

THE RELATIVE VALUE OF TWO OPTIONS FOR PIGEONS DEPENDS  
ON THEIR CONTEXT

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It is well known that when humans are given a choice between two options, their preference is affected by the presence of a third. Generally, there is an increase in preference for the option closer to the third. We show that a shift in preference in the direction away from the third option can occur in animals. We gave pigeons a choice between A, reinforcement following 10 pecks and a 0.5-s delay, and B, reinforcement following 5 pecks and a 1.5-s delay. Once stable preferences were established, we introduced a third stimulus, less preferred than the other two: C, reinforcement following 20 pecks and a 0.5-s delay or D, reinforcement following 5 pecks and a 4.5-s delay. We found that pigeons presented with C showed an increased preference for B, whereas pigeons presented with D showed an increased preference for A. Our results were consistent with the similarity or attentional hypothesis, which suggests that the third option should interfere with the option more similar to it or would draw attention to the less preferred component of the third option and generalize to the option more similar to it. Possible accounts for the differences in outcomes are suggested.

*Key words:* context, relative value, binary choice, trinary choice, pigeons

According to the constant-ratio rule of choice behavior (Luce, 1959; Tversky, 1972), the relative preference between two options should be independent of the presence or absence of other options that may be added to the choice set. However, Simonson and Tversky (1992) found that a third option may indeed alter the preference between two other options. This change in preference has been referred to as *context-dependent choice* (Shafir, Waite, & Smith, 2002). An example of such an effect, described by Simonson and Tversky, is when buyers have a choice between two computers and one computer has less memory but is less expensive, whereas the other has more memory but costs more. Although some people may prefer the computer with less memory because of its lower cost, when offered a third choice, a more expensive computer with even more memory than the second, those individuals may now show a greater preference for the second or moderately priced computer.

Simonson and Tversky (1992) proposed that context-dependent choice could be attributed to one of two mechanisms, *tradeoff contrast* (the initially more expensive computer may appear more attractive *in contrast* to the still more expensive third alternative; see, e.g., the Ebbinghaus illusion, Roberts, Harris, & Yates, 2005) or *extremeness aversion* (a bias to choose the middle valued alternative because it avoids the most extreme values, the one that costs the most, as well as the one with the least memory; Simonson & Tversky, 1992).

Tradeoff contrast may be related to Helson's (1964) adaptation level theory. Helson hypothesized that stimuli are judged relative to a weighted average of the other stimuli presented. Thus, the value of a stimulus will depend on the adaptation level or background value resulting from those other stimuli. Although Helson was primarily concerned with the perceptual value of sensory stimuli (e.g., their brightness), his theory can also be applied to their hedonic value along a particular dimension (e.g., magnitude of reinforcement): If stimuli are presented in the context of another that has lower value, then they would be viewed differently from stimuli that are presented in the context of another that has higher value. Thus, the adaptation level of FR5 and FR10 would be lower than the adaptation level of FR5, FR10, and FR20; that could make the FR5 appear more preferred relative

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to the latter adaptation level. A similar argument can be made for a delay of reinforcement manipulation.

Extremeness aversion also has its parallel in simpler learning procedures. For example, when subjects are trained to respond to a stimulus of a particular sensory value and are later tested with stimuli of different values, they generally show a gradient of stimulus generalization such that they will respond to the test stimulus in direct proportion to its similarity to the training stimulus. Although that tendency was thought to be largely fixed (a given degree of similarity would always result in a similar degree of generalization; see, e.g., Hull, 1943), there is evidence that the degree of responding depends not only on the test value, but also on the *range* of values tested (Hansen, Tomie, Thomas, & Thomas, 1974). Thus, if a particular test stimulus is the most extreme of the test values, then there will be less responding to it than if there are even more extreme test values. Once again, although this research was conducted with stimuli that differed along a visual dimension (in this case line orientation), these effects may also be applicable to context-dependent choices such as those proposed by Simonson and Tversky (1992). Given that analogous relational performance is context dependent (i.e., generalizes along the visual dimensions of the training stimuli), it is reasonable to ask if context-dependent choice of the kind reported by Simonson and Tversky can be found in nonhuman animals as well.

Hurly and Oseen (1999) tested wild hummingbirds for their tendency to avoid risk; these researchers found that hummingbirds preferred a constant amount of food over a somewhat variable, but equal average amount of food (i.e., they were risk averse). However, when Hurly and Oseen introduced a still more variable amount of food, the birds now preferred the somewhat variable amount over the constant amount. On the other hand, when Schuck-Paim and Kacelnik (2002) manipulated the variance of the delay to reinforcement, they found not only that European starlings were strongly risk prone (they preferred higher variance to lower variance), but also that they showed regular and consistent preferences in binary and trinary choices (i.e., they found no evidence of context-dependent choice).

Shafir et al. (2002) adopted a different approach to the question of context-dependent choice testing bees and gray jays. They varied two options along two variables: amount of food and effort required to obtain it (length of a tube through which the subjects had to pass to obtain the food). The researchers did this to better simulate the conditions described by Simonson and Tversky (1992), in which each option had one characteristic that made it more valuable than the other (e.g., for one option there was more food but greater effort was required to obtain it). When they introduced a third, relatively unattractive option that provided still less food or required still greater effort, they found that the relative preference between the two original options changed. For both species, when the third option involved increasing the effort, it resulted in an increased preference for the middle-valued effort option (the one that initially required more effort) and when the third option involved decreasing the amount of food, it also resulted in a greater preference for the middle-valued food option (the one that initially involved less food). This result is consistent with the tradeoff contrast or extremeness aversion account proposed by Simonson and Tversky (1992).

Why should the preference between two alternatives (A and B) be affected by the introduction of a third (C)? If it does affect that relation, then the direction of that effect is not entirely clear. On the one hand, if it affects other animals the same way that it affects humans and C is a more extreme value of B, then, in contrast to C or to avoid the negative aspects of the extremes (A and C), the preference for B might increase. On the other hand, if the choice involves differences in hedonic value along two dimensions that may compensate for each other (e.g., effort and delay of reinforcement), then the least preferred attribute of C (e.g., greater effort) may draw attention to that dimension (i.e., the one with the least effort) and away from the compensating dimension (i.e., greater delay of reinforcement associated with the one with least effort); in that case, subjects would prefer the option that is most different from C. This prediction is consistent with the similarity hypothesis (Huber, Payne, & Puto, 1982; Tversky 1972), which proposes that a third option will compete more with an option that is more similar

to it or, if the third option is better than the other two, then it may enhance the one that is more similar to it (Morgan, Hurley, Bateson, Asher, & Healy, 2012). In our experiment to assess in which direction preference is affected by the introduction of a third stimulus, we added a schedule associated with a less preferred level of an attribute of the two initial options (the number of pecks required or the delay to reinforcement).

In Phase 1, we assessed the relative preference between two alternatives: Option A that required 10 pecks to obtain reinforcement after a delay of 0.5 s and Option B that required 5 pecks to obtain reinforcement after a delay of 1.5 s. In Phase 2, for half of the pigeons, we evaluated the effect on the relative preference between A and B of adding trials either with a clearly less preferred peck requirement (20 pecks, Option C) or for the remaining pigeons, with a clearly less preferred delay of reinforcement (4.5 s, Option D). We first tested the pigeons with the new requirement on separate nonchoice trials because recently, Tan *et al.* (2015) found that honeybees choosing between two available options changed their preferences if a third, singly presented option had been experienced during testing. Finally, in Phase 3, we gave the pigeons a trinary choice among the three alternatives, A, B, and C or A, B, and D.

## Method

### Subjects

The subjects were eight White Carneau pigeons (*Columba livia*) maintained at 80-85% of their free-feeding body weight. The pigeons were individually housed in wire cages, with free access to water and grit, in a colony room that was kept at 23 ° C and was maintained on a 12:12-h light/dark cycle, with lights on at 07:00. The animals were cared for in accordance with University of Kentucky animal care guidelines. The experiment was conducted once a day, 6 days a week, at approximately the same time of day for each pigeon. All pigeons had previous experience with color discrimination tasks.

### Apparatus

The experiment was conducted in a sound-attenuating standard BRS/LVE (Laurel, MD)

operant test chamber measuring 35 cm high, 30 cm long, and 35 cm across the response panel. Three circular response keys, 2.5 cm in diameter, were arranged horizontally on the response panel, 9 cm apart, center to center. Behind each key was a 12-stimulus inline projector (Industrial Electronics Engineering, Van Nuys, CA), which projected red, green, blue, and yellow hues (Kodak Wratten Filter Nos. 26, 60, 38, and 9, respectively). Directly above the center key, 30 cm from the floor, a 28-V, 0.1-A houselight provided general illumination. The food hopper was accessible through a 6-cm-wide x 5-cm-high opening that was centered horizontally on the response panel, 9.5 cm above the floor. When the hopper was raised to provide grain to the pigeons, a 28-V, 0.04-A light illuminated its opening. A computer using the MED-PC (Med Associates Inc.) software controlled the experiment and recorded the data in an adjacent room.

### Procedure

**Pretraining.** The pigeons were trained to peck four stimuli (red, green, yellow, and blue) singly presented on each of the three keys. On each trial, one key was turned on, and one peck at the lit key was followed by 2 s of food. A 10-s intertrial interval separated the trials. Each session was composed of 60 trials (five blocks of 12 trials), and each color appeared the same number of times on each key. Each pigeon received two sessions of pretraining. Following pretraining, the pigeons were exposed to three phases of testing.

**Baseline Preference Test.** Each baseline session was composed of two types of trials: choice trials and forced trials. A choice trial started with the illumination of two of the keys, each with a different color. For half of the pigeons, the hues were red and green; for the remaining pigeons, the hues were blue and yellow. Each color signaled a specific option. A peck on one of the keys turned off the other key, and the chosen key remained on until the peck requirement was met: 10 pecks for Option A—Fixed Ratio (FR) 10— or 5 pecks for Option B—Fixed Ratio (FR) 5. When the peck requirement was met, the key turned off and reinforcement was provided following a delay: 0.5 s for Option A and 1.5 s for Option B. Reinforcement consisted of 2-s access to mixed grain, followed by a 10-s

intertrial interval, during which the houselight was turned on. The colors associated with each option were counterbalanced over pigeons. A forced trial was similar to a choice trial, but only one of the options was presented at the start of the trial.

A session consisted of 48 trials: 24 choice trials and 24 forced trials (12 of each option), randomly interspersed. The location of the options varied between trials, with the constraint that each option was presented the same number of times on each of the three response keys. Baseline preference testing was conducted for 30 sessions at which point the preferences were relatively stable. At the end of the baseline phase, the animals were divided in two groups, Group C and Group D. The groups were matched for the degree to which they preferred the A and B options.

**Binary Test.** This phase was similar to baseline testing, with one exception. For Group C, single Option C trials were introduced (20 pecks were required and there was a 0.5-s delay to reinforcement). For Group D, single Option D trials were introduced (5 pecks were required and there was a 4.5-s delay to reinforcement). That is, Option A and C shared the same delay to reinforcement (0.5 s), but Option A required fewer pecks than Option C (10 pecks vs. 20 pecks). On the other hand, Options B and D shared the same peck requirement (5 pecks), but Option B had a shorter delay to reinforcement than Option D (1.5 s vs. 4.5 s; see Fig. 1). For pigeons for which Stimuli A and B were red and green, Stimuli C and D were yellow and blue. For pigeons for which Stimuli A and B were yellow and blue, Stimuli C and D were red and green. A session consisted of 60 trials: 24 choice trials and 36 forced trials (12 trials with each of the three stimuli; A, B, and C or A, B, and D), randomly interspersed. All choice trials involved a choice between alternatives A and B. The binary test consisted of 12 sessions.

**Trinary Test.** The Trinary Test consisted of the same single stimulus trial types as the Binary Test; however, on some of the choice trials the pigeons had a choice among all three stimuli. Each of the three stimuli appeared equally often on each of the three pecking keys. Each session consisted of 84 trials, 24 trinary-choice trials, 24 binary-choice (A vs. B) trials, and 36 forced trials

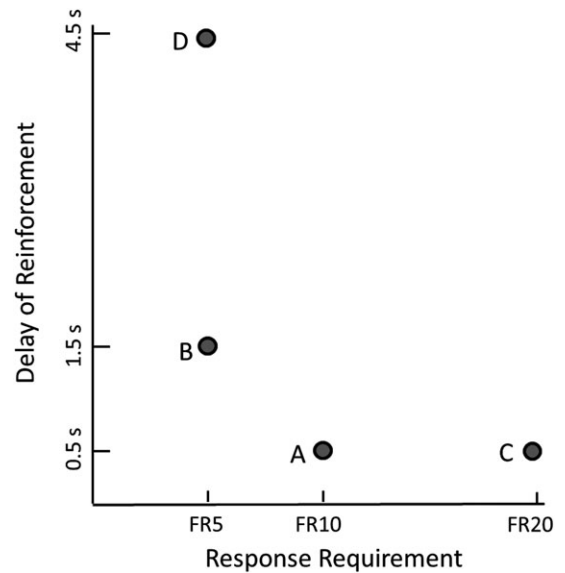


Fig. 1. Mapping of the four alternatives as a function of their two components: peck requirement and delay to reinforcement. Initial training involved the choice between Options A and B. Following training, Group C received single stimulus trials with Option C and Group D received single stimulus trials with Option D.

(12 with each stimulus), randomly interspersed. The trinary test consisted of 22 sessions.

## Results and Discussion

### Baseline Preference Test

Preference was indicated by the proportion of trials on which there was choice of Option B (5 pecks, FR5, with 1.5 s delay of reinforcement, DR1.5 s). The pigeons showed considerable variance in their preference between the two alternatives on the baseline preference test. The range of preference for the FR5-DR1.5 s stimulus pooled over the last three sessions of baseline training was .47 to .88 with a mean of .69 (SD = .17). A single sample *t*-test confirmed that the preference for the FR5-DR1.5 s was significantly above chance  $t(7) = 3.16, p = .02$ , Cohen's  $d = 1.12$ .

We asked if the preference for Option B could be predicted from the time from the first peck to reinforcement. A significant correlation was found between the ratio of delay to reinforcement (DelayA/DelayB) and the preference for Option B over A ( $r = .718$ ,

$p = .045$ ). That is, B was preferred to the extent that reinforcement came sooner for a response to Option B than to A.

When the pigeons were divided into two groups (Group C and Group D) matched for preference, the mean preference for Group C was .69 (SD = .13) and for Group D it was .70 (SD = .23). The difference was not statistically significant,  $t < 1$ . The results of baseline preference testing appear in Table 1 and in the left panel of Figure 2 plotted separately for Groups C and D, in blocks of two sessions.

Binary Test

On the Binary Test, the two groups showed opposite patterns of preference in response to the introduction of the third option. For Group C, associated with the FR20-DR0.5 s option there was an *increase* in preference for Option B (FR5-DR1.5 s), whereas for Group D, associated with the FR5-DR4.5 s option, there was a *decrease* in preference for Option B (see middle panel of Fig. 2). Because matching the two groups for initial preference between the A and B alternatives resulted in considerable within-group variability, we analyzed the change in preference that resulted from the introduction of the C or D option. Individual preferences, pooled over the last three sessions of Baseline and Binary Test, appear in Table 1. A  $t$ -test for independent groups based on the difference in

preference between the last three sessions of the Baseline Preference Test and the last three sessions of the Binary Test indicated that the change in preference was significantly different between the two groups,  $t(6) = 3.21$ ,  $p = .018$ , Cohen's  $d = 2.27$ . All of the pigeons in Group C showed an increased preference for the B stimulus (mean = .08) and all of the pigeons in Group D showed a decreased preference for the B stimulus (mean =  $-.13$ ). A nonparametric binomial test indicated that the probability that all eight pigeons would show a similar context-dependent effect (i.e., in the direction away from the third option, see Fig. 1) was  $p = .004$ . Individually, two of the four pigeons in Group C significantly increased their preference for Option B, whereas two of the four pigeons in Group D significantly decreased preference for Option B (binomial tests with  $\alpha = .05$ ).

Because of the large variance in baseline preference, we asked if the change in preference that resulted from the introduction of the Options C and D was related to the initial preference for Option B. We found that there was a small negative correlation between the initial preference and the effect of the introduction of a less preferred third stimulus; the correlation was not statistically significant,  $r = -.082$ ,  $t < 1$ . Because the effect of the introduction of the C or D schedules had opposite effects for the two groups, we asked if the

Table 1

Preference for Option B (FR5-DR1.5 s) during the last three sessions of Baseline and Binary Test for pigeons in Group C (FR20-DR0.5 s) and Group D (FR5-DR4.5 s)

		Preference for Option B		
		Baseline	Binary Test	Difference
Group C	P1	.61	.79	.18
	P2	.64	.75	.11
	P3	.88	.89	.01
	P4	.63	.64	.01
	Mean	.69	.77	.08
Group D	P5	.53	.50	-.03
	P6	.93	.88	-.05
	P7	.86	.65	-.21
	P8	.47	.25	-.22
	Mean	.70	.57	-.13

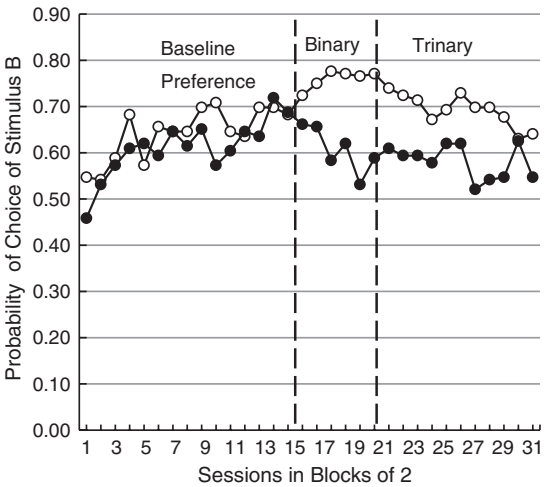


Fig. 2. Mean proportion of choices to Option B (FR5-DR1.5 s) on the binary tests of the experiment in all three phases. Group C, open circles, Group D, filled circles.

change in preference was correlated with the initial preference for the B option. That is, for example, if the preference for Option B was high, then the introduction of C, which resulted in an increase in the preference for Option B, may have constrained the increase in preference for Option B. In fact, the baseline preference for Option B was negatively correlated with the reverse coded change in the preference for Option B (the increased preference for Option B for Group C and decreased preference for Option B for Group D), but the correlation was not statistically significant ( $r = -.23$ ,  $t < 1$ ).

Another possibility is that the shift in preference resulted from the decrease in time from the first peck to reinforcement. We found that there was no significant difference between options A and B in how much their time-to-food changed between Baseline and Binary Test. For Group C, the mean change in time-to-food (Baseline–Binary latency) was 1.39 s for Option A and 0.02 s for Option B. That is, although the latency decreased for both A and B options, it decreased more for Option A; in other words, the pigeons became relatively more efficient in completing the FR10 than the FR5 requirement. That would suggest that there should have been a shift in preference in the direction of Option A, but in fact the opposite occurred. Furthermore, there was no significant difference in the latency between options A and B for Group C (paired samples  $t$ -test,  $t(3) = 1.23$ ,  $p = .31$ ).

For Group D, the mean change in time-to-food (Baseline–Binary latency) was  $-0.23$  s for Option A and  $-0.08$  s for Option B. That is, the latency actually increased slightly for the pigeons in Group D, but it increased more for Option A than for Option B, which would suggest that there should have been an increased preference for Option B. However, those pigeons actually showed a decreased preference for Option B. Furthermore, there was no significant difference in the latency between Options A and B for the pigeons in Group D (paired samples  $t$ -test,  $t(3) = .83$ ,  $p = .46$ ). Thus, the difference in the time to reinforcement for the two groups cannot account for shifts in preference for the two groups.

The effect of the introduction of a less preferred third option that we found is consistent with the attentional hypothesis. Specifically, preference increased for the stimulus that was

more different from the newly introduced stimulus: Preference for Option B increased with introduction of Option C, whereas preference for Option A increased with introduction of Option D. This result indicates that pigeons became more sensitive to the new, presumably less preferred characteristic of the new stimulus on the binary test: Pigeons in Group C became more sensitive to the peck requirement, and pigeons in Group D became more sensitive to the delay of reinforcement. The differential sensitization could have occurred because for Group C, the most salient component of the new stimulus was the aversiveness of the FR 20, which would have drawn attention to the more favorable FR5 (associated with Option B) and away from the less favorable FR10 (associated with Option A). Thus, preference for Option B increased.

The same argument can be made for Group D: Pigeons in Group D became more sensitive to the introduction of the relatively aversive 4.5-s delay of reinforcement associated with Option D, which would have drawn attention to the relatively more preferred 0.5-s delay of reinforcement associated with Option A. Hence, preference for Option B decreased.

### Trinary Test

With the introduction of three choices on the Trinary Test, the difference between the two groups on both the binary-choice and trinary-choice trials was reduced (see the right panel of Fig. 2 for the data from the binary-choice trials). On the first three sessions of the Trinary Test, on the binary-choice trials, the difference in the change in preference for Option B for Groups C and D (relative to baseline) was significantly different,  $t(6) = 3.91$ ,  $p = .008$ . The same comparison on trinary-choice trials was also significantly different,  $t(6) = 3.31$ ,  $p = .02$ . Options C and D were rarely selected: For example, over the last three sessions, the proportion of choices of C and D were between 0 and .08 (Mean = .02).

However, when similar tests were conducted on the last three sessions of the Trinary Test, the difference on binary-choice trials was no longer statistically significant,  $t(6) = 1.39$ ,  $p = .21$ . Nor was the difference statistically significant on the trinary choice trials,  $t < 1$ . Apparently, either the added training or the

prolonged experience with trinary-choice trials disrupted the context-dependent choice effect even on binary-choice trials.

The schedules involved in the present research could be functionally described in terms of the delay between the first response and reinforcement. Depending on the time it takes to fulfill the FR response requirement, the time it takes to make 10 pecks and wait 0.5 s may take a bit longer than the time it takes to make 5 pecks and wait 1.5 s. This difference could account for the small average preference for B over A. But, in both cases, the introduction of either C (FR20-DR0.5 s) or D (FR5-DR4.5 s) should have increased the total time to reinforcement. What effect the introduction of a stimulus associated with a poorer schedule should have had on the richer schedules associated with the A and B options is not clear; however, if the delay of reinforcement associated with the various schedules was responsible for the change in preference for Option B, then it should have affected Groups C and D similarly. Yet the effect of the introduction of the C and D schedules on the preference for Option B was in opposite directions for the two groups.

The effects found in the present experiment are consistent with Tversky's (1972) similarity hypothesis. According to this hypothesis, presentation of a stimulus associated with a third option should compete with the option more similar to it. In the case of the FR20 option (C), it should compete more with the FR10 option (A), resulting in an increase in the preference for the FR5 option (B). On the other hand, in the case of the DR 4.5 s option (D), it should compete more with the DR 1.5 s option (B), resulting in a decrease in the preference for Option B.

However, the results of the present experiment are inconsistent with the typically found context-dependent choice effect reported by Simonson and Tversky (1992), in which preference increased for the middle-valued stimulus. In those cases, the effect was attributed to either a contrast (or adaptation level) effect or to an extremeness aversion (or range) effect. The difference in the direction of the results found here and that of previous research suggests that the mechanisms involved in these effects may be different. In the present experiment, instead of contrast between the third option and the more similar original option,

the pigeons appear to generalize the less preferred property of the third option to the more similar option, thus leading to a stronger preference for the option more different from the new one.

But, what form of generalization would be applicable to this effect? Stimulus generalization would apply to the similarity of the training stimuli, yet the stimulus colors used to signal the four schedules were selected to result in minimal stimulus generalization. Furthermore, the stimuli associated with the four different schedules were assigned such that any stimulus preference would be controlled. Alternatively, it could be a form of response generalization. However, response generalization typically refers to similar responses made to the same training stimulus; in this case, all of the training stimuli were different.

So, in what sense does generalization apply to the present results? It cannot be simply that the schedules associated with both C and D represent increases in the delay to reinforcement from the first response, because that should have led to similar results upon the introduction of C (an increase in FR) and D (an increase in delay to reinforcement). Instead, we suggest that increased attention to the specific dimension manipulated by the introduction of C or D accounts for the effects observed.

The results of the present experiment demonstrate that the preference between two stimuli associated with options FR10-DR0.5 s and FR5-DR1.5 s can be affected by presentation of a novel option of presumably lesser value on separate trials. The direction of the change in preference appears to be related to the more aversive property of the novel option. Thus, if the novel option involves a relatively aversive increase in the peck requirement (FR20), then it appears to draw attention to that property of the other two options, resulting in a shift in preference to the stimulus associated with the lower FR value (FR5). Similarly, if the novel option involves a relatively aversive increase in the delay to reinforcement (4.5 s), then it appears to draw attention to that property of the other two options resulting in a shift in preference to the stimulus associated with the shorter delay to reinforcement (0.5 s).

More difficult to reconcile with the findings of the present experiment are the results

reported with bees and jays by Shafir et al. (2002), in which options that varied in magnitude of reinforcement and effort (or delay to reinforcement) were varied between the original options. In their experiments, when the third option involved reinforcement that was more difficult to obtain or the third option introduced a greater magnitude of reinforcement, it resulted in an increase in the preference for the middle valued option, as with humans. It may be that magnitude of reinforcement (as well as price for humans) has special characteristics that favor contrast or extremeness aversion, whereas delay of reinforcement, in keeping with Tversky's (1972) similarity hypothesis, favors generalization.

That the direction of context effects may vary depending on the dimension being tested is highlighted by the results of Morgan et al. (2012) with rufous hummingbirds. They evaluated the effect of the introduction of a third option on two options that varied along a single magnitude of reinforcement dimension. When the options differed in the concentration of sucrose available, adding a lower concentration option increased the preference for the middle concentration (consistent with a context effect); however, when the options differed in the volume of liquid provided, addition of a larger volume option significantly increased the preference for the lowest-volume option. Thus, the effects of the introduction of a third option are not always obvious. They may depend not only on the dimension along which the manipulation is made, but also on whether the third option is more favorable than, or worse than, the other two. Although there is now mounting evidence that presentation of a third option can affect the relative preference between two initial options, the conditions under which

presentation of a third option results in a generalization versus a contrast effect will have to await further research.

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