

*EMERGENT IDENTITY MATCHING AFTER SUCCESSIVE MATCHING TRAINING,  
I: REFLEXIVITY OR GENERALIZED IDENTITY?*

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This research investigated the source of an ostensible reflexivity effect in pigeons reported by Sweeney and Urcuioli (2010). In Experiment 1, pigeons learned two symmetrically reinforced symbolic successive matching tasks (hue–form and form–hue) using red–green and triangle–horizontal line stimuli. They differed in their third concurrently trained baseline task: form–form matching with stimuli appearing in the symbolic tasks (triangle and horizontal) for one group versus hue–hue matching with stimuli not appearing in the symbolic tasks (blue and white) for the other. During subsequent nonreinforced probe tests, all pigeons in the former group and most pigeons in the latter group responded more to the comparisons on matching than on nonmatching red–green probes. In Experiment 2, the latter group was tested on nonreinforced form–form probes. One of the 4 pigeons responded significantly more to the comparisons on matching than on nonmatching triangle–horizontal probes. These data are consistent with generalized identity and at least one other interpretation of the reflexivity results and question the functional stimulus assumption of Urcuioli's (2008) stimulus-class theory.

*Key words:* reflexivity, generalized identity, successive matching, stimulus equivalence, stimulus classes, pigeons, key peck

This article reports the first set of a series of experiments to evaluate an ostensible reflexivity effect in pigeons reported by Sweeney and Urcuioli (2010). As we pointed out in that paper, if our results were a confirmed instance of reflexivity, they would be the first unambiguous demonstration of this phenomenon in any animal, including humans. Consequently, it is important empirically and theoretically to replicate those results and to clarify their origin(s) as precisely as possible. The two experiments described here are initial steps in that direction, examining the possibility that generalized identity matching might provide a viable alternative explanation for our results.

Reflexivity refers to the finding that subjects will match individual stimuli to themselves following training on arbitrary or symbolic matching-to-sample. This emergent effect is one of the three behavioral indices of stimulus equivalence (Sidman & Tailby, 1982). Specifically, if subjects are explicitly taught arbitrary matching relations of the form A–B and B–C, where the first letter denotes two or more

sample stimuli and the second letter denotes the corresponding reinforced comparison stimuli, they may now be able to match A samples to A comparisons (A–A matching), B samples to B comparisons (B–B matching), and C samples to C comparisons (C–C matching). If the latter behavior is observed, the assumption is that this was not part of the subject's repertoire prior to explicit baseline training but, instead, is a consequence of such training (Saunders & Green, 1992).

Human participants, however, are likely to bring to an experiment the ability to match virtually any stimulus to itself without exposure to the experimental training contingencies. This ability could presumably reflect prior arbitrary matching experiences but, more likely, it reflects a preexperimental history in which they have explicitly learned what constitutes identical or "same" stimuli versus non-identical or "different" stimuli (e.g., Hayes, 1991). Having already learned an unknown number of identity relations, the ability to match the experimental stimuli to themselves may simply reflect generalization of this prior learning—i.e., generalized identity matching (Barros, Galvão, & McIlvane, 2002; Oden, Thompson, & Premack, 1988; Peña, Pitts, & Galizio, 2006; see also Barnes, 1994). In fact, generalized identity has been closely aligned with reflexivity by Sidman (e.g., Sidman, 1990, 1992; Sidman & Tailby, 1982) and others (e.g.,

This research was supported by NICHD Grant R01 HD061322. The author thanks Dana Harkins and Cody Neal for their assistance in conducting this research.

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doi: 10.1901/jeab.2011.96-329

Dube & McIlvane, 1992; Zentall, 1998). Nevertheless, their origins are not necessarily the same: Generalized identity, by definition, arises from a history of reinforced identity responding; the latter can purportedly arise solely from a history of reinforced arbitrary matching responding.

Separating these in human participants is probably an impossible task (Saunders & Green, 1992). By contrast, such separation should be possible in nonhuman animals given our substantially greater control over and knowledge of subjects' preexperimental histories. Moreover, a recent theory of equivalence-class formation (Urcuioli, 2008) specifies the particular sets of training relations that should yield reflexivity in the pigeon, an animal that also exhibits another aspect of stimulus equivalence—viz., symmetry, the untrained ability to match A to B after explicit training to match B to A (Frank & Wasserman, 2005; Urcuioli, 2008). This theory was prompted in part by the finding that pigeons show symmetry after training on go/no-go or successive matching (Wasserman, 1976) despite the fact that they show no evidence of this emergent effect after training on *n*-alternative matching (D'Amato, Salmon, Loukas, & Tomie, 1985; Lionello-DeNolf & Urcuioli, 2002; Lipkens, Kop, & Matthijs, 1988; Urcuioli, 2008, Experiments 1A, 1B, and 2).

Unlike *n*-alternative matching, the contingencies of standard successive matching (Wasserman, 1976; cf. Konorski, 1959) guarantee that half of all trials end in nonreinforcement independent of the level of go/no-go discriminative performances. Urcuioli (2008) proposed that this continual juxtaposition of nonreinforced sample-comparison relations with reinforced sample-comparison relations throughout successive matching training facilitates formation of stimulus classes containing the elements of the reinforced combinations. A second assumption is that those elements (for pigeons, at least) are not the nominal stimuli per se but, rather, are compounds consisting of the nominal stimuli plus their ordinal position within a trial (viz., first or second). This latter assumption is equivalent to saying that pigeons discriminate if a particular stimulus in a trial serves as the sample or as the comparison.

These assumptions, along with a third I will describe shortly, predicted that pigeons explicitly trained on A-B, B-A, and B-B successive

matching would then be able to match the A stimuli to themselves (i.e., A-A matching; reflexivity). A-B and B-A refer to symmetrically reinforced (i.e., "mirror-image") arbitrary matching tasks and the third (B-B) refers to identity matching using the stimuli appearing in arbitrary matching. Pigeons trained in this fashion (Sweeney & Urcuioli, 2010) did, in fact, respond more to A comparisons that matched their preceding A samples than to A comparisons that did not match their preceding A samples during a subsequent A-A reflexivity test. The issue addressed here concerns the status of the explicitly trained B-B relations in producing this emergent effect.

One plausible account is that the reinforced identity relations learned with one set of stimuli (B-B) simply generalized to another set of stimuli (A-A). Besides, the A samples and A comparisons in testing were already familiar via prior appearances as samples and as comparisons in the A-B and B-A baseline relations, respectively, which may have increased the likelihood of observing a generalized identity effect. Sweeney and Urcuioli (2010), however, found this account unconvincing given that other pigeons trained on reinforced B-B oddity relations along with the A-B and B-A symbolic relations did not show a corresponding, generalized oddity effect. Nevertheless, it would probably be unwise to simply dismiss a generalized identity account on this basis alone.

By contrast, Urcuioli's (2008) theory posits that the B-B baseline relations are necessary for generating the stimulus classes containing the reflexive A elements. Relevant to this theoretical account is the assumption that elements common to more than one stimulus class cause their respective classes to merge, and it is in this role that the baseline B-B relations are crucial. To illustrate, Sweeney and Urcuioli (2010) trained pigeons on the following reinforced relations: red sample → triangle comparison and green sample → horizontal-lines comparison (A-B successive matching); triangle sample → red comparison and horizontal-lines sample → green comparison (B-A successive matching); and triangle sample → triangle comparison and horizontal-lines sample → horizontal-lines comparison (B-B successive matching). Using "1" to denote a stimulus appearing first in a trial (i.e., as a sample), "2" to denote a stimulus

appearing second in a trial (i.e., as a comparison), and letters to denote the nominal stimuli, the following stimulus classes should develop: [R1, T2], [T1, R2], [T1, T2] and [G1, H2], [H1, G2], [H1, H2]. These have been grouped in such a way to make the common elements easier to locate—e.g., T2 for the [R1, T2] and [T1, T2] classes and T1 for the [T1, R2] and [T1, T2] classes, etc. If common elements result in class merger, the net effect of training will be two 4-member classes, [*R1*, *R2*, T1, T2] and [*G1*, *G2*, H1, H2]. The italicized elements highlight the elements of the untrained and reflexive (A–A) relations. Thus, in testing pigeons should peck more to the red comparison (R2) after the red sample (R1) and to the green comparison (G2) after the green sample (G1) than to the comparisons of the mismatching combinations, as they did.

Note that this observed emergent behavior is labeled “reflexivity” even though its proposed theoretical basis describes the matching of functionally different stimuli (e.g., R1 to R2). But if ordinal position is differentiated, this means that the effect is technically not matching “each stimulus to itself” (which, instead, would entail matching R to R). Nevertheless, a theoretically naïve observer would likely describe the novel (untrained) stimulus relations seen in testing as “matching each stimulus to itself” even though from a strictly observational standpoint, the second of two sequentially presented stimuli is not an identical stimulus to the first in all respects. The important point is that Urcuioli’s (2008) theoretical account explains how certain baseline training conditions in pigeons may yield such untrained relations when ordinally defined functional stimuli become members of a common stimulus class.

According to this stimulus-class explanation, the A–A emergent effect would not have occurred had baseline identity training involved stimuli not appearing in the arbitrary matching tasks. For example, if blue (B) and white (W) stimuli were used for baseline identity matching, the theory predicts the following stimulus classes: [R1, T2], [T1, R2], [B1, B2] and [G1, H2], [H1, G2], [W1, W2]. Here, no element appears in more than one class, so there can be no class merger and, hence, no classes containing both R1 and R2, and G1 and G2. In sum, Urcuioli’s (2008) theory claims that B–B identity training with

stimuli appearing in A–B and B–A arbitrary matching is crucial for obtaining emergent A–A matching. By contrast, a generalized identity account states that the particular stimuli used for baseline identity training does not matter—i.e., they can be the same as those appearing in arbitrary matching or they can be entirely different. These contrasting predictions were tested here.

## EXPERIMENT 1

Experiment 1 compared emergent hue–hue successive matching after training on hue–form (A–B), form–hue (B–A), and form identity (B–B) matching (cf. Group IREF in Sweeney & Urcuioli, 2010) versus training on the same two symbolic tasks plus hue identity (C–C) matching using samples and comparisons different from those appearing in the symbolic tasks. If the results of Sweeney and Urcuioli represent reflexivity via the stimulus class mechanism proposed by Urcuioli (2008), then comparison response rates should be higher on matching than on nonmatching test trials only in the comparably trained group of this experiment. Conversely, if those results are an instance of generalized identity matching, then those differences in comparison–response rates should be apparent in both groups.

## METHOD

### *Subjects*

Eight experimentally naïve White Carneau pigeons between 1–2 years old, obtained from the Double “T” Farm (Glenwood, IA), participated in this experiment. Upon arrival in the lab, pigeons were housed in individual wire-mesh, stainless-steel cages in a colony room with a 14-hr–10-hr light–dark cycle (lights on at 07:00) and had free access to Purina ProGrains over a period of 7–21 days so that free-feeding body weights could be established. Immediately prior to their experimental participation, pigeons were randomly divided into two groups of 4 and were gradually reduced to 80% of their free-feeding weights by restricted feeding. The 80% body weights were maintained throughout the experiment by confining food access to the experimental sessions. The only exceptions were home-cage feedings on the 1 day/week that sessions were not run and periodic, supplemental feedings when pigeons did not

obtain sufficient food in a session to maintain their 80% weights. Water and grit were always available.

### *Apparatus*

Two operant chambers (BRS/LVE, Laurel MD) consisting of Model PIP-016 three-key panels inside Model SEC-002 enclosures were used in the experiment. Each center response key, the only ones used, could be back-illuminated by Model IC-901-IDD inline projectors equipped to display a solid, inverted white triangle on a black background, three white horizontal lines on a black background, and red, green, blue, and white homogeneous fields (BRS/LVE Pattern 692). GE No. 1829 bulbs mounted 7.6 cm above the 2.5-cm-diameter center keys served as house lights. The house light in each chamber was directed toward the ceiling by a metal housing that partially covered the bulb. A 5.8 cm × 5.8 cm opening in the response panel directly below the center key permitted access to a rear-mounted food hopper which, when raised, was illuminated by a miniature bulb (ESB-28). Ventilation and masking noise were provided by a blower fan attached to the outside of each chamber. IBM-compatible computers controlled stimulus presentation and recorded all experimental events.

### *Procedure*

*Preliminary training.* All pigeons initially learned to eat quickly and reliably from a periodically raised and illuminated food hopper, after which their key pecking to a white center-key stimulus was shaped by the method of successive approximations. They were then trained in three successive 60-trial sessions to peck blue and white, red and green, and triangle and horizontal lines on the center key, in that order. Each stimulus appeared 30 times in pseudorandom order in a session with a 10-s intertrial interval (ITI) separating successive stimulus presentations. A single peck to the center-key stimulus appearing on each trial immediately turned it off and produced food reinforcement. In the final phase of preliminary training, pigeons received fixed-interval (FI) training with blue and white, red and green, and triangle and horizontal lines, in that order. There were five 60-trial sessions with each pair of stimuli; the FI value was

increased from 2 to 5 s across these sessions. The ITI during FI training was 15 s, the first 14 s of which was dark. The house light came on for the last 1 s of the ITI and remained on until the end of the next reinforcement cycle. Reinforcement durations were constant within a session for each pigeon but could vary between 2–6 s across sessions so as to maintain 80% body weights.

*Successive matching training.* After completing preliminary training, pigeons began training on three concurrent successive matching discriminations (see Table 1). All pigeons were trained on hue–form (A–B) and form–hue (B–A) symbolic matching in which the samples for one task served as the comparisons for the other, and vice versa, and for which the baseline relations were mirror images of one another. Thus, if responding to the triangle comparison after the red sample (R→T) and to the horizontal-lines comparison after the green sample (G→H) were reinforced in the hue–form (A–B) task, then responding to the red comparison after the triangle sample (T→R) and to the green comparison after the horizontal sample (H→G) were likewise reinforced in the form–hue (B–A) task. The remaining sample–comparison combinations in each task were nonreinforced. The reinforced and nonreinforced symbolic (A–B and B–A) relations were counterbalanced across the pigeons in each group (not shown in Table 1).

The groups differed in their other successive matching task. Group RF was trained on form–form (B–B) identity matching with the triangle and horizontal stimuli appearing in its two symbolic tasks. In this task, comparison responding was reinforced only when the form comparison matched the preceding form sample (viz., on T→T and H→H trials). Group GI, on the other hand, was trained on hue–hue (C–C) identity with stimuli (blue and white) that did not appear in its two symbolic tasks. Here, too, comparison responding was reinforced only when a blue or white comparison matched a preceding blue or white sample (viz., on B→B and W→W trials).

Training sessions consisted of 96 trials divided equally among the three baseline tasks. The 12 possible sample–comparison sequences appeared eight times in random order in each session with the restriction that none occurred more than twice in a row. Every successive matching trial began with a sample

Table 1  
Successive Matching Training Contingencies for the Two Groups in Experiment 1.

<i>Group RF</i>		
Hue-Form (A-B) Matching	Form-Hue (B-A) Matching	Form-Form (B-B) Identity
R → T - FI 5 s	T → R - FI 5 s	T → T - FI 5 s
R → H - EXT	H → R - EXT	T → H - EXT
G → T - EXT	T → G - EXT	H → T - EXT
G → H - FI 5 s	H → G - FI 5 s	H → H - FI 5s
A1 → B1 +	B1 → A1 +	B1 → B1 +
A1 → B2 -	B2 → A1 -	B1 → B2 -
A2 → B1 -	B1 → A2 -	B2 → B1 -
A2 → B2 +	B2 → A2 +	B2 → B2 +
<i>Group GI</i>		
Hue-Form (A-B) Matching	Form-Hue (B-A) Matching	Hue-Hue (C-C) Identity
R → T - FI 5 s	T → R - FI 5 s	B → B - FI 5 s
R → H - EXT	H → R - EXT	B → W - EXT
G → T - EXT	T → G - EXT	W → B - EXT
G → H - FI 5 s	H → G - FI 5 s	W → W - FI 5 s
A1 → B1 +	B1 → A1 +	C1 → C1 +
A1 → B2 -	B2 → A1 -	C1 → C2 -
A2 → B1 -	B1 → A2 -	C2 → C1 -
A2 → B2 +	B2 → A2 +	C2 → C2 +

*Note.* R = red, G = green, B = Blue, W = White, T = triangle, H = horizontal, FI = fixed interval schedule, EXT = nonreinforced, A and C = hue, B = form, 1 and 2 = individual hue (or form) stimuli, + = reinforced, - = nonreinforced. The first stimulus in the trial sequence (the sample) is shown to the left of the arrows, and the second stimulus (the comparison) is shown to the right. Counterbalancing of the hue-form and form-hue matching contingencies has been omitted.

stimulus on the center key. A single peck to the sample stimulus initiated a 5-s observation period followed by a 500-ms blank interval and, then, onset of a comparison stimulus. For reinforced sequences, the first peck to the comparison stimulus after 5 s (an interval initiated by a key peck) turned it off and produced access to food. For nonreinforced sequences, the comparison and the house light went off automatically 5 s after comparison onset. Successive trials were separated by a 15-s ITI with the house light off for the first 14 s. The house light came on for the last 1 s of the ITI and remained on until the end of the next reinforcement cycle (reinforced sequences) or comparison offset (nonreinforced sequences). As before, reinforcement duration was constant within a session but could vary from 1.8 to 6.0 s across sessions as needed to maintain 80% body weights.

A discrimination ratio (DR), computed by dividing the total number of comparison pecks on reinforced trials by the total number of comparison pecks on both reinforced and nonreinforced trials, was used to assess acquisition of each successive matching discrimination.

Only those pecks occurring within 5 s of comparison onset were used in these computations. The acquisition criterion was a  $DR \geq .80$  on all three of each group's matching tasks for five of six consecutive sessions. After meeting this criterion, pigeons received a minimum of 10 additional training sessions to insure stable performances and ended when criterion was again met for 5 of 6 consecutive sessions.

*Successive matching testing.* After overtraining, all pigeons except 1 received eight test sessions, each consisting of 96 baseline trials distributed equally across the three baseline tasks and eight nonreinforced (A-A) probe trials, two each of the following: R→R, R→G, G→R, and G→G. Test sessions were run in two-session blocks separated by a minimum of five baseline sessions at criterion levels of performance (viz.,  $DRs \geq .80$  for all three baseline tasks for five of six consecutive sessions). In every test session, each of the 12 possible baseline trials was presented at least once prior to the first nonreinforced probe trial. In addition, successive probe trials were separated by a minimum of six baseline trials.

The dependent variable of interest was the comparison-response rate on the untrained matching (R→R and G→G) and nonmatching (R→G and G→R) probes.

Pigeon RF1 was tested only twice. After its second test session, this pigeon inexplicably lost the required level of baseline performance and was unable to reestablish it after 80 training sessions. Consequently, its experimental participation ended at that point.

#### RESULTS AND DISCUSSION

*Acquisition and baseline performances.* Group GI acquired its three baseline tasks to criterion rapidly and in considerably fewer sessions than Group RF despite the fact that the groups shared the same two symbolic tasks. For Group GI, the average number of training sessions to the first criterial session was 20.8 for blue-white identity matching, 22.0 for hue-form symbolic matching, and 28.5 for form-hue symbolic matching. Group RF, on the other hand, needed an average of 113.2 sessions to reach criterion on form-form identity matching, 57.8 for hue-form symbolic matching and 105.5 sessions for form-hue symbolic matching. The Group RF pigeons also had a difficult time maintaining high levels of discriminative performance already achieved on a particular task as performance improved on one (or more) of the other tasks. Nevertheless, once the Group RF pigeons met criterion, they maintained this level of performance during overtraining. For the last five sessions preceding testing, the DRs for form identity, hue-form symbolic, and form-hue symbolic matching in Group RF were .84, .87, and .89, respectively, a statistically nonsignificant difference,  $F(2, 3) = 2.00$ . The corresponding DRs for blue-white identity, hue-form symbolic, and form-hue symbolic matching in Group GI were .94, .93, and .92, respectively,  $F(2, 3) = 0.49$ .

Most pigeons maintained high levels of discriminative performance on their respective baseline tasks throughout testing. For example, no baseline DR dropped below .80 for any of the Group GI pigeons on any test session. For Group RF, the DR for some pigeons fell below .80 on one or more baseline tasks during a test session or two, but the drop was small (*viz.* in the .75–.79 range), temporary, and not cause for concern.

*Test performances.* Figures 1 and 2 show the test results from each Group RF and Group GI pigeon, respectively. The data are averaged

over all eight test sessions except for Pigeon RF1 (run for only two test sessions) and Pigeon RF4 for which one session was excluded from the analysis because the house light burned out during testing. Open circles plot baseline performances on form-form (B-B) matching for Group RF and on hue-hue (C-C) matching with the blue and white stimuli for Group GI and represent the average of a random selection of four baseline matching and four baseline nonmatching trials from each test session. Filled symbols plot the nonreinforced probe-trial performances with red and green samples and comparisons.

Both groups continued to show much higher rates of comparison responding on matching than on nonmatching baseline trials. Of greater interest, of course, are performances on the nonreinforced probe trials used to assess emergent hue-hue identity. In Group RF, every pigeon responded at higher rates on matching than on nonmatching probes. The difference was especially pronounced for Pigeons RF1 and RF4: Their comparison-response rates were 200% higher on matching than on nonmatching probes,  $F(1, 14) = 18.50$  and  $F(1, 54) = 33.56$ , respectively. The differences were noticeably smaller for Pigeons RF2 and RF3, although each difference was also statistically significant in analysis of variance (ANOVA),  $F_s(1, 62) = 9.15$  and 7.76, respectively.

In Group GI, too, every pigeon responded at higher rates on matching than on nonmatching probes, although the difference was statistically significant only for Pigeons GI3 and GI4,  $F_s(1, 62) = 9.63$  and 14.73, respectively. Pigeon GI2 rarely responded on any probe trial from the fifth test session onward; if those sessions are excluded from the analysis, the difference in its matching versus nonmatching response rates was also statistically significant,  $F(1, 30) = 5.51$ .

This experiment yielded two noteworthy findings. First, the test results from Group RF replicate the corresponding results from the comparably trained group (IREF) in Sweeney and Urcuioli (2010). In that experiment and in the present one, baseline training on two symmetrically reinforced (mirror-image) arbitrary successive matching tasks plus identity matching involving one pair of training stimuli (triangle and horizontal forms) yielded emergent identity matching involving the other pair of training stimuli (red and green hues).

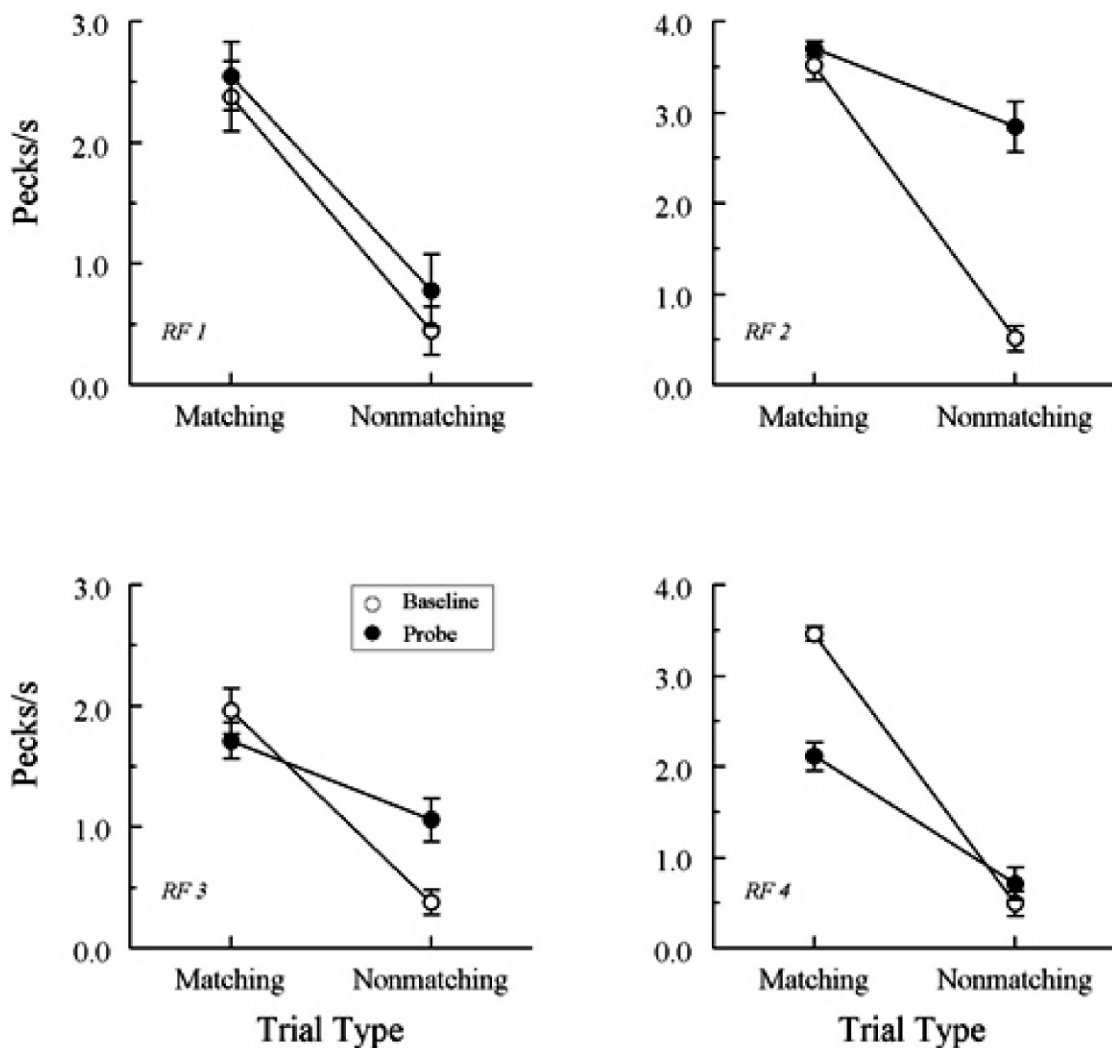


Fig. 1. Comparison pecks/sec ( $\pm 1$  SEM) on form-identity baseline trials (open circles) and nonreinforced hue-hue probe trials (filled circles) averaged over test sessions for each Group RF pigeon in Experiment 1. Matching = trials on which the comparison matched the preceding sample. Nonmatching = trials on which the comparison did not match the preceding sample. Note that the ordinate for 2 of the pigeons (RF1) and RF3) differs from the other 2.

Second, this emergent effect was also evident when baseline identity training involved a pair of stimuli (blue and white hues) that did not appear in either of the two arbitrary baseline tasks. These latter data from Group GI suggest that the emergent effect in both groups may well be an instance of generalized identity matching: Explicit training on identity matching with one set of stimuli generalizes to identity matching with another set of stimuli. If correct, Sweeney and Urcuioli's data do not represent reflexivity, and an appeal to the stimulus class mechanism proposed by Urcuioli

(2008) to account for their results would be unnecessary.

Considering the theoretical importance of the present results and the likelihood of a viable alternative explanation of the Sweeney and Urcuioli (2010) results, the next experiment was designed to provide another independent test of generalized identity matching in Group GI.

## EXPERIMENT 2

In Experiment 1, Group GI learned A-B, B-A, and C-C successive matching and was then tested

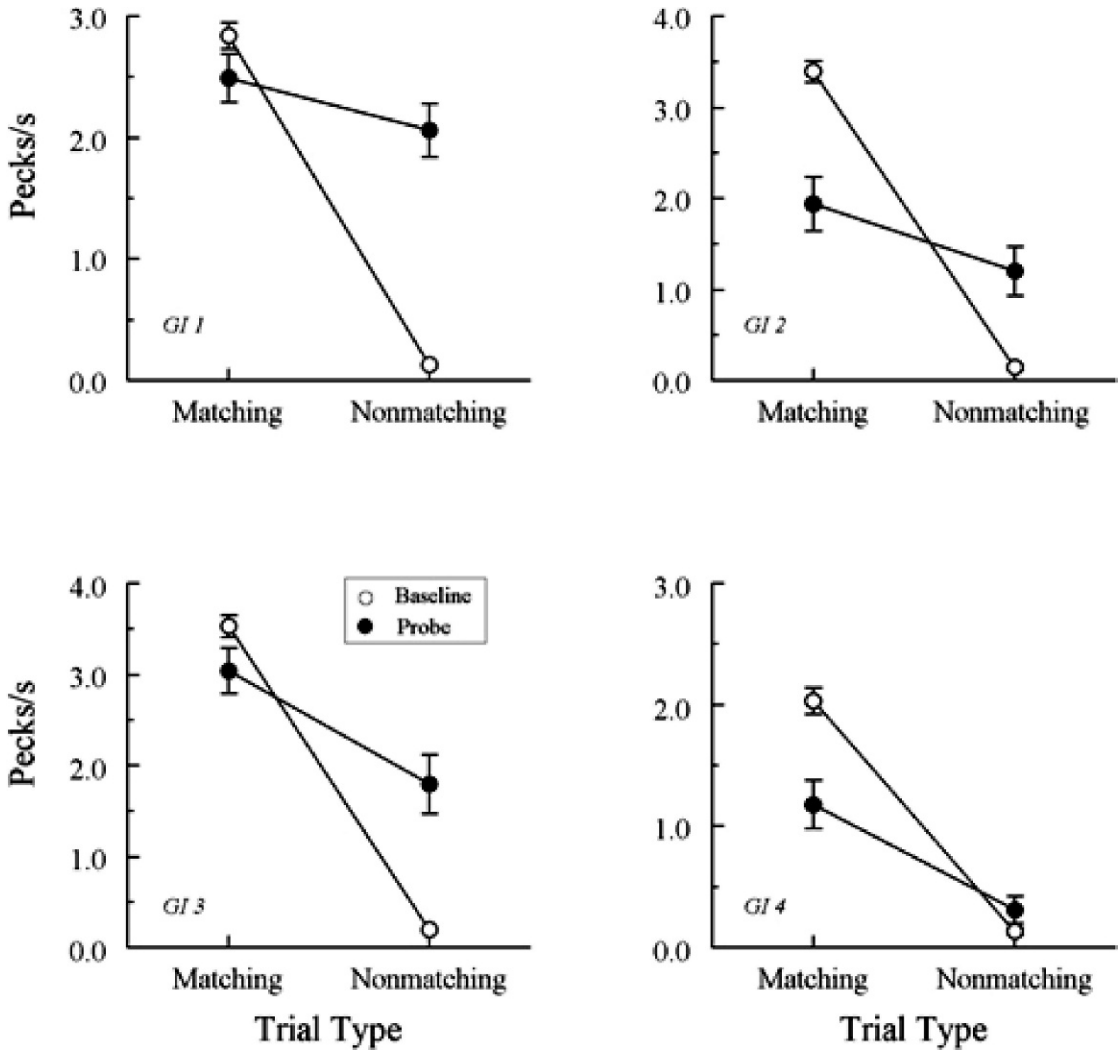


Fig. 2. Comparison pecks/sec ( $\pm 1$  SEM) on hue-identity baseline trials (open circles) and nonreinforced hue-hue probe trials (filled circles) averaged over eight test sessions for each Group GI pigeon in Experiment 1. Matching = trials on which the comparison matched the preceding sample. Nonmatching = trials on which the comparison did not match the preceding sample. Note that the ordinate for 2 of the pigeons (GI1 and GI4) differs from the other 2.

on A-A matching. Their test results indicated that the explicitly trained C-C identity performances generalized to A-A identity performances. If so, a reasonable expectation is that such generalization should also extend to B-B identity matching. In terms of the actual training and test stimuli, the next experiment asked whether explicit training to match blue and white stimuli to one another in successive matching will also yield an untrained ability to match the familiar triangle and horizontal lines to one another.

## METHOD

### *Subjects and Apparatus*

The 4 pigeons from Group GI participated in this experiment. The apparatuses used were the same as those described in Experiment 1.

### *Procedure*

*Baseline retraining.* The Group GI pigeons were returned to the three concurrent successive matching tasks that constituted their baseline training (cf. Table 1) for between



5–15 sessions. Prior to form identity testing, discriminative performance on all three tasks had to be at criterion levels ( $DR \geq .80$ ) for five of six consecutive sessions.

*Form identity testing.* Each pigeon again received a total of eight test sessions, this time with two each of the following (B–B) sample–comparison sequences: T→T, T→H, H→T, and H→H. These nonreinforced form-identity probes were interspersed among 96 baseline trials in a test session. As in Experiment 1, test sessions were run in two-session blocks separated by a minimum of five baseline sessions at criterion levels of performance. Likewise, each baseline trial was presented at least once before the first nonreinforced probe trial, and a minimum of six baseline trials separated successive probe trials.

*Hue identity testing—Part 2.* As a final manipulation and a check on the test results from Experiment 1, each Group GI pigeon received eight additional hue identity test sessions with R→R, R→G, G→R, and G→G probes following the completion of form identity testing and reestablishment of criterion on their baseline tasks. Once again, test sessions were run in two-session blocks and were structured in the same fashion as previously described.

#### RESULTS AND DISCUSSION

*Baseline performances.* Over the last five sessions preceding the first form-identity test, DRs for the hue–form, form–hue, and blue–white identity baseline tasks averaged .93, .95, and .92, respectively. Across the eight form-identity test sessions, DRs for tasks generally ranged from .85–.97. There were some instances in which the DR for a given task fell below .80 but these were seen in only 2 pigeons and occurred on just four sessions between them. Over the last five sessions preceding the first hue identity test, the DRs for the three baseline tasks were .91, .89, and .93, respectively. During these eight test sessions, baseline DRs mostly ranged from .82–.98, and there was only one instance in which a baseline DR fell below .80.

*Test performances.* Figure 3 shows the test results from each Group GI pigeon averaged over the eight form-identity tests. Once again, each pigeon responded in a highly differential fashion to the comparisons on the baseline matching versus nonmatching trials (open circles). On the nonreinforced probe trials

(filled circles), comparison response rates for 3 pigeons were noticeably higher on matching than on nonmatching trials, although the difference was statistically significant only for Pigeon GI2,  $F(1, 62) = 6.33$ .

Figure 4 shows individual results for the second round of hue identity tests. Again, baseline performances (open circles) were well-maintained during testing. Comparison responding on the nonreinforced probe trials (filled circles) was higher on matching than on nonmatching probes for all pigeons except GI3 which responded equally often on both types of test trials. For 2 of the other pigeons (GI 2 and GI4), the differences in probe-trial comparison-response rates were quite substantial,  $F_s(1, 62) = 46.99$  and  $15.63$ , respectively. The difference for the remaining pigeon (GI1), although numerically not as large, was nonetheless statistically significant in ANOVA,  $F(1, 62) = 4.13$ .

In summary, only 1 of the 3 GI pigeons showing evidence of generalized hue identity matching in Experiment 1 showed evidence in Experiment 2 of generalized form identity matching (viz., GI 2). A possible consequential difference between these experiments was the physical similarity/dissimilarity between the probe-trial stimuli and the baseline identity stimuli. The red and green hues used for A–A testing are more similar in appearance to the blue and white hues used in training (e.g., all involved homogeneous displays; see also Wright & Cumming, 1971) than were the triangle and horizontal line B–B test stimuli.

#### GENERAL DISCUSSION

The results of the two experiments reported here suggest that the apparent reflexivity effect in pigeons reported by Sweeney and Urcuioli (2010) may, instead, have been an instance of generalized identity matching. In other words, after explicitly learning identity matching with one set of stimuli during baseline successive matching training, many pigeons exhibited the same discriminative performances with novel matching versus nonmatching combinations of other, familiar stimuli during testing. In Experiment 1, all four Group RF pigeons responded more to the comparisons on matching A–A probe trials than to the comparisons on nonmatching A–A probe trials. In addition, 3 of the 4 Group GI

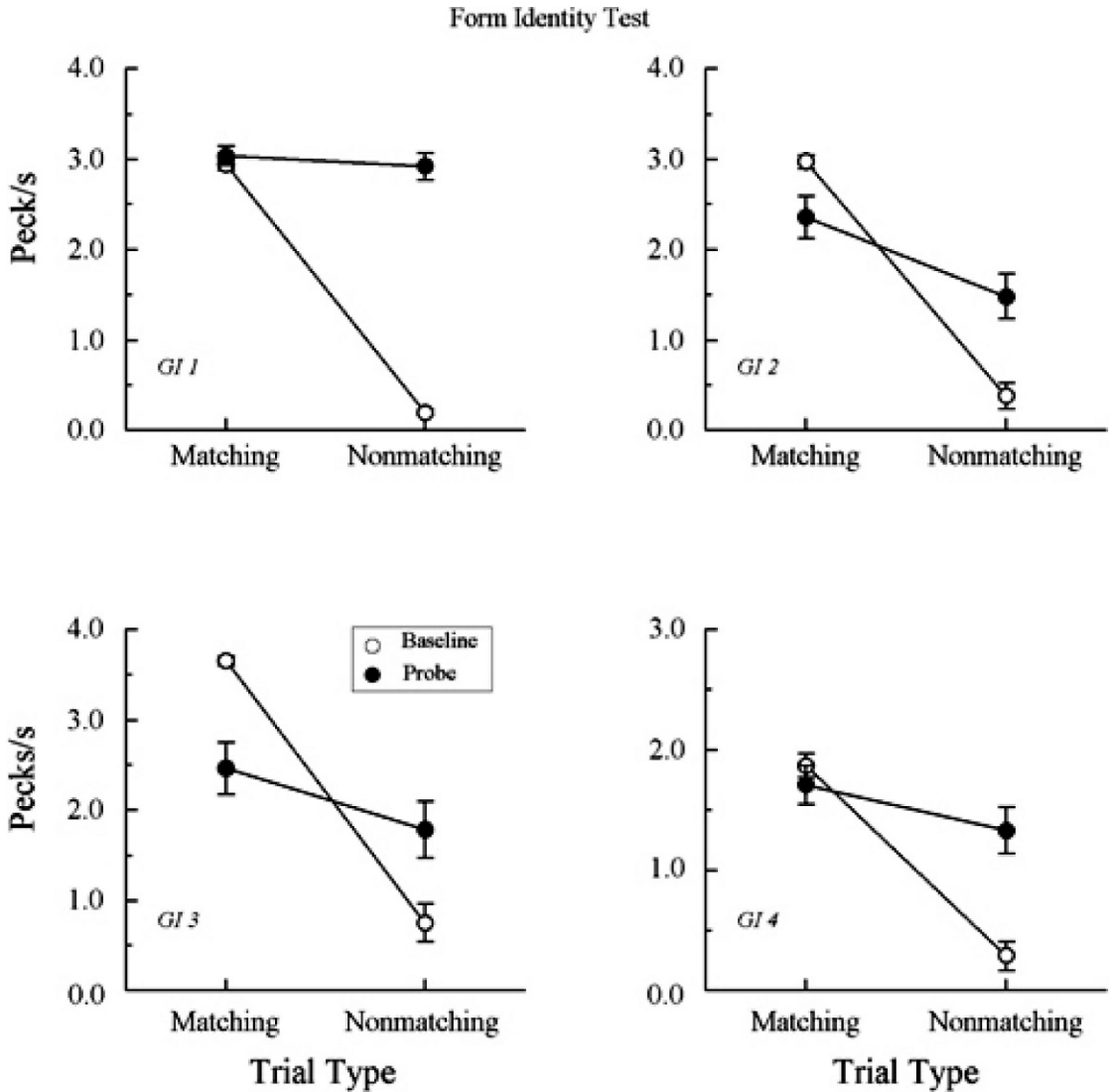


Fig. 3. Comparison pecks/sec ( $\pm 1$  SEM) on hue-identity baseline trials (open circles) and nonreinforced form-form probe trials (filled circles) averaged over the eight test sessions for each Group GI pigeon in Experiment 2. Matching = trials on which the comparison matched the preceding sample. Nonmatching = trials on which the comparison did not match the preceding sample. Note that the ordinate for 1 pigeon (GI4) differs from the other 3.

pigeons showed the same effect. What differed between groups were the stimuli used for baseline identity training: Triangle and horizontal lines (i.e., the same stimuli appearing in the concurrently trained arbitrary matching tasks) for Group RF versus blue and white hues (stimuli not appearing in arbitrary matching) for Group GI. This variable had no noticeable effect on subsequent, nonreinforced A-A probe-trial performances. According to Urcuioli

(2008), the manipulation should have yielded A-A emergent matching in Group RF—which it did—but not in Group GI which, contrary to theoretical prediction, it also did.

Experiment 2 provided another test of generalized identity in Group GI, this time with the familiar triangle and horizontal-line samples and comparisons (i.e., emergent B-B matching). Given the results of Experiment 1, the same pattern of matching versus nonmatch-

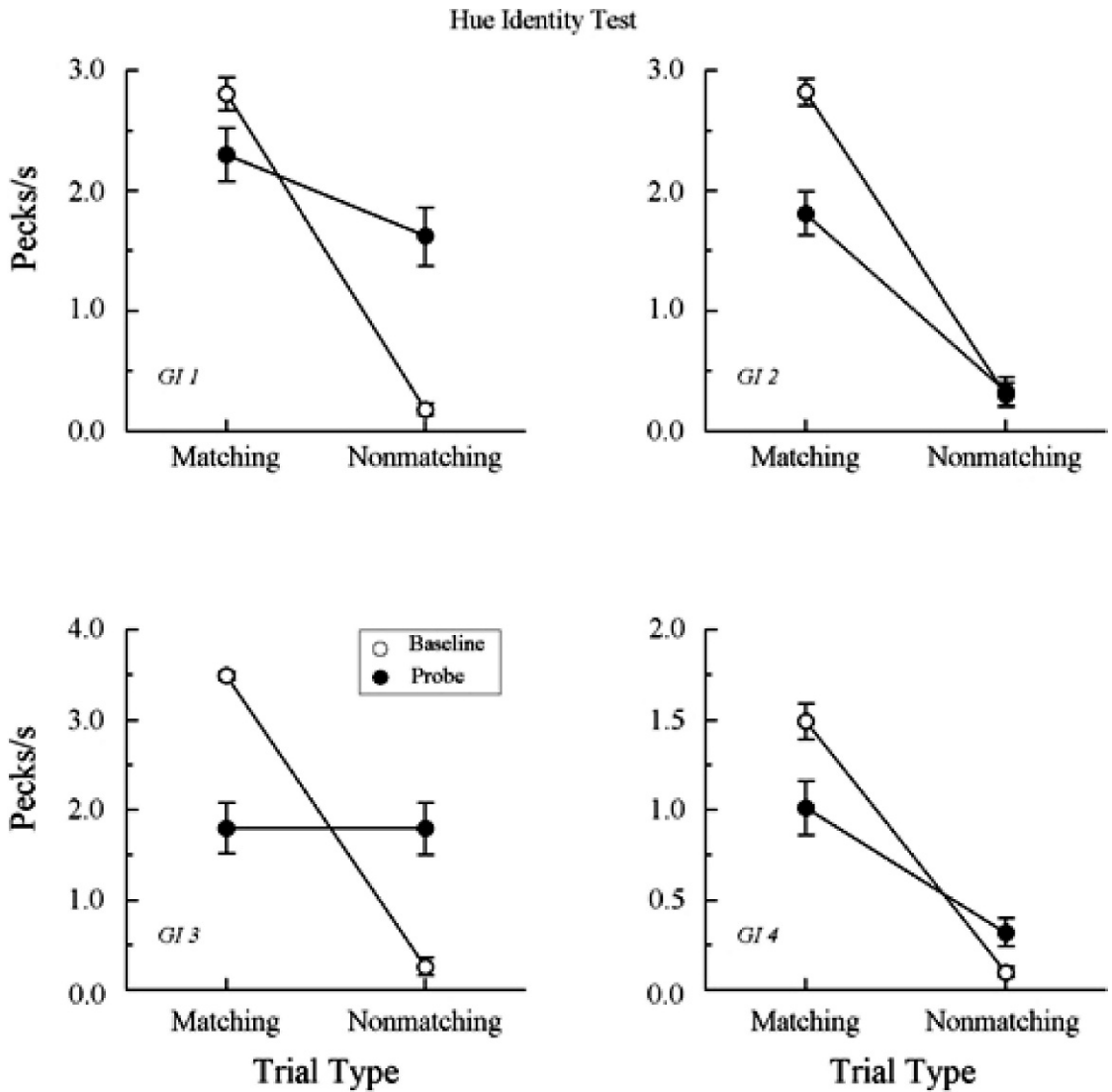


Fig. 4. Comparison pecks/sec ( $\pm 1$  SEM) on hue-identity baseline trials (open circles) and nonreinforced hue-hue probe trials (filled circles) averaged over the eight test sessions for each Group GI pigeon in Experiment 2. Matching = trials on which the comparison matched the preceding sample. Nonmatching = trials on which the comparison did not match the preceding sample. Note that the ordinate for 2 of the pigeons (GI1 and GI2) differs from the other 2.

ing probe-trial differences was expected. Unlike with the red and green probe-trial stimuli, however, only 1 pigeon (GI 2) exhibited an emergent B-B effect. This pigeon was notable in its consistency by showing emergent A-A matching in Experiment 1, B-B matching in Experiment 2, and reproducing its response-rate difference on A-A matching when retested on those emergent relations in Experiment 2.

The pattern of test results was far less consistent within and between the other Group GI

pigeons, however. Probe-trial performance by Pigeon GI 4 on its second A-A test resembled its performance on the A-A test in Experiment 1 (like GI 2), but it did not show emergent B-B matching in Experiment 2. Pigeon GI 1 showed no evidence of emergent A-A matching in Experiment 1, no evidence of emergent B-B matching in Experiment 2, but an A-A effect upon retesting in Experiment 2. Finally, GI 3 showed a clear emergent A-A effect in Experiment 1 but no evidence for emergent B-B

matching in Experiment 2 and it did not reproduce its initial A–A test performances.

A consistent pattern of A–A and B–B results like that shown by Pigeon GI 2 would have been a more compelling argument for a generalized identity interpretation of the results. Nevertheless, the variability observed in Group GI should not obscure the fact that the probe-trial differences, when observed, are another example of derived relational responding in pigeons (e.g., Frank & Wasserman, 2005; Urcuioli, 2008). Moreover, if the data interpretation is accurate, the results are unusual and noteworthy given that generalized identity and same/different matching in pigeons are, at best, difficult to observe when baseline training involves only a small number of exemplars (Wright, 1997; Wright & Katz, 2006; but see Blaisdell & Cook, 2005; Cook, Kelly, & Katz, 2003). Here, the number of reinforced identity exemplars during baseline training was the smallest possible: two.

More noteworthy, perhaps, is that Group GI's positive test results raise important questions about the mechanism(s) of pigeons' stimulus-class formation proposed by Urcuioli (2008). Central to that theoretical account is the assumption that the functional stimuli in successive matching are the nominal matching stimuli (e.g., red, green, etc.) plus their ordinal position within a trial—i.e., whether a given stimulus appears first (as a sample) or second (as a comparison). Thus, a red sample (R1) is functionally different than a red comparison (R2). Urcuioli's theoretical account also proposes that pigeons will show emergent effects like symmetry, reflexivity, etc. when (1) their baseline training generates classes of reinforced stimuli that have members in common, and (2) those common members cause their respective classes to merge, thus yielding larger classes containing the elements appearing on the emergent relations test.

These assumptions accurately predict the test results observed in Group RF. But the corresponding (positive) test results from Group GI are not predicted because identity training with stimuli not appearing in the concurrently trained arbitrary matching tasks cannot yield the class merger necessary to obtain the observed emergent effects. Furthermore, the theory states that the arbitrary matching tasks by themselves (namely A–B and B–A) cannot support emergent (A–A or B–B) effects because the functional-stimulus

designations of those tasks are A1–B2 and B1–A2, where “1” and “2” represent a stimulus' ordinal position as a sample or comparison. Note the implicit lack of common elements in such a designation.

An alternative view is that the emergent effect observed in Group RF reflects the stimulus-class mechanisms proposed by Urcuioli (2008), whereas generalized identity explains the corresponding results from Group GI in Experiments 1 and 2. Of course, this view raises more questions than answers. Besides, without more discerning data than provided here, it is clearly unparsimonious and obviously unsubstantiated.

There is, however, another plausible account that appears to fit the test results in both groups quite well—viz., transitivity (D'Amato et al., 1985; Kuno, Kitadate, & Iwamoto, 1994; Steirn, Jackson-Smith, & Zentall, 1991; Strasser, Ehrlinger, & Bingman, 2004). Ignoring or rejecting the functional stimulus assumption of Urcuioli (2008), the baseline A–B and B–A arbitrary matching tasks would properly be represented as “A–B” and B–A”. For instance, pigeons may learn in baseline training that responding to a triangle is reinforced after red (an example of A–B) and vice versa (B–A). If the learned [red–triangle] and [triangle–red] conditional relations are transitive, pigeons should then preferentially respond to red after red (and to triangle after triangle) in testing. Stated otherwise, A–A (and B–B) matching should emerge in testing if the baseline A–B and B–A relations are transitive. This account predicts that the emergent effects reported here do not require identity baseline training of any type. It also fits the pattern of results shown by Group IREF in Sweeney and Urcuioli (2010) and presents another challenge to the stimulus-class formation assumptions of Urcuioli (2008). Future research will examine whether transitivity is a viable alternative to generalized identity as an explanation of the present successive matching findings and those of Sweeney and Urcuioli.

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Received: March 22, 2011

Final Acceptance: July 28, 2011