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Emergent Identity Matching after Successive Matching Training:
Reflexivity or Generalized Identity?

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Running head: Reflexivity versus Generalized Identity

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Abstract

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 non-reinforced probe tests, all pigeons in the former group and most pigeons in the latter group responded more to the comparisons on matching than on non-matching red-green probes. In Experiment 2, the latter group was tested on non-reinforced form-form probes. One of the four pigeons responded significantly more to the comparisons on matching than on non-matching 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

Emergent Identity Matching after Successive Matching Training:

Reflexivity or Generalized Identity?

This paper 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 pre-experimental history in which they've 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 & Tailby, 1982; Sidman, 1990, 1992) and others (e.g., 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 non-human animals given our substantially greater control over, and knowledge, of subjects' pre-experimental histories. Moreover, a recent theory of equivalence-class formation (Urcuioli, 2008) specifies the particular sets of training relations that should yield reflexivity in pigeons, 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 non-reinforcement independent of the level of go/no-go discriminative performances. Urcuioli (2008) proposed that this continual juxtaposition of non-reinforced 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 \rightarrow triangle comparison and green sample \rightarrow horizontal-lines comparison (A-B successive matching); triangle sample \rightarrow red comparison and horizontal-lines sample \rightarrow green comparison (B-A successive matching); and triangle sample \rightarrow triangle comparison and horizontal-lines sample \rightarrow 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 four-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 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 (2010) represent reflexivity via the stimulus class mechanism proposed by Urcuioli (2008), then comparison response rates should be higher on matching than on non-matching 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 14h-10h 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 four 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 one 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 x 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 pseudo-random 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 non-reinforced. The reinforced and non-reinforced 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 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 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 non-reinforced 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 (non-reinforced 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 non-reinforced 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 5 of 6 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 one received 8 test sessions, each consisting of 96 baseline trials distributed equally across the three baseline tasks and 8 non-reinforced (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 5 baseline sessions at criterion levels of performance (viz., DRs ≥ 0.80 for all three baseline tasks for 5 of 6 consecutive sessions). In every test session, each of the 12 possible baseline trials was presented at least once prior to the first non-reinforced 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 non-matching (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 re-establish 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 0.84, 0.87, and 0.89, respectively, a statistically non-significant 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 0.94, 0.93, and 0.92, 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 0.80 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 task 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 8 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 non-matching trials from each test session. Filled symbols plot the non-reinforced 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 non-matching baseline trials. Of greater interest, of course, are performances on the non-reinforced probe trials used to assess emergent hue-hue identity. In Group RF, every pigeon responded at higher rates on matching than on non-matching probes. The difference was

especially pronounced for pigeons RF1 and RF4: Their comparison-response rates were 200% higher on matching than on non-matching 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 non-matching 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 non-matching 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). 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 was then tested 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 four pigeons from Group GI participated in this experiment. The apparatuses used were the same as those described in Experiment 1.

Procedure

Baseline re-training. 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 5 of 6 consecutive sessions.

Form identity testing. Each pigeon again received a total of 8 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 non-reinforced 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 5 baseline sessions at criterion levels of performance. Likewise, each baseline trial was presented at least once before the first non-reinforced probe trial, and a minimum of 6 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 8 additional hue identity test sessions with R→R, R→G, G→R, and G→G probes following the completion of form identity testing and re-establishment 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 0.93, 0.95, and 0.92, respectively. Across the 8 form identity test sessions, DRs for tasks generally ranged from 0.85 – 0.97. There were some instances in which the DR for a given task fell below 0.80 but these were seen in only two 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 0.91, 0.89, and 0.93, respectively. During these 8 test sessions, baseline DRs mostly ranged from 0.82 – 0.98, and there was only one instance in which a baseline DR fell below 0.80.

Test performances. Figure 3 shows the test results from each Group GI pigeon averaged over the 8 form identity tests. Once again, each pigeon responded in a highly differential fashion

to the comparisons on the baseline matching versus non-matching trials (open circles). On the non-reinforced probe trials (filled circles), comparison response rates for three pigeons were noticeably higher on matching than on non-matching 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 non-reinforced probe trials (filled circles) was higher on matching than on non-matching probes for all pigeons except GI3 which responded equally often on both types of test trials. For two of the other pigeons (GI 2 and GI4), the difference 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 one of the three 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 suggested 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 non-matching 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 non-matching A-A probe trials. In addition, three of the four Group GI 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, non-reinforced 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., on emergent B-B matching). Given the results of Experiment 1, the same pattern of matching versus non-matching probe-trial differences was expected. Unlike with the red and green probe-trial stimuli, however, only one 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 re-tested on those emergent relations in Experiment 2.

The pattern of test results was far less consistent within and between and 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-

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 re-testing 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 – 2.

More noteworthy, perhaps, is that Group GI's positive test results raise important questions about mechanism(s) of pigeons' stimulus-class formation proposed by Urcuioli (2008). Central to that theoretical account is the assumption that the functional stimuli in tasks such as successive matching are comprised of 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 (viz., A-B and B-A) cannot support emergent (A-A or B-B) effects because the functional-stimulus definition of those tasks designate them as 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 (2010).

References

- Barnes, D. (1994). Stimulus equivalence and relational frame theory. *The Psychological Record, 44*, 91-124.
- Barros, R., Galvão, O., & McIlvane, W. J. (2002). Generalized identity matching-to-sample in *cebus apella*. *The Psychological Record, 52*, 441-460.
- Blaisdell, A. P., & Cook, R. G. (2005). Two-item same-different concept learning in pigeons. *Learning & Behavior, 33*, 67-77.
- Cook, R. G., Kelly, D. M., & Katz, J. S. (2003). Successive two-item same-different discrimination and concept learning by pigeons. *Behavioural Processes, 62*, 125-144.
- D'Amato, M. R., Salmon, D. P., Loukas, E., & Tomie, A. (1985). Symmetry and transitivity in the conditional relations in monkeys (*Cebus apella*) and pigeons (*Columba livia*). *Journal of the Experimental Analysis of Behavior, 44*, 35-47.
- Dube, W. V., & McIlvane, W. J. (1992). An analysis of generalized identity matching-to-sample test procedures. *The Psychological Record, 42*, 17-26.
- Frank, A. J., & Wasserman, E. A. (2005). Associative symmetry in the pigeon after successive matching-to-sample training. *Journal of the Experimental Analysis of Behavior, 84*, 147-165.
- Hayes, S. C. (1991). A relational control theory of stimulus equivalence. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 19-40). Reno, NV: Context Press.
- Konorski, J. (1959). A new method of physiological investigation of recent memory in animals. *Bulletin de L'Academie Polonaise des Sciences, 7*, 115-117.

Kuno, H., Kitadate, T., & Iwamoto, T., (1994). Formation of transitivity in conditional matching to sample by pigeons. *Journal of the Experimental Analysis of Behavior*, 62, 399-408.

Lionello-DeNolf, K. M., & Urcuioli, P. J. (2002). Stimulus control topographies and tests of symmetry in pigeons. *Journal of the Experimental Analysis of Behavior*, 78, 467-495.

Lipkens, R., Kop, P. F. M., & Matthijs, W. (1988). A test of symmetry and transitivity in the conditional discrimination performances of pigeons. *Journal of the Experimental Analysis of Behavior*, 49, 395-409.

Oden, D. L., Thompson, R. K. R., & Premack, D. (1988). Spontaneous transfer of matching by infant chimpanzees (*Pan troglodytes*). *Journal of Experimental Psychology: Animal Behavior Processes*, 14, 140-145.

Peña, T., Pitts, R. C., & Galizio, M. (2006). Identity matching-to-sample with olfactory stimuli in rats. *Journal of the Experimental Analysis of Behavior*, 85, 203-221.

Saunders, R. R., & Green, G. (1992). The nonequivalence of behavioral and mathematical equivalence. *Journal of the Experimental Analysis of Behavior*, 57, 227-241.

Sidman, M. (1990). Equivalence relations: Where do they come from? In H. Lejeune & D. Blackman (Eds.), *Behavior analysis in theory and practice: Contributions and controversies* (pp. 93-114). Hillsdale, NJ: Erlbaum.

Sidman, M. (1992). Equivalence relations: Some basic considerations. In S. C. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 15-27). Reno, NV: Context Press.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching-to-sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, 37, 5-22.

Steirn, J. N., Jackson-Smith, P., & Zentall, T. R. (1991). Mediation use of internal representations of food and no-food events by pigeons. *Learning and Motivation, 22*, 353-365.

Strasser, R., Ehrlinger, J. M., & Bingman, V. P. (2004). Transitive behavior in hippocampal-lesioned pigeons. *Brain, Behavior, and Evolution, 63*, 181-188.

Sweeney, M. M., & Urcuioli, P. J. (2010). A reflexivity effect in pigeons. *Journal of the Experimental Analysis of Behavior, 94*, 267-282

Urcuioli, P. J. (2008). Associative symmetry, “anti-symmetry”, and a theory of pigeons’ equivalence-class formation. *Journal of the Experimental Analysis of Behavior, 90*, 257-282.

Wasserman, E. A. (1976). Successive matching-to-sample in the pigeon: Variation on a theme by Konorski. *Behavior Research Methods & Instrumentation, 8*, 278-282.

Wright, A. A. (1997). Concept learning and learning strategies. *Psychological Science, 8*, 119-123.

Wright, A. A., & Cumming, W. W. (1971). Color-naming functions for the pigeon. *Journal of the Experimental Analysis of Behavior, 15*, 7-17.

Wright, A. A., & Katz, J. S. (2006). Mechanisms of *same/different* concept learning in primates and avians. *Behavioural Processes, 72*, 234-254.

Zentall, T. R. (1998). Symbolic representation in animals: Emergent stimulus relations in conditional discrimination learning. *Animal Learning & Behavior, 26*, 363-377.

Table 1

Successive Matching Training Contingencies for the Two Groups in Experiment 1

<i>Group RF</i>		
<u>Hue-Form (A-B) Matching</u>	<u>Form-Hue (B-A) Matching</u>	<u>Form-Form (B-B) Identity</u>
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 5 s
A1 → B1 +	B1 → A1 +	B1 → B1 +
A1 → B2 -	B2 → A1 -	B1 → B2 -
A2 → B2 -	B1 → A2 -	B2 → B1 -
A2 → B2 +	B2 → A2 +	B2 → B2 +
<i>Group GI</i>		
<u>Hue-Form (A-B) Matching</u>	<u>Form-Hue (B-A) Matching</u>	<u>Hue-Hue (C-C) Identity</u>
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 → B - FI 5 s
A1 → B1 +	B1 → A1 +	C1 → C1 +
A1 → B2 -	B2 → A1 -	C1 → C2 -
A2 → B2 -	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 = non-reinforced, A and C = hue, B = form, 1 and 2 = individual hue (or form) stimuli, + = reinforced, - = non-reinforced. 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.

Author Note

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Figure Captions

Figure 1. Comparison pecks/sec (± 1 SEM) on form-identity baseline trials (open circles) and non-reinforced hue-hue probe trials (filled circles) averaged over the 8 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 two of the pigeons (RF1) and RF3) differs from the other two.

Figure 2. Comparison pecks/sec (± 1 SEM) on hue-identity baseline trials (open circles) and non-reinforced hue-hue probe trials (filled circles) averaged over the 8 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 two of the pigeons (GI1 and GI4) differs from the other two.

Figure 3. Comparison pecks/sec (± 1 SEM) on hue-identity baseline trials (open circles) and non-reinforced probe trials (filled circles) averaged over the 8 form-form 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 one pigeon (GI3) differs from the other three.

Figure 4. Comparison pecks/sec (± 1 SEM) on hue-identity baseline trials (open circles) and non-reinforced probe trials (filled circles) averaged over the 8 hue-hue 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 two of the pigeons (GI1 and GI2) differs from the other two.

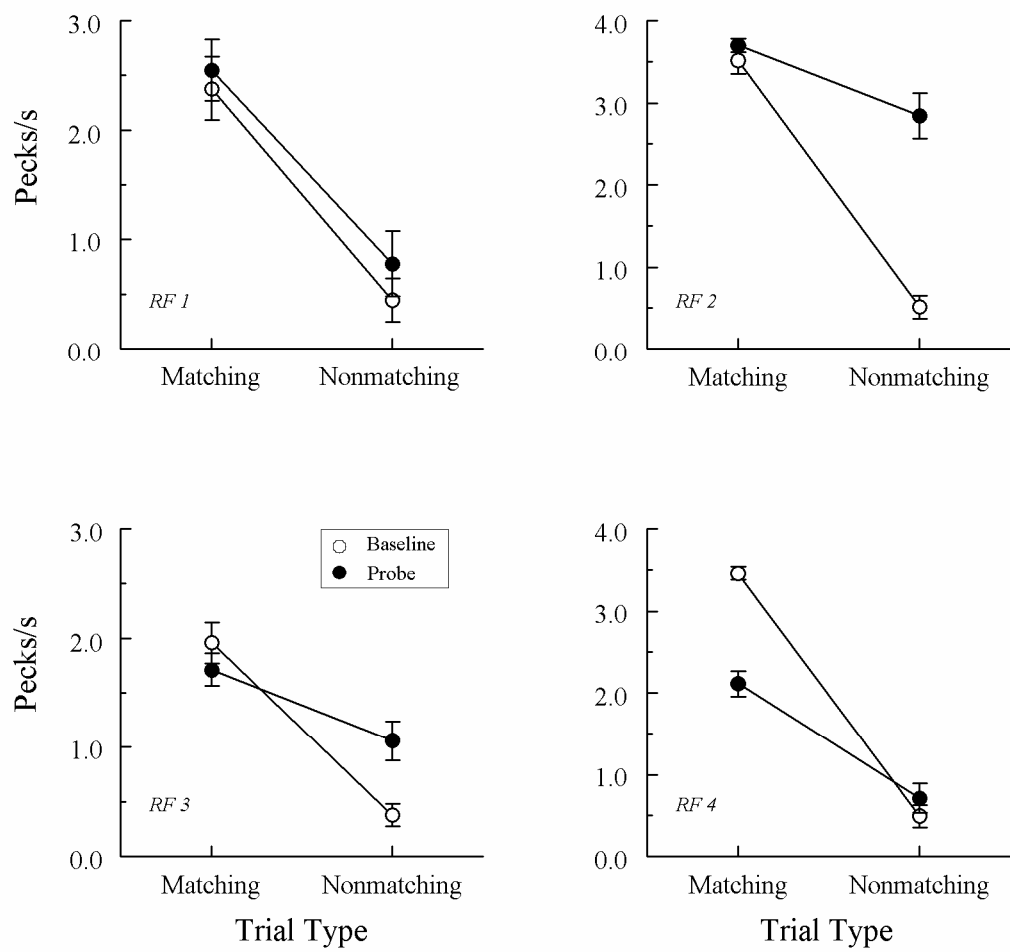


Figure 1

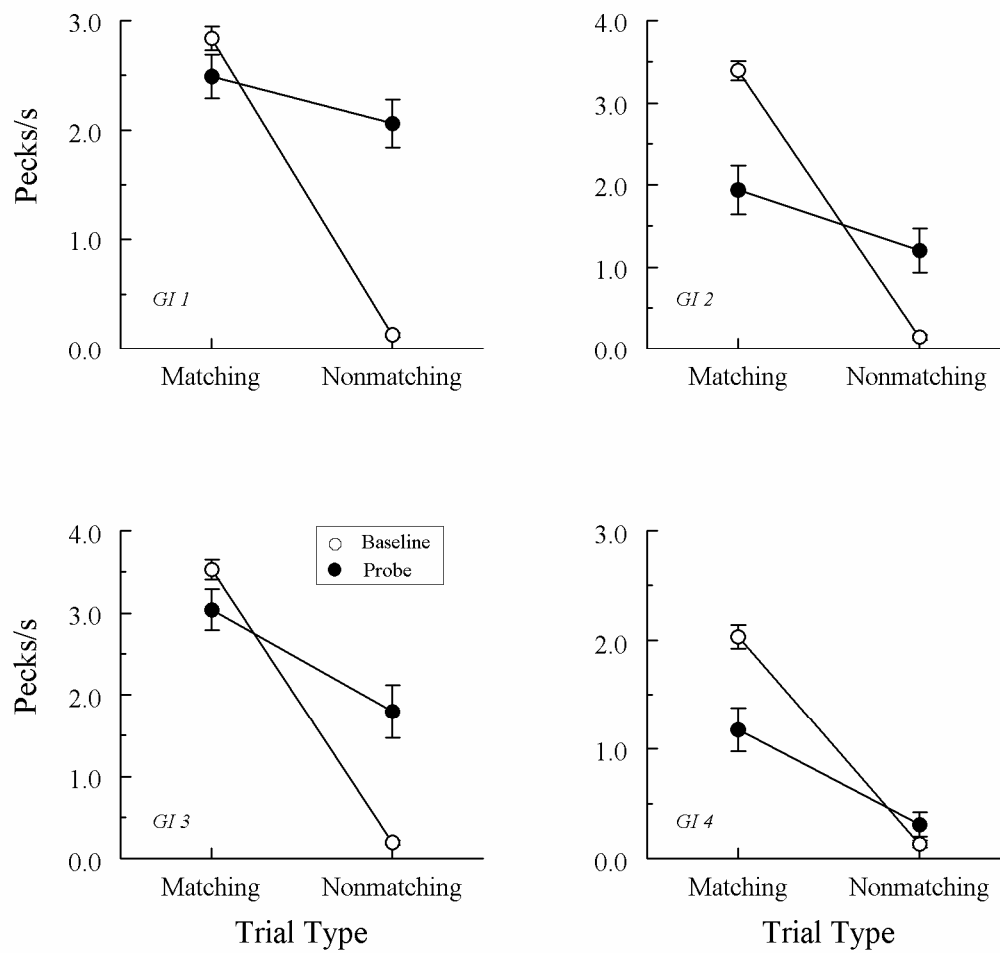


Figure 2

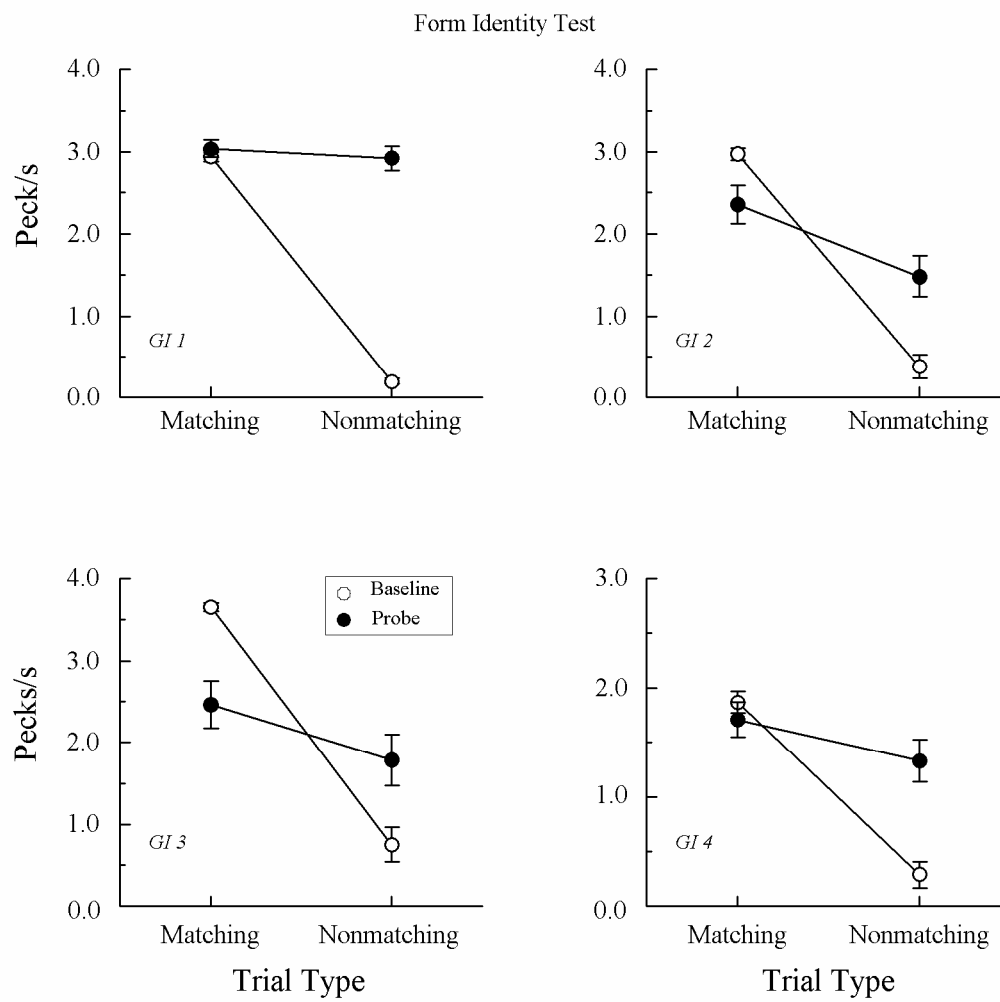


Figure 3

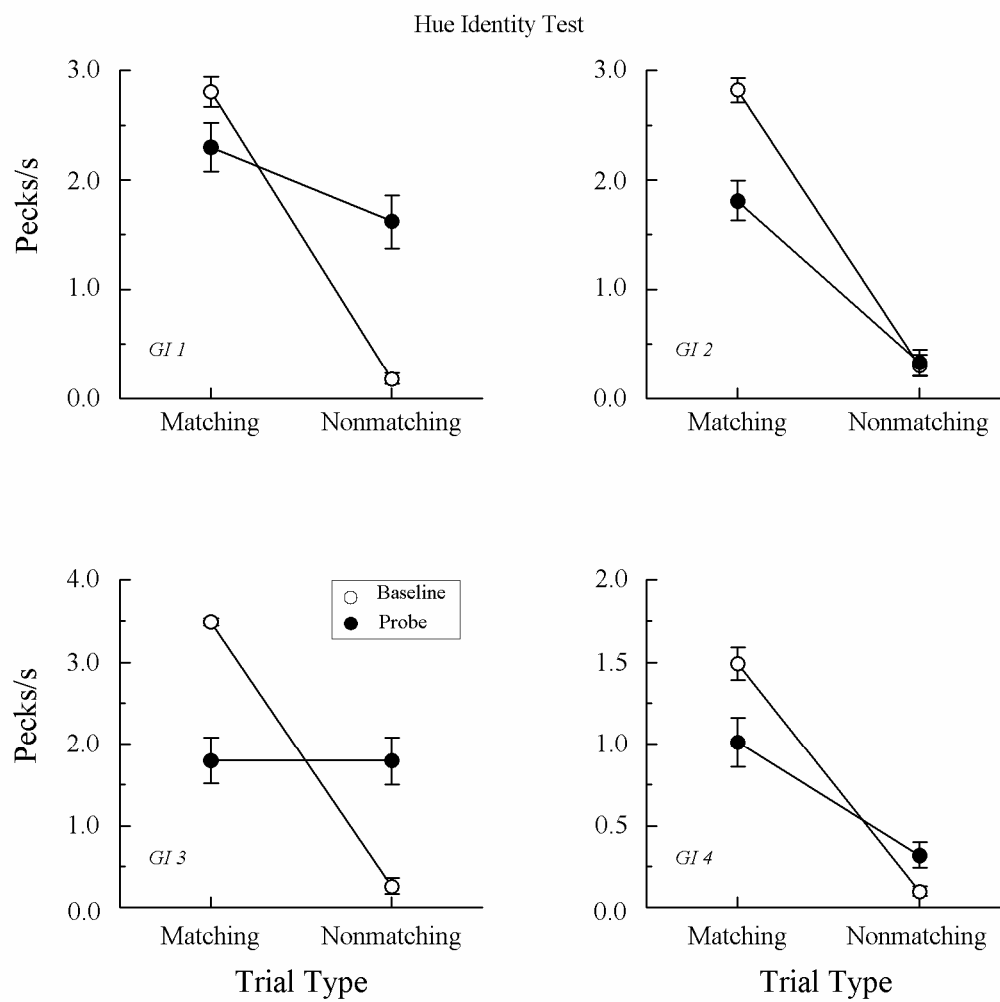


Figure 4