidence that some of the value of the S⁺ transfers to the S⁻. When the value of the S⁺ is altered outside the context of the simultaneous discrimination, two very different predictions are made concerning its effect on its S⁻, depending on whether one views the S⁺ as an occasion setter or as a stimulus capable of transferring value. In four experiments, pigeons were trained with two similar simultaneous discriminations, A⁺B⁻ and C⁺D⁻, and two single-stimulus trial types, A and C, (in which A always had greater nominal value than C). According to value transfer theory, on test trials, B should always be preferred over D, because B and D should be affected by the net values of A and C, respectively. According to an occasion setting account, however, D should be preferred over B because the presence of D signals a higher probability of reinforcement for responding to C than when C is alone, and/or the presence of B signals a lower probability of reinforcement for responding to A than when A is alone. In all four experiments, the pigeons preferred B over D, a result consistent with value transfer theory. Thus, an S⁻ can acquire value from an S⁺ even when that value is conditioned in a "context" different from that of the simultaneous discrimination.

Traditionally, it has been assumed that acquisition of a simultaneous discrimination results in an association between the S⁺ and reinforcement (excitation) and an association between the S⁻ and nonreinforcement (inhibition; Hull, 1943; Spence, 1936), and that no direct relation develops between the two discriminative stimuli. Interactions between these stimuli can occur through similarity-based generalization, but these interactions should be derivable from the original single-stimulus functions (Spence, 1937).

There is evidence, however, from research with successive discriminations that reinforcement associated with one stimulus can directly affect responding to another. It has been shown, for example, that responding to a positive stimulus often increases with the introduction of a negative stimulus (i.e., positive behavioral contrast; see, e.g., Reynolds, 1961).

More recently, it has been suggested that a different kind of relation may develop between two arbitrary stimuli when they are presented in the context of a simultaneous discrimination. Fersen, Wynne, Delius, and Staddon (1991) proposed a theory of value transfer in which a relation is established between the stimuli presented in a simultaneous discrimination. According to this theory, when two stimuli are presented simultaneously, the stimulus associated with reinforced responding will transfer some of its value to the other stimulus (e.g., S⁻ can acquire excitatory value independent of its similarity to the

S⁺, merely by being presented with the S⁺; see also Steirn, Weaver, & Zentall, 1995; Zentall & Sherburne, 1994).

Zentall and Sherburne (1994) conducted direct tests of value transfer theory. They first trained pigeons to discriminate between two pairs of hue stimuli. For the A¹⁰⁰ B⁰ pair, responses to A always resulted in reinforcement, whereas responses to B never resulted in reinforcement. For the C⁵⁰ D⁰ pair, responses to C resulted in reinforcement on a random 50% of the trials, whereas responses to D never resulted in reinforcement. After training with these two discriminations, the pigeons were given a choice between B and D, both of the stimuli to which responding had never been reinforced. According to value transfer theory, B should acquire more excitatory value from A than D should acquire from C; thus, B should be preferred over D. Consistent with this prediction, there was a strong preference for B over D on test trials in which responses were nondifferentially reinforced.

In a later study, the mechanism underlying value transfer between simultaneously presented stimuli was investigated (Zentall, Sherburne, Roper, & Kraemer, 1996). Zentall et al. proposed that a Pavlovian association developed between the simultaneously presented stimuli. To test this hypothesis, they conducted a series of experiments in which, following initial training, the value of one of the stimuli in a pair was either increased or decreased. In Zentall et al.'s Experiment 3, pigeons were first trained with A⁵⁰ B⁰ and C⁵⁰ D⁰, two discriminations in which the stimuli had similar reinforcement histories. Then, in Phase 2, the pigeons were trained with a new combination of two of the stimuli from Phase 1, A¹⁰⁰ C⁰. When these pigeons were then given a choice between B and D, they showed a strong preference for B over D. Thus,

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changing the value of the S^+ retroactively affected the value of the S^- with which it had been paired.

These results are consistent with the notion that the value of B is determined not only by the value that A has acquired in the context of B, but also by its later acquired value. If A increases in value, B does as well. However, these results are inconsistent with the notion that the value of A is signaled by the presence of B. In the example described (Zentall et al., 1996, Experiment 3), the value of A was lower when B was present than when B was absent. If one thinks of the AB pair as a Pavlovian compound, the value of B is determined by the difference in value between A when it is presented alone and A when it is presented in the AB compound. Thus, the presence of B could be construed as a stimulus "responsible" for a reduction in the probability of reinforcement of A from 100% to 50%, and B could acquire inhibitory (or at least less excitatory) strength than it would have otherwise (see, e.g., Wagner & Rescorla, 1972). It may be, however, that because in Zentall et al. (1996, Experiment 3) the value of A changed in a separate, later phase of training, B did not acquire the ability to appropriately signal the relative value of A.

In the present research, we asked whether the relative signaling function of an S^- could be demonstrated when the value of its paired S^+ was increased or decreased on single-stimulus trials interspersed with simultaneous discrimination training trials. This notion of a signaling stimulus is functionally equivalent to that of an occasion setter. In this case, B sets the occasion for the reduced value of A. When occasion setters are presented prior to the discriminative stimulus whose value they signal, the occasion setters typically do not enter into association with the reinforcer (Ross & Holland, 1981). If, however, as is the case with a simultaneous discrimination, the occasion setter is presented simultaneously with the discriminative stimulus, it should enter into association with the reinforcer (Ross & Holland, 1981).

According to a signaling or occasion setting account, if A^{100} trials are interspersed among $A^{50} B^0$ trials, the animals should learn that the presence of B is associated with a lower value of A than when A is presented alone. Similarly, if C^0 trials are interspersed among $C^{50} D^0$ trials, the animals should learn that the presence of D is associated with a higher value of C than when C is presented alone. BD test trials should then reflect the choice between B, a signal for a decrease in the value of A, and D, a signal for an increase in the value of C.

In the terminology of occasion setting, if the signal sets the occasion for a reduction in value for the S^+ , as is the case with $A^{50} B^0$, A^{100} training, the task is considered to be a feature-negative discrimination, and the occasion setter, B, should become relatively inhibitory (e.g., Holland & Coldwell, 1993). Furthermore, if the signal sets the occasion for an increase in value for the S^+ , as is the case with $C^{50} D^0$, C^0 training, the task is considered to be a feature-positive discrimination, and the occasion setter, D, should become relatively excitatory (e.g., Ross & Holland, 1981). According to this view of

occasion setting, when the pigeons are given a choice between B and D, D should be preferred.

EXPERIMENT 1

In Experiment 1, pigeons were trained with two simultaneous discriminations, $A^{50} B^0$ and $C^{50} D^0$, and two single-stimulus presentations, A^{100} and C^0 , on intermixed trials. The pigeons were then tested for their preference for B versus D. If B signals that the value of A has been reduced (relative to A alone) and D signals that the value of C has increased (relative to C alone), D should be preferred over B (see Ross & Holland, 1981). On the other hand, if the value that A can transfer to B depends on its overall value (i.e., the value that A acquired alone as well as the value that A acquired in the context of B), B should be preferred over D.

Method

Subjects

The subjects were 8 experimentally naive White Carneaux pigeons, 5–8 years old, maintained at 80% of their free-feeding weights. They were housed in individual cages in a room maintained on a 12:12-h light:dark cycle, and they had free access to water and grit.

Apparatus

The test chamber contained a pigeon compartment measuring 37 cm high, 34 cm across the response panel, and 30 cm from the response panel to the back wall. Mounted on the response panel were three rectangular pecking keys, each 3.2 cm wide and 2.2 cm high. The pecking keys were mounted side by side, 0.5 cm apart, with their bottom edges 24.0 cm above the wire mesh floor. Only the left and right response keys were used in this experiment.

Located behind each pecking key was a 12-stimulus, in-line projector with 28-V, 0.1-A lamps that projected four hues, red (R), yellow (Y), green (G), and blue (B) produced by Kodak Wratten filters Nos. 26, 9, 60, and 38a, respectively.

Midway between the bottom of the pecking keys and the floor was the opening to a rear-mounted grain feeder that provided reinforcement. Chamber illumination was provided by a 28-V, 0.1-A shielded house light located 5.0 cm above the center response key. The test chamber was connected to a computer in an adjacent room. A speaker mounted on the response panel provided white masking noise.

Procedure

Pretraining. The subjects were first trained to eat from the grain feeder. Following magazine training, the pigeons were shaped by the method of successive approximations to peck once at each lit key in order to obtain reinforcement. A single peck to the stimulus turned it off, and reinforcement was available for 2.5 sec. After a 10-sec intertrial interval (ITI), the next trial began. Each trial began with one of the four stimuli (R, Y, B, or G) presented randomly on either the left or the right response key. Each session consisted of 24 trials. Once pecking was established to all four stimuli on the left and right, the number of responses required for reinforcement was increased gradually to five (fixed ratio, FR, 5). Pretraining was complete when the subjects completed two 24-trial sessions with FR5, required to each stimulus.

Training. Discrimination training began the day after pretraining was completed. Each simultaneous discrimination trial began with the presentation of one pair of stimuli—one stimulus on the left key, the other on the right key. The first peck made to either stimulus turned off the other stimulus. The pigeon was then re-

quired to peck four more times to the chosen stimulus to end the trial. For the stimulus pair $A^{50} B^0$, five pecks to A led to reinforcement on a random 50% of the trials and then the 10-sec ITI, whereas five pecks to B led directly to the 10-sec ITI. The stimulus pair $C^{50} D^0$ was treated the same as was the $A^{50} B^0$ pair. Each single-stimulus trial began with the presentation of either A or C on either the left or the right response key. When A^{100} was presented, five pecks to it led to reinforcement on 100% of the trials and then the ITI. When C^0 was presented, it remained on for 6 sec, regardless of whether responses were made, and it was followed by the ITI. The four pre-training stimuli were divided into two pairs, R/Y and G/B. The stimulus pairs were selected to ensure that the most similar hues were adequately discriminated and to minimize the physical similarity between stimuli used as the test pair, BD. Assignment of the hues was such that, over subjects, each stimulus served equally often as A, B, C, and D (see Table 1). The four trial types A, C, AB, and CD occurred in random order. Each stimulus occurred equally often on the left and right. Each session consisted of 128 trials, 32 of each of the four trial types. As each subject reached a criterion of 90% correct on both of the simultaneous discriminations for two consecutive sessions, it was tested on the following day. The design of Experiment 1 is presented in Table 2.

Testing. Test trials involved presentation of B and D on the left and right. One peck to either stimulus terminated the other stimulus. Five pecks turned off the remaining stimulus and started the ITI. Reinforcement occurred on half of the trials regardless of choice. The test session consisted of 32 test trials randomly intermixed among 96 training trials.

Results and Discussion

The mean number of sessions to criterion was 7.0 ($SE = 0.98$). The mean number of sessions to acquire the AB discrimination ($2.5, SE = 0.53$) did not differ significantly from the mean number of sessions to acquire the CD discrimination [$3.5, SE = 2.70; t(7) = 1.06, p > .05$]. The acquisition data for Experiment 1 appear in Table 3. During the test session, the pigeons chose B over D on 90.4% ($SE = 2.93$) of the test trials (see Table 3). This preference differs significantly from chance [$t(7) = 13.76, p < .001$].

The results appear to support a value transfer account, because the mean value of the positive stimulus predicted the relative value of the negative stimulus with which it appeared in training. The results do not support a signaling account, according to which the negative stimulus should have signaled the relative change in value of the positive stimulus with which it appeared.

Table 1
The Counterbalancing Groups of Experiments 1–4

Subgroup	Training Stimuli (A, B, C, D)	Test Stimuli (B, D)
1	R, Y, G, B	Y, B
2	Y, R, B, G	R, G
3	G, B, R, Y	B, Y
4	B, G, Y, R	G, R
5	R, B, Y, G	B, G
6	B, R, G, Y	R, Y
7	Y, G, R, B	G, B
8	G, Y, B, R	Y, R

Note—R, red; Y, yellow; G, green; B, blue. Counterbalancing Groups 5–8 were used only in Experiment 4.

Table 2
The Design of Experiments 1–4

Experiment	Training	Testing
1	$A^{100}, A^{50} B^0, C^0, C^{50} D^0$	B D
2	$A^{100}, A^{50} B^0, C^{25}, C^{50} D^0$	B D
3	$A^{100}, A^{100} B^0, C^{25}, C^{100} D^0$	B D
4	$A^{100}, A^{25} B^0, C^{25}, C^{25} D^0$	B D

Note—Superscripts refer to probability of reinforcement associated with each of the stimuli. See Table 1 for counterbalancing.

Although the two simultaneous discriminations AB and CD were not acquired at significantly different rates, there were significantly more nonreinforced responses to D ($M = 63.8, SE = 14.85$) than to B ($M = 16.1, SE = 4.57$) in training [$t(7) = 3.31, p < .05$]. This difference can be attributed to the extinction of responding to presentation of C alone (C^0), which resulted in the temporary, relative avoidance of C presented in the context of D ($C^{50} D^0$). The relative avoidance of C in the presence of D meant that the proportion of nonreinforced responses to D was greater than to B, and if there were more nonreinforced responses to D than to B, a preference for B over D on test trials could have resulted (see Couvillon & Bitterman, 1992; Wynne, Fersen, & Staddon, 1992). In other words, because D was chosen more often than B in training, D may have acquired more inhibitory strength than B.

However, if the pigeons' choice of B over D occurred because nonreinforced responses to D were proportionately greater than to B, then a positive correlation should also exist between the number of choices of D relative to B in training and the preference for B over D in test. A Pearson's r correlation performed on these data, however, resulted in a negative correlation [$r(7) = -.75, p < .01$]. The negative correlation suggests that the more a pigeon chose D relative to B in training, the weaker was its choice of B in test. Thus, the difference in nonreinforced responses to B and D in training was apparently not responsible for the preference for B in test. The negative correlation may reflect initial stimulus preferences that persisted in test, but they cannot account for the overall preference for B over D, because each of the four stimulus hues served equally often as B and D. The absence of a positive correlation between responses to D in training and choice of B in test suggests that although there were differential histories of nonreinforcement to B and D in training, it is unlikely that these differences can account for the results of the experiment.

EXPERIMENT 2

Although differential nonreinforcement histories associated with B and D in training did not appear to be responsible for the preference for B over D in test, they do provide a potential confound. To address this issue, in Experiment 2, when C was presented alone, responses to it were reinforced on a random 25% of the trials. It was anticipated that the partial reinforcement of responses to C presented alone might have two effects. First, it might

Table 3
Acquisition and Test Data From Experiment 1

Pigeon	Training			Test % Choice of B
	No. of Choices		%D/Total	
	B	D		
1	5	22	82	91
2	6	107	95	88
3	23	37	62	100
4	5	56	92	75
5	38	48	56	100
6	16	99	86	94
7	6	14	70	91
8	30	127	81	84
<i>M</i>	16.1	63.8	78.0	90.4
<i>SE</i>	4.57	14.85	4.96	2.93

decrease the difference between responding to B and to D in training, because C should not be avoided in training. But second, it might also decrease the effect of single-stimulus presentations of C on the value of D, because the difference in reinforcement probability between C²⁵ presented alone and C⁵⁰ presented with D should be reduced. Thus, it was anticipated that the preference for B over D might be somewhat reduced in Experiment 2, relative to that found in Experiment 1.

Method

Subjects

The subjects were 8 experimentally naive White Carneaux pigeons similar to those used in Experiment 1.

Apparatus

The operant chamber and stimuli were the same as those used in Experiment 1.

Procedure

Pretraining. The pretraining phase was identical to that of Experiment 1.

Training. The training phase was similar to that of Experiment 1, except that when the C stimulus was presented alone, the pigeon was required to respond to it on an FR5 schedule and reinforcement was provided for responding to C on a random 25% of the trials. The design of Experiment 2 is presented in Table 2.

Testing. The single test session was the same as in Experiment 1.

Results and Discussion

The mean number of sessions to criterion during training was 4.25 ($SE = 0.31$). Again, the mean number of sessions to acquire the AB discrimination (2.5, $SE = 0.27$) did not differ significantly from the mean number of sessions to acquire the CD discrimination [2.9, $SE = 0.35$; $t(7) = 0.75$, $p > .05$]. Once again, the numbers of nonreinforced responses to B and to D in training were compared. The number of nonreinforced responses to D was greatly reduced in Experiment 2 and, in contrast to the results of Experiment 1, there were not significantly more nonreinforced responses to D (27.0, $SE = 3.99$) than to B [18.3, $SE = 2.46$; $t(7) = 1.75$, $p > .05$]. Thus, allowing reinforced responses to C presented alone facil-

itated acquisition of the CD discrimination and reduced the number of nonreinforced responses to D. The acquisition data for Experiment 2 appear in Table 4.

During the test session, the pigeons chose B over D 79.9% ($SE = 7.37$) of the test trials (see Table 4). Although the preference for B over D was somewhat reduced in Experiment 2, it still differed significantly from chance [$t(7) = 4.05$, $p < .01$]. Again, the value transfer account was supported.

Furthermore, similarly to the results of Experiment 1, a Pearson's r correlation performed on the data showed that the choice of B on test trials was negatively correlated with the proportion of nonreinforced responses to D [$r(7) = -.57$], although in Experiment 2 the correlation was not significant. Thus, if pigeons tended to choose D more than B in training, they tended to choose B less in test. Therefore, once again, the choice of B over D in test could not be attributed to possible differences in the history of nonreinforcement in training.

EXPERIMENT 3

In Experiments 1 and 2, the values of both A and C presented alone differed from their values when they were presented in a simultaneous discrimination. Thus, single-stimulus presentations of A¹⁰⁰ might have increased the value that transferred from A to B and single-stimulus presentations of C⁰ might have decreased the value that transferred from C to D.

The purpose of Experiment 3 was to try to separate these two effects. Would a change in the single-stimulus value of C (relative to its value in the context of D) but not in the single-stimulus value of A (relative to its value in the context of B) be sufficient to produce a preference for B over D on test trials? To answer this question, in Experiment 3, the probability of reinforcement associated with reinforced responding to C continued to depend on whether D was present, or not, as it did in Experiments 1 and 2 (i.e., C²⁵, C¹⁰⁰ D⁰); however, the value of A by itself was the same as when it was presented in the simultaneous discrimination with B (i.e., A¹⁰⁰, A¹⁰⁰ B⁰). Thus, in Experiment 3, D could still serve as a

Table 4
Acquisition and Test Data From Experiment 2

Pigeon	Training			Test % Choice of B
	No. of Choices		%D/Total	
	B	D		
1	19	19	50	91
2	11	20	65	91
3	16	36	69	41
4	10	47	82	56
5	28	19	40	75
6	22	24	52	97
7	27	36	57	94
8	13	15	54	94
<i>M</i>	18.2	27.0	58.6	79.9
<i>SE</i>	2.46	3.99	4.60	7.37

signal for the increased value of C, whereas B was no longer associated with a decrease in the value of A. According to value transfer theory, the net value of A should still be greater than the net value of C. For this reason, A should still transfer more value to B than C should transfer to D, and B should be preferred over D on test trials.

Method

Subjects

Eight experimentally naive pigeons similar to those from Experiments 1 and 2 served as subjects.

Apparatus

The operant chamber and stimuli were the same as in Experiments 1 and 2.

Procedure

Pretraining. The pretraining phase was identical to that of Experiments 1 and 2.

Training. The training phase was similar to that of Experiments 1 and 2, except for the reinforcement probabilities associated with A and C in the context of the simultaneous discriminations. For the stimulus pair $A^{100}B^0$, responding to A led to reinforcement on 100% of the trials, whereas responding to B led only to the 10-sec ITI. For the stimulus pair $C^{100}D^0$, responding to C led to reinforcement on 100% of the trials, whereas responding to D led only to the ITI. Each single-stimulus trial began with the presentation of either the A or the C stimulus on either the left or the right response keys, and when A^{100} was presented, responding led to reinforcement on 100% of the trials, whereas when C^{25} was presented, responding led to reinforcement on a random 25% of the trials. The design of Experiment 3 is presented in Table 2.

Testing. The single test session was the same as in Experiments 1 and 2.

Results and Discussion

The mean number of sessions to reach criterion in training was 5.6 ($SE = 0.57$). The mean number of sessions to acquire the AB discrimination (3.4, $SE = 0.50$) did not differ significantly from the mean number of sessions to acquire the CD discrimination [3.0, $SE = 4.2$; $t(7) = 0.57$, $p > .05$]. Once again, analysis of the training data indicated that there were not significantly more nonreinforced responses to D (22.4, $SE = 3.70$) than to B [25.8, $SE = 6.68$; $t(7) = 0.08$, $p > .05$]. The training data from Experiment 3 appear in Table 5.

During the test session, the pigeons chose B over D 68.9% ($SE = 13.31$) of the test trials (see Table 5). Although the mean choice of B over D was only somewhat less than it was in Experiment 2, because of particularly high variability in these scores, this preference was not statistically significantly different from chance [$t(7) = 1.42$, $p > .05$]. Although the preference for B over D did not reach statistical significance in Experiment 3, the present results are not significantly different from those found in Experiments 1 and 2 [$t(14) = 1.58$ and 0.72 , respectively, both $ps > .05$], and they clearly do not support predictions based on the signaling of relative value. Once again there was a negative correlation between the proportion of responses to D in training and preference for B in test [$r(7) = -.60$, $p < .05$].

Table 5
Acquisition and Test Data From Experiment 3

Pigeon	Training			Test % Choice of B
	No. of Choices		%D/Total	
	B	D		
1	9	27	75	9
2	14	31	68	94
3	14	20	59	97
4	7	25	76	22
5	19	16	46	94
6	56	40	44	44
7	43	10	19	100
8	44	10	18	91
<i>M</i>	25.8	22.4	50.5	68.9
<i>SE</i>	6.68	3.70	8.17	13.31

EXPERIMENT 4

In Experiment 3, although B did not signal a decrease in the probability of reinforcement to A (relative to the probability of reinforcement to A when it was presented alone), D did signal an increase in the probability of reinforcement to C. The purpose of Experiment 4 was to ask whether similar results would be obtained if B could serve as a signal for a decrease in the probability of reinforcement to A, whereas D could not serve as a signal for an increase in the probability of reinforcement to C.

A secondary purpose of Experiment 4 was to rule out the possibility that stimulus generalization (i.e., the similarity in hue between the S^+ and the S^-) might account for the transfer of value from the S^+ to the S^- . In Experiment 4, half of the pigeons were trained with discriminations involving the same hue pairs that were used in Experiments 1–3, R/Y and G/B. The remaining pigeons were trained with discriminations involving different hue pairs, R/B and Y/G (see Table 1).

Method

Subjects

Sixteen experimentally naive pigeons similar to those from Experiments 1–3 served as subjects.

Apparatus

The operant chamber and stimuli were those used in Experiments 1–3.

Procedure

Pretraining. The pretraining phase was identical to that of the first three experiments.

Training. The training phase was similar to that of Experiment 3, except that responding to both A and C in the context of simultaneous discriminations was reinforced on a random 25% of the trials, as was responding to C presented alone, whereas responding to A was reinforced on 100% of the trials with A presented alone. Furthermore, half of the pigeons were trained with discriminations involving R/Y and G/B stimulus pairs (Group R/Y), whereas the remaining pigeons were trained with discriminations involving R/B and Y/G stimulus pairs (Group R/B). As in the previous experiments, each stimulus served equally often as A, B, C, and D. The design of Experiment 4 is presented in Table 2.

Testing. The test phase was identical to that of Experiments 1–3.

Results and Discussion

The mean number of sessions to criterion during training was 5.6 ($SE = 0.50$). The mean number of sessions to acquire the AB discrimination (2.8, $SE = 0.31$) was significantly less than the mean number of sessions to acquire the CD discrimination [4.2, $SE = 0.32$; $t(15) = 3.50$, $p < .01$]. The training data from Experiment 4 appear in Table 6.

During the test session, pigeons chose B over D on 87.1% ($SE = 5.49$) of the test trials (see Table 6). This preference for B was significantly different from chance [$t(15) = 6.79$, $p < .001$]. Thus, once again, the results support the value transfer hypothesis. Furthermore, the preference for B over D was no less for Group R/B than for Group R/Y. When the counterbalancing subgroups were considered separately, the preference for B over D was significant for Group R/Y [77.2%, $SE = 9.81$; $t(7) = 2.78$, $p < .05$], and it was actually greater for Group R/B [96.8%, $SE = 2.00$; $t(7) = 23.50$, $p < .001$]. Thus, stimulus generalization cannot account for the effects found in Experiments 1–3.

Analysis of the number of nonreinforced responses to B and D in training indicated that although there were significantly more responses to D ($M = 52.9$, $SE = 4.66$) than to B [$M = 20.3$, $SE = 3.22$; $t(7) = 6.09$, $p < .001$], once again, the relative number of nonreinforced responses to D in training was not significantly correlated with the preference for B in test ($r = .25$).

Table 6
Acquisition and Test Data From Experiment 4

Pigeon	Training			Test
	No. of Choices		%D/Total	
	B	D		
% Choice of B				
Group R/Y				
1	32	75	70	97
2	22	58	73	84
3	20	69	78	56
4	23	60	72	22
5	24	56	70	100
6	55	27	33	65
7	27	52	66	97
8	29	40	58	97
<i>M</i>	29.0	54.6	65.0	77.2
<i>SE</i>	3.96	5.42	5.01	9.81
Group R/B				
9	10	38	79	100
10	9	39	81	100
11	5	52	91	84
12	3	27	90	100
13	28	95	77	94
14	14	74	84	100
15	11	42	79	100
16	13	42	76	97
<i>M</i>	11.6	51.1	82.1	96.9
<i>SE</i>	2.69	7.92	2.02	2.00
Grand <i>M</i>	20.3	52.9	73.6	87.1
<i>SE</i>	3.22	4.66	3.42	5.49

GENERAL DISCUSSION

The results from the present experiments, which were obtained under a variety of training conditions, offer further support for value transfer theory. The results demonstrate that when stimuli are presented in the context of a simultaneous discrimination, the value transferred from the positive stimulus to the negative stimulus depends not only on the value of the S^+ in the context of the S^- , but also on the value of the S^+ on other trials (e.g., when it is presented alone). In all four experiments, when the value of the S^+ s in the two simultaneous discriminations was held constant, it was the value of the S^+ s obtained *outside* of the simultaneous discrimination context that determined the value that transferred to the S^- s. Furthermore, the results of all four experiments were consistent in offering no support for the occasion setting or signaling hypothesis.

According to the signaling hypothesis, the value of the S^- should depend on the degree to which the S^- signals that the S^+ has more or less value than in the absence of the S^+ . In the context of the present designs, this means that D should signal that C has more value than in its absence (Experiment 3), or that B should signal that A has less value than in its absence (Experiment 4), or that both effects should occur (Experiments 1 and 2). Thus, D should have been preferred over B in all four experiments. But clearly it was not.

The present results also suggest that the association between the S^- and its S^+ does not depend on the fact that they are always presented together (i.e., within-event conditioning), because presentations of the S^+ by itself (as often as with the S^-) do not appear to substantially reduce the degree to which the S^+ can transfer value to the S^- .

Zentall et al. (1996) found results consistent with the notion that when stimuli are presented in a simultaneous discrimination, a bidirectional association develops between the two stimuli, such that when the value of one of the stimuli (either the S^+ or the S^-) is then increased or decreased, the value of the other stimulus also increases or decreases accordingly. They argued that within-event associations developed during training, and apparently, experience with either discriminative stimulus in the context of a new discrimination did not weaken those within-event associations sufficiently to prevent the newly acquired value from transferring to the other stimulus from the original discrimination. Similarly, in the present experiments, the single stimulus presentations of the S^+ s were not sufficient to substantially weaken those within-event associations.

Interestingly, Dorrance and Zentall (1998) found that following training on two simultaneous discriminations, if the value of only one of the S^+ s was altered, not only was there transfer of the new value of the S^+ to the S^- , but also the within-event association between the S^+ and S^- appeared to be weakened. However, the results of Zentall et al. (1996) and of the present experiments suggest that by presenting both S^+ s by themselves (or, in the case of Zentall et al., 1996, together) outside of the simultaneous

discrimination context, the hypothesized weakening of within-event associations would be equated, and the only differential effects remaining would result from value transfer.

The idea that value can be acquired by an S^- merely by its simultaneous presentation with an S^+ has now received much empirical support. However, the mechanism responsible for the transfer of value from the S^+ to the S^- is not well understood. Zentall et al. (1996) suggest that direct, S^- -US (trace) conditioning could not be responsible for value transfer because it cannot account for the fact that altering the value of the S^+ by itself, following S^+S^- discrimination training, has a corresponding effect on S^- . Furthermore, their finding that altering the value of the S^- by itself following S^+S^- discrimination training had a corresponding effect on S^+ suggests that higher order conditioning is not the defining mechanism. If it were, one would expect that the S^- might benefit from the presence of the S^+ , but one would not expect the S^+ to benefit from the presence of the S^- .

Instead, Zentall et al. (1996) proposed that within-event conditioning might be involved in value transfer. However, within-event conditioning is not consistent with the results of the present experiments. In the present experiments there were equal numbers of presentation of the S^+S^- discrimination and of S^+ alone, and such procedures should not be conducive to within-event conditioning. Thus, although attempts have been made to explain value transfer in Pavlovian terms, the phenomenon does not seem to be easily explained by any single Pavlovian or instrumental mechanism.

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