

Notes and Comment

Alternative accounts are preferable to value transfer theory: Commentary on Dorrance, Kaiser, and Zentall (1998)

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Dorrance, Kaiser, and Zentall (1998) trained pigeons on two concurrent simultaneous discriminations (A+B-; C+D-), with interspersed single-stimulus trials in which responding to the two positive discriminanda was differentially reinforced (A+; C±). In each of four separate experiments, the birds showed a preference for stimulus B over stimulus D. Dorrance et al. concluded that the results of these experiments were best described in terms of value transfer theory (VTT; Fersen, Wynne, Delius, & Staddon, 1991). They reject the possibility that the results of these experiments might have been caused by differential nonreinforced experience with the test stimuli (B and D) on the basis of correlational analyses within each experiment. However, differences between experiments in choice of B over D are well predicted by differences in their history of reinforcement. Previous findings that were thought to favor VTT are also entirely consistent with a simpler associative analysis.

Dorrance, Kaiser, and Zentall (1998) have reported a series of experiments on simultaneous discrimination learning by pigeons in which the value of the positive discriminative stimulus (S+) was varied outside the context of the simultaneous discrimination. Following concurrent training on two such discriminations, the relative value of the two S- stimuli was assessed by means of a choice procedure. In all four experiments, an S- trained in a discrimination with an S+ of higher value was preferred. A simplified version of the design, denoted Design 1, is shown in Table 1. Each of two pairs of stimuli (A-B and C-D) is presented on a series of simultaneous discrimination trials, with choice responses to A or C reinforced, and choice responses to B or D, nonreinforced. Interspersed with these trials are single-stimulus trials on which stimulus A or C is presented alone, with responding to stimulus A reinforced with a greater probability than that for responding to stimulus C. Following this training, the pigeons were presented with a choice between B and D.

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In each of the four experiments, the pigeons showed a preference for stimulus B. Dorrance et al. (1998) interpret these results in terms of value transfer theory (VTT), in which it is assumed that some of the value of the S+ in a simultaneous discrimination transfers to the S-. Thus, according to VTT, choice responding would be more likely to B than to D in the simplified design shown in Table 1, because more value would transfer to B from A, which is reinforced during the single-stimulus trials, than would transfer from C to D. The authors compare this account with an occasion setting account, which fails, as the authors note, to predict the observed preferences in any of the four experiments.

Value transfer is not the only mechanism that can account for these data, however. The greater reinforcement of stimulus A over stimulus C on the interspersed trials would presumably cause the two simultaneous discriminations in Design 1 to differ in difficulty. As a result, more errors would be observed on C-D trials than on A-B trials, possibly leading to a greater degree of inhibitory control accruing to stimulus D. Such a difference was clear in Dorrance et al.'s (1998) Experiments 1, 2, and 4, and it was precisely these experiments that revealed the greatest preference of B over D. Dorrance et al. seek to discount this simple mechanism, based on the different reinforcement history of stimuli B and D, by means of a simple, yet problematic, analysis. They report a negative correlation in three out of the four experiments (Experiments 1, 2, and 3) between two measures: the proportion of nonreinforced responses to B and D that were to D during training (%D choice), and the proportion of test responses on B-D trials that were to B (%B choice). They argue that this contradicts the simpler account: If the preference for B over D depended on the birds' having made more nonreinforced responses to D, one would expect a positive correlation between these two measures.

This argument, however, is not valid, owing to the factors that cause %D choice to vary between subjects. The differential reinforcement account clearly predicts a positive correlation between relative nonreinforced experience on training (%D choice) and preference on test (%B choice) if %D choice is varied independently of other factors, because more differential nonreinforced exposure will produce a greater preference for stimulus B. A positive correlation is not predicted as a result of variation between subjects within these procedures, however, because %D choice does not vary independently of other factors. Rather, each animal's individual characteristics will determine the amount of nonreinforced exposure that it receives to B and D during training.

The reason for this can be expressed most easily in terms of an analogy: The number of lessons that a stu-

Table 1
Simplified Representation of Designs
Used to Test Value Transfer Theory

Design	Concurrent/ Pretraining	Discrimination	Test	Preference
1	A++ C±	A+B- C+D-	B vs. D	B
2	-	A+B- C±D-	B vs. D	B
3	A+C- B+C- /E+C-	A+B- C+D-	B vs. D	B

Note—Relative reinforcement probability to each stimulus within each design is denoted by the + and - symbols, with - indicating nonreinforcement or the lowest reinforcement probability, and ±, +, and ++ representing progressively increasing reinforcement probability.

dent driver requires before taking the test for a driver's license would not be predicted to show a positive correlation with test performance. An experiment to determine whether driving tuition was effective would presumably involve giving subjects in different conditions differing amounts of training, and assignment of subjects to training conditions would be randomized. In such a procedure, a positive correlation between number of lessons and test performance would be predicted. However, if the number of lessons were not experimentally manipulated, the drivers who were nervous, or poorly skilled, would undertake more lessons before attempting a driving test, and they could quite conceivably be more likely to fail *in spite of their greater training*. This would result in either no correlation (if all drivers were trained to an equivalent skill level), or a negative correlation (if poor or nervous drivers were more likely to fail, even after more lessons).

Analogous arguments can be applied to the procedures used by Dorrance et al. (1998). All birds within these experiments were trained to a 90% correct criterion on the two discriminations: Thus the animals in each experiment who got most differential training were those that needed it most to learn to the criterion; as such they would not show enhanced preference as a result of this training. Thus the differential reinforcement account cannot be rejected on the basis of the observed negative correlations across subjects. In common with VTT, the differential reinforcement account does not necessarily predict a negative correlation between individual subjects' %D choice in training and their %B choice in test, yet there are several reasons why one might expect one.

The first possibility is based on the simple idea that "good" discriminators tend to perform well on both measures of discrimination: It is reasonable to suggest that good discriminators make only slightly more errors when learning the more difficult C+D- [C-] discrimination than they do when learning the easier A+B- [A+] discrimination in a procedure of the type shown as Design 1 in Table 1. Good discriminators will thus produce relatively low %D choices for a given schedule, yet these animals will discriminate well on the basis of any difference in associative history, producing relatively high %B choices. The reverse pattern, of poor performance on the difficult discrimination giving a high %D choice and lit-

tle discrimination on the basis of this experience lowering a %B choice, is also possible.

A very similar argument can be based on differences in rates of learning: Animals that produce many more unreinforced responses to D than to B are those that learn the more difficult discrimination slowly. Because the animals that experience a higher %D choice during training are those that are slower to learn, this increased exposure should not result in an increase in preference for B.

As Dorrance et al. (1998) acknowledge, the simplest explanation for the negative correlation is one, however, in terms of differences in stimulus preference: An initial high preference for the stimulus used as B will decrease %D choice (because the animal will respond more to B during training) and increase %B choice (because the animal will respond more to B during test). Similarly, a high preference for stimulus D would have the reverse effect of increasing %D choice and decreasing %B choice.

The differential reinforcement account cannot be disregarded on the basis of Dorrance et al.'s (1998) finding of a negative correlation between %D choice during training and %B choice on test within each procedure. However, the prediction of a positive correlation between these two measures across procedures would be the key test of such an account. Do the procedures, rather than the subjects, that produce a greater difference in error rates during training produce greater preferences during test?

The experiments reported by Dorrance et al. (1998) allow just such an analysis to be performed. Four experiments were conducted in which the only systematic variation between them consisted in the reinforcement probabilities to each of the four stimuli. Figure 1 shows the test preference for B over D reported in each of the four experiments (%B choice) plotted against the proportion of incorrect responses made during simultaneous discrimination training that were to stimulus D (%D choice). In accord with the differential reinforcement account of the data, a clear linear trend is revealed, with the reinforcement history of stimuli B and D an excellent predictor of test preference. A simple linear regression analysis, in which the two groups of Experiment 4 (R|Y and R|G) were included as independent data points, revealed a significant correlation [$r = .96; F(1,3) = 37.25, p < .01$]. It is clear that these data do not favor VTT: A simpler mechanism based solely on reinforcement of each stimulus provides a full account of the development of such a preference and correctly predicts the observed pattern of preference across procedures.

VTT was originally proposed as an account of pigeons' performance on a pseudo transitive-inference problem (Fersen, Wynne, Delius, & Staddon, 1991); there too the past history of reinforcement and nonreinforcement associated with each stimulus in the series is sufficient to account for pigeons' choices on test (Wynne, 1995). Zentall and his colleagues have used two other experimental designs to provide evidence for VTT. They are schematically represented as Designs 2 and 3 in Table 1. In both cases, a preference for B over D on test is attributed to B's acquiring

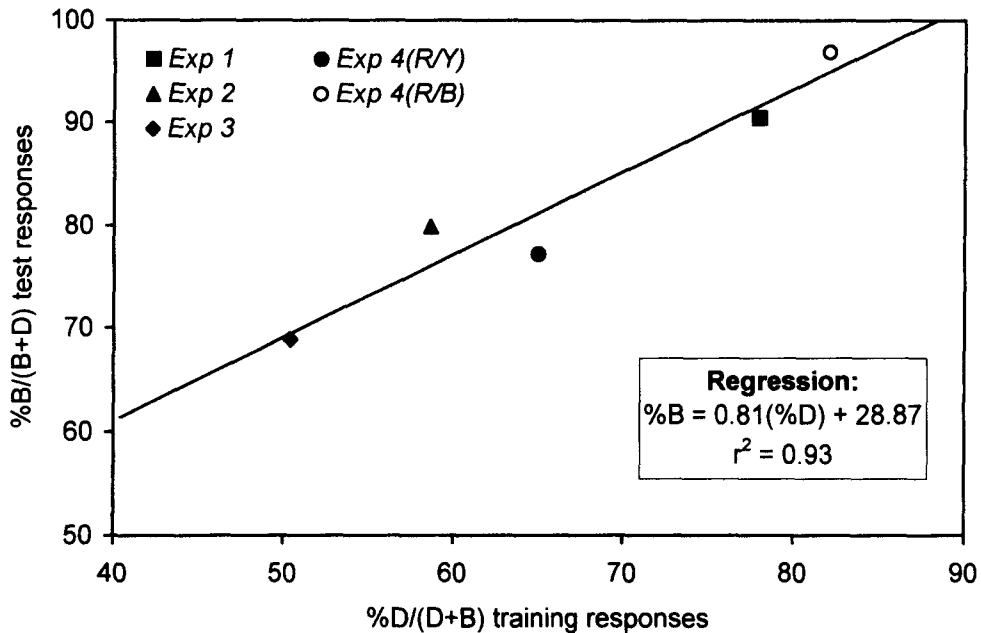


Figure 1. Preference for test stimulus B over D during test (%B) as a function of the relative nonreinforced choices to D during training (%D) in the four experiments as reported by Dorrance, Kaiser, and Zentall (1998). The two groups of Experiment 4 are presented separately, so that each point is the mean of the data from 8 subjects. The linear regression line of predicted test preference from relative nonreinforced training choices is shown.

greater value through its association with A than D acquires through its association with C. Design 2 is very similar to the Design 1 employed by Dorrance et al. (1998), except that C is partially reinforced, and A is consistently reinforced within the context of the A–B and C–D discrimination (Clement, Weaver, Sherburne, & Zentall, 1998, Experiment 2; Zentall & Sherburne, 1994; Zentall, Sherburne, Roper, & Kraemer, 1996; Zentall, Weaver, & Sherburne, 1996). In Design 3, A is consistently reinforced, whereas discrimination training is given prior to the C–D trials in which C is consistently nonreinforced (Steirn, Weaver, & Zentall, 1995). To the extent that these designs ensure that C has less value than A, they must equally ensure that the C–D discrimination will be learned more slowly than the A–B discrimination, thus ensuring that birds received more nonreinforcement for response to D than to B. In each case, the differential reinforcement account is rejected by recourse to the argument that, across subjects, there is a negative correlation between the degree to which D received greater responding during training and the preference for B on test. As I have shown, such a correlation is not appropriate when used across subjects within a procedure: The predicted positive correlation is revealed by the between-procedures analysis of Dorrance et al.'s data shown in Figure 1.

A common finding following training a wide variety of schedules involving either simultaneous or sequential presentation of stimulus pairs is that of perceptual differentiation (e.g., Aitken, Bennett, McLaren, & Mackintosh, 1996; see Hall, 1991, for a review)—that is, reduced generalization between the stimuli. Given that VTT pro-

poses that excitatory associative strength generalizes from the S+ to the S– more as a consequence of exposure, it is in direct contradiction with this principle. Attempts to find evidence for a negative transfer, in which some of the inhibitory or “negative” value of the S– transfers to the S+, using similar procedures have generally been unsuccessful: For example, no preference for C over A is observed following training on concurrent simultaneous discriminations of the type A+B– | C+D± (Clement et al., 1998, Experiment 2). If the preference of B over D revealed in these designs does not, as has previously been stated, require positive transfer of value from the S+ to the S–, other evidence must be found for VTT if it is not to be rejected in favor of the simpler account which also concords with perceptual differentiation results.

There are indeed two further observations apparently consistent with VTT. First, the analysis presented in Figure 1 of the Dorrance et al. (1998) procedures suggests that reinforcement history does not give a complete account of the preference for B over D: The regression line predicts a residual preference even when there are equivalent levels of nonreinforced responding to B and D during training. Second, there is some evidence that postdiscrimination manipulation of the values of S+ or S– may influence the value of the stimulus with which it was paired (Zentall, Sherburne, et al., 1996, Experiments 1 and 3). Value transfer predicts these preferences by appeal to an associative link between S+ and S– of each simultaneous discrimination. However, the experimental designs employed by Zentall and his colleagues allow a much simpler explanation: There was greater primary stimulus generalization between

the S⁺ and S⁻ of each discrimination problem than there was between the stimuli of different problems.

With one exception (Dorrance et al., 1998, Experiment 4: R/B), the stimuli used in all studies discussed above were consistently paired red–yellow and blue–green (Clement et al., 1998, Experiment 2; Steirn et al., 1995; Zentall & Sherburne, 1994, Experiment 2; Zentall, Sherburne, et al., 1996a; Zentall, Weaver, & Sherburne, 1996), other than the first experiment of Zentall and Sherburne's (1994) study, in which red–green and dot–circle pairings were used.¹ Although each stimulus was used equally frequently in each of the four roles (A, B, C, or D), the critical issue is whether generalization *within* each pair is greater than that *between* the pairs. Given the general spectral ordering, R→Y→G→B with increasing frequency, it seems reasonable to expect greater generalization between R and Y and between B and G than between R and G, B and Y, R and B, and possibly between Y and G (see Zentall & Edwards, 1984). Indeed, the R–Y and G–B pairs are excluded as test pairs (A–C or B–D) precisely because they are “stimuli that might be treated as similar without explicit training to discriminate between them” (Clement et al., 1998, p. 367). There will certainly have been greater generalization from R to G and from dot to circle, than from either color to either shape.

Because generalization within each S+S⁻ pairing would be greater than generalization between pairs A–D and C–B *before* simultaneous discrimination training, both of the observations thought to be consistent with VTT could be due to simple, nonacquired generalization: The residual value transfer in the absence of differential reinforcement, predicted by the regression analysis in Figure 1, and also the results of Zentall, Sherburne, et al.'s (1996) study. Stimulus B will receive more generalized excitation, or transfer more positive value, from stimulus A than it does from stimulus C because it is more similar to A than to C. Likewise, stimulus D will receive more generalized excitation from stimulus C than from stimulus A. This transfer is a consequence of the stimulus pairings used, not of their having been paired in a simultaneous discrimination.

This possibility is considered twice by Zentall and his colleagues: Zentall and Sherburne (1994) explicitly discount simple generalization within the R–Y and B–G pairs as a complete explanation for the observed preference for B over D (in a procedure schematically represented as Design 2 in Table 1) by consideration of the magnitude of preference in the different counterbalancing conditions; likewise, Dorrance et al. (1998) found a higher preference for B in one group of Experiment 4 (R/B), which were given less similar colors as discriminanda pairs, than in the second group (R/Y). However, these differences in preference can be explained by the differential reinforcement hypothesis: The different conditions influence the relative difficulty of the A versus B and C versus D discriminations and therefore the reinforcement histories of stimuli B and D. Although there is presumably less nonacquired generalization between stimuli A and B in Group R/B than in Group R/Y in Dorrance et al.'s Exper-

iment 4, a greater preference for B over D in the former group is predicted by the %D choice scores (see Figure 1).

The additional consideration of within-pair generalization predicts that an enhancement in preference for B over D, over and above that predicted by differences in reinforcement history, would be observed if A had a higher value than C. Thus the differential reinforcement hypothesis is entirely consistent with the findings of Zentall, Sherburne, et al. (1996), and with the possibility of residual value transfer in the regression analysis above, if nonacquired generalization between stimulus pairs is taken into account.

Given that other investigations of the acquired changes in similarity during discriminative exposure to a pair of stimuli reveal enhanced perceptual differentiation—that is, reduced generalization between these stimuli—and given the adequacy of preexisting theories of discrimination learning to account for the data described above, it seems that there is as yet no reason to accept the acquired enhancement of generalization between the S⁺ and S⁻ in a simultaneous discrimination proposed by VTT.

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NOTE

1. The color stimuli were keylights illuminated by color-filtered light; the dot and circle stimuli were a small white dot, or circle, presented on the keylight respectively.