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Within-trial contrast: The effect of probability of reinforcement in training☆

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ABSTRACT

There is evidence that pigeons prefer conditioned reinforcers that are preceded by greater effort over those that are preceded by less effort (an effect that has been attributed to within-trial contrast). In past research the probability of reinforcement for correct choice of the conditioned reinforcer has been 100%, however, the high level of reinforcement for both alternatives in training may result in a performance ceiling when choice between those alternatives is provided on test trials. In the present study we tested this hypothesis by including a group for which the probability of reinforcement in training was only 50%. Pigeons were trained on two simultaneous discriminations, one that was preceded by a 30 peck requirement the other by a single peck requirement. On test trials, we found a significant preference for the S+ that required the greater effort in training for pigeons trained with 100% and a small but nonsignificant effect for pigeons trained with 50% reinforcement. Although the hypothesis that the within-trial contrast effect was constrained by a performance ceiling was not confirmed, we did find a reliable within-trial contrast effect with 100% reinforcement.

Within-trial contrast is a phenomenon reported by Clement et al. (2000) in which pigeons were trained on two simultaneous discriminations, each involving a pair of colors (e.g., red S+, yellow S− and green S+, blue S−). On half of the trials, pigeons had to peck a circle stimulus once, to obtain, for example, the red/yellow discrimination. On the remaining trials, they had to peck the circle 20 times to obtain the green/blue discrimination. On test trials, when the pigeons were given a choice between the two positive stimuli, they showed a significant preference for the stimulus that required 20 pecks to obtain. Clement et al. proposed that this counterintuitive effect resulted from contrast between the effort that preceded the discrimination and the conditioned reinforcement associated with the discrimination. That is, the value of the reinforcer (or the stimulus that predicted it) was greater when it was preceded by a less preferred event (see Zentall and Singer, 2007).

The results of several studies have shown not only that the effect can be replicated in pigeons (Clement and Zentall, 2002; Friedrich and Zentall, 2004), starlings (Kacelnik and Marsh, 2002 and humans (Alessandri et al., 2008a,b; Klein et al., 2005) but also that other less preferred events that precede a discrimination can produce a preference for the S+ stimulus that follows. For example, DiGian et al. (2004) found that a delay that preceded a discrimination increased the preference for the S+ stimulus that followed and Friedrich et al. (2005) found that when the absence of food preceded a discrimination it increased the preference for the S+ stimulus that followed (when on other trials a discrimination was preceded by the presentation of food). Similarly, Alessandri et al. (2008b) found that when the initial event required greater force to obtain the discrimination it increased the preference for the S+ stimulus that followed.

However, several studies have reported a failure to replicate the original finding with pigeons and the results of these studies may identify constraints on the effect. For example, Vasconcelos et al. (2007) presented the results of six experiments that failed to replicate the within-trial contrast effect. In each of these experiments the pigeons were given 20 sessions of training following the acquisition of the simultaneous discriminations. Although 20 session of overtraining is often enough to produce the effect (Clement et al., 2000; Clement and Zentall, 2002; DiGian et al., 2004; Friedrich et al., 2005), other research suggests that 20 sessions of overtraining is often insufficient (Friedrich and Zentall, 2004; Singer et al., 2007) and 30–60 sessions of overtraining may be needed.

But the amount overtraining does not appear to be the only important variable because other studies that included more extensive training have also failed to find significant within-trial contrast (Arantes and Grace, 2008, experiment 2; Vasconcelos and Urcuioli, 2008a). Arantes and Grace reported that although they failed to find a within-trial contrast effect, their overtrained pigeons had served as subjects in earlier research and although they do not provide details about the prior experience, it is quite likely that the schedules of reinforcement that they experienced were leaner that those experienced in the experiment reported. If so, it may be that prior

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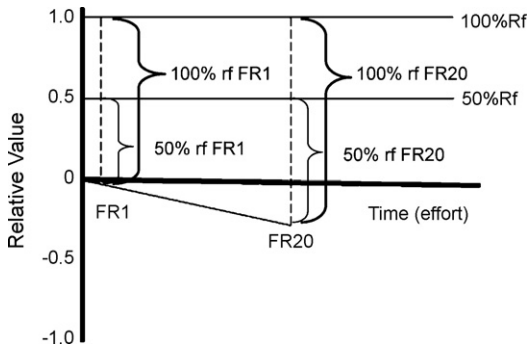

Fig. 1. A model of within-trial contrast. The value of reinforcement depends on the change in value between the negative state caused by pecking and the absolute value of reinforcement. Choice will depend on whichever change in value is larger.

experience with lean schedules of reinforcement reduces the contrast that can be found between the 20 peck requirement and the simultaneous discrimination (Zentall, 2008).

In the case of Vasconcelos and Urcuioli (2008a), five pigeons were trained for 60 sessions on a task similar to that used by Clement et al. (2000) and were similarly tested. Although these pigeons chose the S+ that in training had followed the high effort (30 peck) requirement more than 60% of the time on the first test session, it was not significantly different from chance. But this level was not substantially lower than that reported by Clement et al. (69.2%) and their failure to find a significant effect may be attributable to low power. More recently, Vasconcelos and Urcuioli (2009) attempted to obtain a within-trial contrast effect with experimentally naïve pigeon which were provided with 60 sessions of overtraining. But they too failed to replicate the within-trial contrast effect. However, Vasconcelos and Urcuioli gave their pigeons extensive pretraining (12 sessions) to work up to the 30 peck requirement. It may be that the gradual increase in response requirement reduced the aversiveness of the 30 peck requirement sufficiently to obscure the contrast effect.

Given the apparent variability in the magnitude of the within-trial contrast effect reported, it would be useful to replicate the within-trial contrast effect using a differential response requirement in the initial link and to identify variables that might enhance or diminish the effect. One variable that could affect the magnitude of within-trial contrast is the percentage of reinforcement associated with choice of the S+ stimulus in the simultaneous discrimination. In the Clement et al. (2000) experiment, preference was found not only for the S+ stimulus but also for the S− stimulus that followed the greater effort. Furthermore, the S− effect was larger than the S+ effect. Clement et al. suggested that the S+ preference may have been constrained by a ceiling effect. Given that both S+ stimuli were strongly associated with reinforcement, it is possible that the difference in value between them was reduced by their high absolute value. Such an effect could be produced either by the reduced discriminability between their two values or by the fact that because both had high value, the pigeons tended to respond to the first one that they saw. The hypothesis that the reduced choice of the S+ associated with higher effort resulted from a ceiling effect raises the possibility that a larger within-trial contrast effect might be seen if the probability of reinforcement for choice of the S+ stimulus in training were lowered to 50%.

Another mechanism by which 50% reinforcement could produce a larger effect than 100% reinforcement is presented in Fig. 1. If choice of the S+ stimulus depends on the relative change in value that occurs at the time of reinforcement (or the appearance of the S+ associated with reinforcement) then reducing the value of both stimuli through partial reinforcement could actually increase the relative difference in value between them. To get some sense for how this might occur, imagine for example, that the value of 100% reinforcement is 1.0, the value of 50% reinforcement is 0.5, the value of 1 peck is 0, and the value of 20 pecks is −0.25. With 100% reinforcement, the change in relative value on FR1 and FR20 trials would be 1.0 and 1.25, respectively. That would mean that the relative value on the appearance of the FR20 associated S+ would be 25% greater than the relative value on the appearance of the FR1 associated S+. However, with 50% reinforcement, the change in relative value on FR1 and FR20 trials would be 0.5 and 0.75, respectively. That would mean that the relative value on the appearance FR20 associated S+ would be 50% greater than the relative value on the appearance of the FR1 associated S+. Thus, with 50% reinforcement, the relative difference between the change in value when the S+ stimuli appeared (50%) would be greater than with 100% reinforcement (25%).

But the above argument assumes that it is the relative ratio of the change in value that determines the degree of stimulus preference. Alternatively, the choice of the S+ stimulus may depend on the absolute difference in the value of the two S+ stimuli. In that case, the reduction in value of the two S+ stimuli would be the same with 100% and 50% reinforcement and the magnitude of the within-trial contrast effect should not change.

A third possibility is that a threshold value must be exceeded before there is a contrast effect and 50% reinforcement is not sufficient to exceed that level. If that is the case, the amount of within-trial contrast actually may be reduced or eliminated by partial reinforcement.

In the present experiment we tested the hypothesis that the probability of reinforcement associated with the two S+ stimuli would affect the magnitude of the within-trial contrast effect. Pigeons were trained with a procedure very similar to Clement et al. (2000) except the response requirement for the higher effort schedule was increased from 20 to 30 pecks. For half of the pigeons, choice of the S+ stimulus in each simultaneous discrimination was reinforced 100% of the time. For the remaining pigeons choice of the S+ stimulus in each simultaneous discrimination was reinforced 50% of the time. Because Clement et al. (2000) trained their pigeons with 100% reinforcement but tested them with 50% reinforcement (nondifferentially) we tested half of the pigeons in each group with 100% reinforcement (regardless of their choice) and the remaining half of the pigeons with 50% reinforcement (regardless of their choice).

Finally, given that the results of several experiments have failed to replicate the results of Clement et al. (2000), a second purpose of the present experiment was to replicate their results using a somewhat larger difference in response requirement in the initial link (1 vs. 30 pecks rather than 1 vs. 20 pecks), an extended training procedure (more than 60 sessions of overtraining), and pigeons that did not have a prior history of lean schedules of reinforcement.

1. Method

1.1. Subjects

Sixteen White Carneau pigeons (*Columba livia*), retired breeders (5–8 years of age) that were purchased from the Palmetto Pigeon Plant (Sumter, SC) served as subjects. Pigeons were individually housed in wire cages and maintained at 85% of their free-feeding body weights for the duration of the experiment. Free access to water and grit was given in their home cages, and the pigeon colony room was maintained on a 12:12-h light/dark cycle, lights on at 0700 h. The pigeons were cared for in accordance with the University of Kentucky animal care guidelines. All pigeons had previously served in an unrelated discrete-trial, conditional discrimination (matching-to-sample).