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DISCRIMINATION TRIALS TO INFLUENCE SELF-AWARENESS

by

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ABSTRACT
DISCRIMINATION TRIALS TO INFLUENCE SELF-AWARENESS

by

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The University of Wisconsin-Milwaukee, 2013
Under the Supervision of Professor John C. Moore

Humans often use terms and concepts that include self- as prefix in an effort to explain their behavior (e.g., self-awareness, self-control) (Goldiamond, 1959, 1962, 1965, 1966; Nisbett & Wilson, 1977). Although there are many ways to interpret such terms, they all seem to involve circumstances in which individuals' own prior behavior is discriminative for their subsequent behavior. Behavior under the discriminative control of other behavior may be a kind of self-report (Skinner, 1957). The concepts of self-awareness and self-report can be studied as a behavioral process, without mentalistic inference. In the present research, pigeons were trained in a compound, discrete-trial procedure. The first component of a trial was a conventional matching to sample (MTS) component. The second component was a probe in which the pigeons were presented with two further stimuli, responses to one of which were reinforced conditional on correct performance in the prior matching component. Pigeons' baseline MTS accuracy was 65% on average. In certain conditions after the probe component was added, accuracy increased to above 85% on the MTS and 75% on the probe components, indicating pigeons' own prior behavior can indeed become discriminative for their subsequent behavior. The procedure appears promising as a means for assisting individuals with mental health needs to better come under the discriminative control of the outcomes of their own prior behavior.

Keywords: self-awareness, subsequent behavior, second order contingencies

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0-second Delayed Matching to Sample (0-s DMTS)

centimeter (cm)

Delayed Matching to Sample (DMTS)

Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR)

Differential Reinforcement of Low Rate (DRL)

Differential Reinforcement of Other Behavior (DRO)

Fixed Interval (FI)

Fixed Ratio (FR)

hour (h)

Institute of Electrical and Electronics Engineers (IEEE)

Inter-Response Time (IRT)

Inter-Trial Interval (ITI)

Matching to Sample (MTS)

millisecond (ms)

Newton (N)

n-seconds Delayed Matching to Sample (*n*-s DMTS)

seconds (s)

Simultaneous Matching to Sample (SMTS)

Variable Ratio (VR)

Variable Interval (VI)

watt (W)

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Discrimination Trials to Influence Self-Awareness

Humans and non-humans behave according to the reinforcement contingencies they experience during their lifetime. If the environment changes faster than the rate at which behavior can be selected, appropriate responding and perhaps even survival are less probable. Thus, humans and non-humans demonstrate a phylogenetic advantage when their behavior comes under the discriminative control of the contingencies that govern it. Organisms show an "enormous evolutionary advantage" (Killeen, 1981, p. 91) when their subsequent behavior is based on previous behavior that is under discriminative control of the environment, known as second order discrimination. As Killeen (1978) put it, learning continues to evolve to "keep animals en rapport with the causal structure of their environments" (p. 88). This relation can be called "self-awareness" (Eisler, 1984; Shimp, 1983).

Yet, humans and non-humans often lack awareness and accuracy of discriminations based on their behavior (Goldiamond, 1959, 1962, 1965, 1966; Nisbett & Wilson, 1977). Humans tend to make erroneous "implicit a priori theories about causal connections" (Nisbett & Wilson, 1977, p. 233). Studies requiring vocal descriptions of causal relations between behavior and environment continue to demonstrate this weakness. Participants tend to inaccurately report if and when behavior occurs, and if and when behavior changes. In addition, they often incorrectly identify the stimuli that produce or follow a response (Goldiamond, 1959, 1962, 1965, 1966; Nisbett & Wilson, 1977). Inaccurate reports of behavior lead to inaccurate discriminations based on their behavior (Nisbett & Wilson, 1977). Non-humans also often lack self-awareness of their

behavior. When they inaccurately identify causal connections, the resulting decrease in food and water supply and protection and shelter, lead to a decrease in survival rate.

Much of the current applied and basic literature on self-awareness uses mediating or cognitive processes to explain behavior and its effect on the environment. For example, "structures of consciousness" are created, describes, and attributed to cause behavior change (e.g., Ford & Smith, 2006). Common schemas attempt to identify self-awareness through designing either "introspection" or "memory" based tasks. Prospective memory is a category used to describe "remembering to carry out intended actions at an appropriate point in the future" (McDaniel & Einstein, 2007, p. 1), and such activities are considered "critical to maintaining life" (p. 2). The concept of "self" is very important to mediating constructs, as the "self" is the means by which these studies attempt to articulate behavior change. Although these studies do show methods towards an investigation, they fail to identify the appropriate processes that occasion and maintain the intended action, as their explanations are circular: They create a hypothetical construct, and then identify the construct as the cause. For example, the "self" as a "structure of consciousness" is required to initiate intended future action. When recall of intended future action is successful, the "self" is identified as the process that recalled the necessary information based on the hypotheses of such experiments. When recall of intended future action is unsuccessful, a lack of self is the cause.

Behaviorism "does not deny the possibility of self-observation or self-knowledge or its possible usefulness" (Skinner, 1974, p. 18). An awareness of how prior behavior becomes discriminative for subsequent behavior "makes it possible to examine the effect of the world within the skin and the nature of self-knowledge" (Skinner, 1974, p. 19).

Behavior under the discriminative control of other behavior may be a kind of self-report (Skinner, 1957). A self-report of individual behavior provides a useful phylogenetic advantage to that organism. Self-report commonly involves a description of the behavior that was emitted and the contingencies that govern the behavior. Self-reports can provide "clues (1) to past behavior and the conditions affecting it, (2) to current behavior and the conditions affecting it, and (3) to conditions related to future behavior" (Skinner, 1974, p. 35). The organism's behavior is occasioned according to the contingencies in effect, and therefore supplemental behavior can provide information as to the environmental context in which behavior is adaptive.

Applied Research

Typically developing children and adults demonstrate an adaptive arrangement of antecedent stimuli, responses, and subsequent responding, according to environmental control and environmental change. Children may engage in less bed wetting, thumb sucking, nail biting, motor tics, and other habits as they age. Adults often write to-do lists as a means of accomplishing their tasks, arrange cues to buy groceries, and place their keys in a specific location. Whether or not these individuals are aware of the discriminative functions of these stimuli and behaviors, these individuals are still relatively successful at arranging their environments accordingly based on previous behavior.

Individuals who often demonstrate mental health needs (e.g., those with Depression), inappropriate responding (e.g., those with Autism), or who tend to be labeled according to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR, American Psychiatric Association, 2000) may present as "disadvantaged" or less

successful at environmental awareness. In the clinical setting, these clients show a general lack of awareness of their previous and current behavior, or the contingencies under which their behavior occurs (Kohlenberg & Tsai, 2007). Such concerns may limit their access to primary and secondary reinforcement, maintain their current behavior on negative reinforcement paradigms, interfere with behavior acquisition, and result in overall health problems or health decrement due to other factors (e.g., taking medication, limited autonomy). Individuals' diagnostic behaviors that have been studied in relation to the presence or absence of self-awareness and/or self-report include: (a) Developmental disorders [(e.g., motor tics (Woods et al., 1996), stuttering (LaCroix, 1973), dyslexia, trichotillomania (e.g., Friman, Finney, & Christopherson, 1984), nail biting (Ladouceur, 1979), thumb or finger sucking (Ellingson, et al., 2000; Stricker, Miltenberger, Garlinghouse, Deaver, & Anderson, 2001) Tourette's, ADHD (Neef, Bicard, & Endo, 2001), autism, Asperger's, and the other pervasive developmental disorders (Dixon & Cummings, 2001; Tiger, Fisher, & Bouxsein, 2009)]; (b) Cognitive disorders (e.g., dementia; Alzheimer's; Parkinson's; Huntington's disease); (c) Substance and drug related abuse; (d) Psychotic, Mood, and Anxiety disorders; (e) Eating disorders (Critchfield & Kollins, 2001); and (f) sleeping disorders.

Research has demonstrated that such individuals tend to lack awareness of their previous and current behavior, which in turn prevents behavior change from occurring and being successful. Such individuals therefore do not engage in behavior oriented at arranging their environment for subsequent action by themselves or others. These individuals would clearly benefit from discrimination trials that arrange for second order

discriminations, or behavior under the control of behavior that is under discriminative control of the environment.

Most organisms, if not all, may benefit from their prior behavior becoming discriminative for subsequent behavior. Non-humans can adjust their current and future behavior to accommodate a changing environment. They may gather food and water or seek shelter in a different manner or location, or at a different time of the day. Humans with verbal behavior can report a contingency or tact the behavior that was recently emitted. Yet with humans, "the relationship between behavior and a subject's verbal characterization of that behavior has been…exceedingly controversial" (Shimp, 1983, p. 61), as these relations are complex. The investigation between behavior, its controlling contingencies, and a self-report of such contingencies may benefit from analyses independent of verbal behavior with human animals. Using non-human animals eliminates expectancy and demand effects, and allows "better control of the environment, prior history of the subjects, and their genetic endowment" (Moore, 2008, p. 256). Below, the basic studies that have investigated the extent to which non-humans exhibit self-awareness so interpreted are reviewed.

Basic Research

Initial studies on self-awareness with non-humans were designed using primates to procedurally attribute a "self-concept." Chimpanzees and apes as "higher ordered" primates were often used as subjects. After the primate was placed under anesthesia, an object (usually a colored dot) would be placed in an inconspicuous location on its body. Provided with a mirror, primates demonstrated that they could locate the dot on their bodies. This was a supposed sign of "self-recognition," "self-awareness," and a "self-

concept" because the primate could not see the dot directly. As such, scientists believed this to show "qualitative psychological difference among primates" (Gallup, 1970, p. 87), because "lower ordered" primates (such as monkeys) could not demonstrate such "self-directed behavior." They "lack a cognitive category that is essential for processing mirror information about themselves…lack a sense of identity and a sufficiently well-integrated self-concept" (Gallup, 1979, p. 420).

Epstein, Lanza, and Skinner (1981) demonstrated that such an experiment was not a mentalistic attribution account specific to only "higher ordered" organisms. In their research, three pigeons served as subjects in a standard operant chamber. Using a mirror positioned on the chamber wall, pigeons were trained to locate a blue dot on its body. The dots were placed on various locations, one at a time, which the pigeons could not see directly. In just ten days, the pigeons were trained to scan their bodies, locate the dot using the mirror, and peck at the dot for food reinforcement. According to Epstein, Lanza, and Skinner (1981), this result demonstrated that even lower ordered organisms' behavior can come under the control of "self-awareness" contingencies when such contingencies are explicit.

Events that have been conditioned to function as discriminative stimuli for non-human animals to evoke self-awareness behavior include lights and tones (Jans & Catania, 1980), locations of stimuli (Jitsumori & Sugimoto, 1982), temporal patterns of previous responses (Shimp, 1981, 1983), reinforcement schedules (Lattal, 1975; Rilling & McDiarmid, 1965), sequences for stimuli and responses (Wasserman, Nelson, & Larew, 1980), characterization of contingencies (Commons & Nevin, 1981), as well as aspects of animals' own behavior (Eisler, 1984; Killeen, 1978, 1981; Killeen & Smith,

1984; Kramer, 1982; Maki, 1979; and Reynolds, 1966). Studies have also outlined the case for the events in an operant paradigm (antecedents, behavior, and consequences) to exert control over organisms' own prior behavior being discriminative for its subsequent behavior (Maki, Moe, & Bierly, 1977).

Maki, Moe, and Bierly, 1977

Maki, Moe, and Bierly (1977) analyzed whether operant responses and consequential events can serve as sources of stimulus control and affect accurate recall on delayed matching to sample (DMTS) tasks. In the DMTS task, a subject is first presented with one of two stimuli, called the sample. Responding on the sample according to the contingency in effect terminates the sample. With the offset of the sample, a retention interval or time delay is immediately in effect for a specific duration, and is followed by the presentation of two comparison stimuli. One of the comparison stimuli typically matches the sample stimulus. The subject is charged with "recalling" the sample stimulus in its absence, in order to accurately respond on the comparison stimuli, typically for food reinforcement. DMTS procedures are often employed to study animal recall of previous events, or "short term memory." Maki, Moe, and Bierly examined whether or not these stimuli are influenced in the same way by the same independent variables with pigeons as they are with other animals (e.g., dolphins, monkeys). The authors evaluated to what degree pigeons' phylogenetic preparedness influenced accurate responding on DMTS tasks.

In this research, pigeons were trained in a three key operant chamber. In the first phase of training, a single peck to the white center key replaced it with either a red or green sample stimulus. Ten pecks to the sample stimulus produced a darkened retention

interval, which was followed by one side key being illuminated red and the other green, assigned randomly across trials. If the pigeon matched the sample color to the correct comparison stimulus, food reinforcement was provided.

The second phase of training was procedurally similar to the first, but in this phase, between the sample and comparison key presentations the retention interval was now illuminated with the house light. Retention interval illumination has been shown to decrease DMTS accuracy, at a rate faster than the delay in darkness. Across both phases of training, the duration of the retention interval was gradually increased across sessions.

In later experiments of their report, a differential number of responses to the red or green sample [fixed ratio (FR) 1 during the green sample, FR 20 during the red sample] were required prior to a correct match on the comparison stimulus for reinforcement. In the second phase of training, between the sample and comparisons, the retention interval was again illuminated by the house light, and gradually increased. The authors noted that with some animals, increases in retention interval duration and retention interval illumination tend to decrease accuracy at a slower rate when a differential number of responses are required on the sample, prior to responding on the comparison stimulus.

In even later experiments, a single peck to the white center key replaced it randomly with either 2 s access to food or 2 s of darkness as the sample stimulus. Following the 2 s, the side keys were illuminated red and green. Food reinforcement was provided if (a) the sample was 2 s of food and the pigeon pecked the red side key or (b) the sample was 2 s of darkness and the pigeon pecked the green side key. In the second

phase of training, between the sample and comparisons, the retention interval was again illuminated by the house light, and its duration gradually increased.

Maki, Moe, and Bierly (1977) concluded that indeed antecedent stimuli (e.g., colored disks), responses (e.g., FR 1 vs. FR 20), and consequential events (e.g., food vs. no food) can function effectively as discriminative stimuli for subsequent behavior across different species (pigeons, dolphins, and monkeys alike). Such events failed to maintain discriminative functions similarly across species when (a) an amount of house-light illumination (the intensity and duration of illumination) was added prior to or during the retention interval, and (b) when the inter-trial interval (ITI) was decreased in a delayed matching to sample experiment. Further evidence under which pigeons and rats can demonstrate discriminative control over certain aspects of their behavior, and consequently report on such events is reviewed below.

Reynolds, 1966

This research investigated the extent to which prior behavior may function as a discriminative cue for an animal's subsequent behavior. Reynolds (1966) trained three pigeons in a procedure in which they were first presented with a red key. After two pecks on the red key, the key color changed to blue for a fixed period of 30 s, following which it automatically returned to red. Pecks on the blue key were reinforced with food according to a variable-interval (VI) schedule but only if the two pecks on the red key had been at least 18 s apart. Pecks on the blue key were never reinforced if the preceding two pecks on the red key were less than 18 s apart. Thus, the procedure made the availability of reinforcement on the blue key conditional on the temporal properties of a pigeon's responding on the red key. A fast rate of responding on the blue key meant the

pigeon was reporting a longer period of time between its two pecks on the red key, and the availability of reinforcement during blue.

Reynolds' (1966) results showed that the time between the two pecks on the red key was sometimes short and sometimes long, although on average consistently shorter than 18 s. Thus, the pigeons did not consistently respond on the red key in a way that would make reinforcement available when the key was blue. However, the results also showed that responding on the blue key did increase as the actual time between the two pecks on the red key increased. These results indicated that the actual temporal properties of responding on the red key did become discriminative for responding on the blue key, at least to a limited extent, even though the temporal contingencies correlated with the red key didn't effectively control responding on the red key.

Worth noting is that Shimp (1981) reviewed Reynolds (1966) and suggested the study had a confound. Shimp suggested that the pigeons may only have demonstrated a discrimination based on the duration of the red key, rather than the temporal properties of responding on the red key, because of the perfect correlation between the two stimulus features. That is, the time between responses on the red key determined the duration of red. Given that pigeons may have a phylogenetic predisposition to come under the stimulus control of the temporal properties of a visual stimulus rather than the temporal properties of a behavioral stimulus, the temporal properties of the visual stimulus may have come to control behavior.

Reynolds (1966) closed his report by suggesting that training with several different inter-response time (IRT) contingencies might direct a subject's attention to time as the relevant dimension in such contingencies, perhaps resulting in an

improvement in the subject's performance. We return later in the present report to the question of whether training conditions can improve a subject's performance.

Lattal, 1975

This research also investigated the extent to which temporal properties of a behavioral stimulus may come to serve as discriminative for responding. Two pigeons served as subjects and were trained in a three key operant chamber. In the first phase of training, the center key was illuminated yellow and the side keys were darkened. One of two schedules was arranged on the center key: (a) no peck to the key for 10 s (differential reinforcement of other behavior; DRO 10 s), and (b) one peck to the key after 10 s has elapsed (differential reinforcement of low rate; DRL 10 s). After the contingency in effect was met, the center key darkened and immediately one side key was illuminated red and the other green, assigned randomly across trials. Food reinforcement was provided if (a) the sample was the DRO schedule (no peck to the yellow key for 10 s) and the pigeon pecked the green side key or (b) the sample was the DRL schedule (one peck after 10 s elapsed) and the pigeon pecked the red side key. Following training, a reversal of the contingencies was in effect; the DRO sample was now correlated with the red comparison, and the DRL sample was now correlated with the green comparison, both for reinforcement. A second reversal occurred after 30 subsequent sessions following the first reversal. In the second phase of training, a darkened retention interval (delay), between 0 and 36 s, occurred after the pigeon satisfied the sample contingency, prior to the illumination of the side keys.

Lattal's (1975) results showed that the pigeons responded with up to 90% accuracy, even after the reversal conditions, without the retention interval. Accuracy

decreased from about 90% at the 0-1 s delay, to 70% at the 12 s delay, and eventually to 50% at the 36 s delay. Lattal found that pigeons' subsequent behavior could be controlled by previous behavior, as was the case here where pigeons were charged with a matching paradigm under which the emission and omission of responding was the discriminative stimulus for choice responding.

Maki, 1979

Maki (1979) disputed the popular view in animal learning that rehearsal behavior and accurate matching as a demonstration of "short term memory" were prerequisite for acquisition and discrimination of stimulus control as a demonstration of "long term memory." Ten pigeons served as subjects in a three key operant chamber. In the first phase of training, a single peck to the white center key replaced it randomly with a sample stimulus of either 2 s access to food with the hopper lit or 2 s of no food in darkness. Following the 2 s, a darkened retention interval (delay) averaging 6.75 s was in effect. Next, one side key was illuminated red and the other green, assigned randomly across trials. Food reinforcement was provided if (a) the sample was 2 s of food and the pigeon pecked the red side key or (b) the sample was 2 s of darkness and the pigeon pecked the green side key. A 20-s ITI was in effect.

In the second phase of training, a single peck to the white center key replaced it randomly with either a red or green disk, or a vertical or horizontal line, for a fixed period of 10 s. These stimuli were not correlated with reinforcement during this phase in an effort to equalize response tendencies towards each stimulus. Following the 10 s, a peck to the center key produced a 2-s presentation of either food with the hopper lit, or no food and darkness. Following the 2 s, an illuminated retention interval was in effect, and was gradually increased across trials. Next, one side key was illuminated red and the other

green, assigned randomly across trials. Food reinforcement was provided if (a) the sample was 2 s of food and the pigeon pecked the red side key or (b) the sample was 2 s of darkness and the pigeon pecked the green side key.

In the final phase of training, the procedure was the same as above, but the stimuli presented after the offset of the white center key (a red or green disk, or a vertical or horizontal line) were arranged to become discriminative. A red disk or vertical line displayed on the center key was reliably followed by food with hopper light, upon which choosing the red comparison would produce food reinforcement. Alternately, the green disk or horizontal line displayed on the center key was reliably followed by no food and darkness, upon which choosing the green comparison would produce food reinforcement. An illuminated retention interval occurred for half of the pigeons when the sample was a colored disk and for the remaining pigeons when the sample was a line.

Maki (1979) found that the pigeons in the dark retention interval group correctly matched with 90% accuracy, and the pigeons in the illuminated retention interval group correctly matched with only 50% accuracy, at a chance level. Such results support the research that DMTS accuracy decreases more so when the retention interval is illuminated than when the retention duration is in darkness. The retention interval illumination did not interfere with acquisition of the discrimination, yet it had a drastic impact on DMTS accuracy. The author indicated the data demonstrate separate processes between acquisition and maintenance of discrimination learning. Maki (1979) concluded that DMTS accuracy was considered a measure of "short term memory" (p. 84), whereas rate at which acquisition of differential responding occurred was considered a measure of "long term memory."

Shimp, 1981

Research continued to investigate the discriminative properties of temporal events as a stimulus controlling feature. This research investigated the extent to which pigeons could report on their recent temporal patterns of responding, and if or how such a self-report may impact said responding. Shimp (1981) trained five pigeons in a three-key operant chamber. In the first phase of training, responding on the center key intermittently produced food reinforcement when it satisfied either of two IRT contingencies: one contingency required responding with a relatively short IRT between 1.5 and 2 s, and the other with a relatively long IRT between 2 and 12.5 s.

In the second phase, when responding on the center key satisfied an IRT contingency, the responding now intermittently produced a probe. In the probe, red and green comparison stimuli were presented on the side keys, assigned randomly across trials after a retention interval (delay) that varied between .1 and 8 s. Food reinforcement was provided in the probes if (a) the preceding IRT on the center key was short and the pigeon pecked the green key or (b) the preceding IRT on the center key was long and the pigeon pecked the red key. In other words, presentation of the red and green keys was a 0-s delayed arbitrary conditional discrimination task in which the sample was the pigeon's prior behavior: its previously emitted IRT.

Shimp (1981) found that the pigeons responded accurately to the probes on over 90% of the trials with short retention intervals, although their accuracy decreased as the retention interval increased. He concluded that features of a pigeon's prior behavior can indeed become discriminative for its subsequent behavior.

Shimp, 1983

In a further investigation of the relation between temporal patterning of responses and self-report of such responses, Shimp (1983) trained five pigeons in a three-key operant chamber. Much of the procedure was similar to Shimp (1981). In the first phase of training, responding on the center key intermittently produced food reinforcement when it satisfied either of two IRT contingencies, one shorter than the other. This time, however, across conditions, the absolute durations of the pair of IRTs spanned a somewhat larger range, and the longer response pattern was fixed at three times that of the shorter pattern. For example, in one condition, the shorter IRT of the pair was between .6 and 1.2 s, while the longer IRT was between 1.8 and 3.6 s. In another condition, the shorter IRT of the pair was between 6 and 9 s, while the longer IRT was between 18 and 27 s.

In the second phase, as before, when responding on the center key satisfied an IRT contingency, the responding now intermittently produced a probe. In the probe, red and green comparison stimuli were presented on the side keys, their positions assigned randomly across trials. A retention interval was not used. Also as before, food reinforcement was provided following these probes if (a) the preceding IRT on the center key was the shorter of the pair and the pigeon pecked the green side key, or (b) the preceding IRT on the center key was the longer of the pair and the pigeon pecked the red side key. In other words, presentation of the red and green keys was a 0-s delayed arbitrary conditional discrimination task in which the sample was the pigeon's prior behavior: its previously emitted IRT.

Shimp (1983) found that IRT distributions on the center key were more bimodal when the absolute durations of the IRT pair were shorter rather than longer, indicating better adaptation to the IRT contingency. However, the pigeons' probe accuracy was actually higher when the absolute durations of the IRT pair were longer rather than shorter. He concluded that a pigeon's prior behavior can indeed become discriminative for its subsequent behavior, and that contingency controlled responding is a separate process from being able to report the contingency in effect.

Eisler, 1984

Eisler (1984) was interested in the processes associated with the development of behavior and discrimination based on that behavior. He questioned whether the procedures arranged for an animal to report on its most recent behavior can actually provide the sufficient conditions for the animal to emit the behavior required to satisfy the contingency.

In this research, twelve rats served as subjects in a discrete trials procedure. A trial consisted of the presentation of a tone, a brief (300 ms) interruption of the tone, then a presentation of the tone again. For simplicity, we refer to the tone before the interruption as part A, and after the interruption as part B, when part B was as long as part A. The experimental contingency required the rat to refrain from responding during part A, then respond during part B to earn food reinforcement. Lever presses during part A added time before the interruption and made reinforcement unavailable during part B. The schedule durations of parts A and B varied randomly within a session and ranged from 1.3 to 14.8 s.

On average, the percent of trials on which the rats earned reinforcement varied from 12% to 58%, with slightly higher accuracy when parts A and B were shorter rather than longer. Of greater interest for the question of how well animals can discriminate features of their own behavior were the latencies to respond in part B. Analysis of those latencies revealed a bi-modal distribution: short latencies on trials in which reinforcement was available and long latencies on trials in which reinforcement was unavailable because a response had occurred in part A. Importantly, the bimodal distribution of latencies in part B appeared before the rats began to satisfy the reinforcement contingency and largely refrained from responding during part A. Thus, a discrimination was necessary in part A, to make reinforcement available in part B. However, the discrimination in part B, pertaining to whether reinforcement was actually going to be produced, preceded the discrimination in part A. With respect to the experimental question, Eisler concluded that correct reporting of behavior is not sufficient for the behavior being reported on to always be correct. Although the organisms could demonstrate an increase in accurate responding across sessions, they were not able to fully execute the reinforcement contingency in effect. Because the rats were charged with refraining from responding to earn reinforcement in part A, Eisler (1984) reported the rats demonstrated "knowing" the behavioral contingency, without the learned capacity to suppress the "doing."

Killeen, 1978

Killeen (1978) attempted to analyze if pigeons could detect whether their behavior, or an independent source, produced a stimulus change. Four pigeons served as subjects in a three-key operant chamber. Pigeons pecked at a center white key while

simultaneously, a computer produced "pseudo-pecks" at the same rate. Both pigeon

pecks and computer pecks had a .05 probability of darkening the center key and

illuminating the side keys. Following an illumination of the side keys, the pigeon was

charged with identifying whether its own behavior or the computer had produced the

stimulus change. Food reinforcement was provided if (a) the pigeon's own peck produced

the change and the pigeon pecked the right key, or (b) the computer had produced the

stimulus change and the pigeon pecked the left key. An incorrect response produced a

brief time-out period.

Killeen (1978) found that the pigeons responded accurately on about 80% of the

trials. Most incorrect responses were reported when the stimulus change produced by the

computer occurred within .5 to 2 s of the pigeons' response. Therefore, pigeons can be

accurate in their reporting on the discrimination of their most recent behavioral events.

The author identified a possible confound in the study, stating that the learned

discrimination was most likely based on the delay between a response and its effects. For

example, if the pigeon waited to respond and a stimulus change occurred, it was clear that

the computer generated the change.

Killeen, 1981

Killeen (1981) continued to explore the conditions under which pigeons can

accurately report on the discrimination of most recent behavioral events. Three pigeons

served as subjects in a three-key operant chamber. Similar to Killeen (1978), in the first

phase of training, food reinforcement was provided according to a short fixed interval

(FI) schedule if (a) the pigeon's own peck produced the change and the pigeon pecked

the left key, or (b) the computer had produced the stimulus change and the pigeon pecked

the right key. An incorrect response produced a 5-s time-out period. The second phase of training was procedurally the same as in the first phase, except food reinforcement was provided according to a VI schedule, and correctly identifying the stimulus change as computer-generated produced longer access to food reinforcement than correctly identifying the stimulus change as self-generated.

The results demonstrated the pigeons responded accurately on about 80% of the trials. Killeen (1981) observed that most pigeons demonstrated strategies to improve their performance, such as pecking at a high rate for a few seconds and if a stimulus change did not occur, then pausing. Thus he concluded that for most pigeons, the time delay between a pigeon peck and the stimulus change exerted discriminative control (as it had in Killeen, 1978). Nevertheless, both studies (Killeen, 1978, 1981) demonstrated a pigeon's ability to accurately report on the discrimination of their most recent behavioral event.

Killeen and Smith, 1984

Killeen and Smith (1984) continued to investigate pigeons' reports on their most recent behavioral events in further replication of Killeen (1978, 1981). Pigeons served as subjects in a three-key operant chamber. The methods used were generally similar to Killeen (1978, 1981) wherein pigeons were charged with reporting whether their pecks or computer-generated "pseudo-pecks" produced a stimulus change- the termination of the white center key. Following the termination of the center key, the side keys were illuminated. Food reinforcement was provided if (a) the pigeon's own peck produced the change and the pigeon pecked the right, red side key or (b) the computer had produced

the stimulus change and the pigeon pecked the left, green side key. An incorrect response produced a brief time-out period.

In the first phase of training, (a) a delay occurred after the offset of the center key, prior to the onset of the side keys, as a function of the response rate on the center key produced by both the pigeon and computer; and (b) following the offset of the side keys, a varying delay occurred before reinforcement presentation. In the second phase of training, (a) after the offset of the center key, the delay was followed by a retention interval in effect prior to the onset of the side keys. The retention interval varied from 40-360 ms and was independent of the response rate on the center key; and (b) the delay to reinforcement was held constant while the reinforcer magnitude was varied. In the third phase of training, pigeons were charged with performing the same task as above, with a change in the delay. If a pigeon's peck produced the stimulus change, the delay was a constant 20 ms, and if the computer produced the stimulus change, the delay was longer, ranging from 40 to 740 ms and drawn from three different value sets.

The fourth phase of training arranged three conditions: food, light, and null. In the food condition, following the offset of the white center key after responding satisfied a variable ratio (VR) schedule, the food hopper was elevated and illuminated, followed by the onset of the side keys. If a pigeon produced the stimulus change and food hopper, a 20-ms delay to reinforcement was in effect. If the computer produced the stimulus change and food hopper, an average 420-ms delay to reinforcement was in effect. Food reinforcement was provided if (a) the pigeon's own peck produced the change and the pigeon pecked the right, red side key or (b) the computer had produced the stimulus change and the pigeon pecked the left, green side key. The light condition was similar to

the food condition. Following the offset of the white center key after responding satisfied

a VR schedule, the hopper was illuminated but without food available. If a pigeon

produced the stimulus change and food hopper, a 20-ms delay to reinforcement was in

effect. If the computer produced the stimulus change and food hopper, an average 420-ms

delay to reinforcement was in effect. Food reinforcement was provided if (a) the pigeon's

own peck produced the change and the pigeon pecked the right, red side key or (b) the

computer had produced the stimulus change and the pigeon pecked the left, green side

key. During the null condition, following the offset of the white center key after

responding satisfied a VR schedule, the onset of the side keys was immediate. Following

a response on the side keys, no delay to reinforcement was in effect, and reinforcement

was immediately presented if the contingency as described above was met.

Killeen and Smith's (1984) results indicate that the pigeons' accuracy of reporting

on their own recent behavior (responding on the side keys) decreased to 65% with the

addition of a constant, darkened retention interval between the offset of the center key

and the onset of the side keys. When the retention interval varied so that a pigeon's peck

produced a constant time delay and the computer-generated peck produced a varying time

delay prior to the onset of the side keys, accuracy improved up to about 85%. As such,

the retention interval duration functioned as a discriminative stimulus. In addition to the

delay between responding and reporting on recent responding affecting performance,

food and light presentations prior to reporting also influenced accuracy. Both an increase

in food magnitude and light presentation decreased accuracy on the side keys. Food

stimuli prior to reporting decreased accuracy to 55% whereas just the light presentation

decreased accuracy to about 70%. Overall, pigeons accurately established discrimination

of their own behavior so that they could subsequently report on their previously emitted

behavior between responses and stimulus changes in a replication of Killeen (1978,

1981).

Kramer, 1982

Kramer (1982) investigated whether the relation between accurate self-report of

previous behavior and patterns of that behavior are specific to the reinforcement

schedule. Nine pigeons served as subjects in a three-key operant chamber. A discrete

trial, symbolic matching to sample (MTS) procedure was used.

In the first phase of training, the white center key went dark after either (a) one

peck or (b) a short period of time had elapsed (no peck). Following the offset of the

center key, a darkened retention interval was in effect, the duration of which was one of

four different time delays, assigned randomly across trials. Following the retention

interval, both side keys were illuminated white. Food reinforcement was provided if (a)

the sample was one peck to the center key and the pigeon pecked the right side key or (b)

the sample was no pecks to the center key and the pigeon pecked the left side key.

Following reinforcement, a 2-s ITI was in effect.

In the second phase of training, (a) the center key was illuminated for .65 s, (b)

the pigeon was required to emit either two pecks or no pecks on the center key, and (c)

one side key was illuminated red and the other green, assigned randomly across trials.

Food reinforcement was provided if (a) the sample was two pecks to the center key and

the pigeon pecked the green side key or (b) the sample was no pecks to the center key and

the pigeon pecked the red side key.

In the third phase of training, the center key was illuminated red and then changed to green in succession. The sample was first illuminated red (the first sample component) followed by a .25-s interstimulus interval of darkness that ended with a green center key illumination (the second sample component). The center key light durations across components were the same regardless of the peck requirement to prevent a confound between the duration versus response requirement in that color. Four sequences on the center key could occur: (a) one peck on the red followed by one peck on the green, (b) three pecks on the red followed by three pecks on the green, (c) one peck on red followed by three pecks on green, and (d) three pecks on red followed by one peck on green. Following the correct number of responses to the colors on the center key, the key was darkened and one of four darkened retention intervals (delays) was initiated. Following the retention interval, red and green comparison stimuli were presented on the side keys, their positions assigned randomly across trials. Food reinforcement was provided if (a) one or three pecks were emitted when the sample was red (in the first sample component) and the pigeon pecked the side keys when they were illuminated red; and (b) when one or three pecks were emitted when the sample was green (in the second component) and the pigeon pecked the side keys when they were illuminated green. Thus, the pigeon was charged with recalling the number of pecks it emitted under the two different stimulus colors. Following reinforcement, a 4-s ITI was in effect.

A control condition was arranged at the end of the experiment in which the sample key color presentation was arranged by time rather than the sample behavior requirement. The number of responses per colored component could vary, but the time permitted in each component was about equal to the amount of time it would take to

satisfy the response requirement. For example, if the response requirement during testing was three pecks in red, then the pigeon would be presented with the red center key for approximately three times longer than it would be presented with if the requirement was one peck. The control condition measured the extent to which a pigeon recalled the duration of the sample stimulus versus their behavior on the sample, to eliminate a possible confound.

The results indicated that the longer the retention interval, the less accurately the pigeon reported its recent behavior. When the retention interval was between 0- 30 s, accuracy was at or above 80%. When the retention interval was between 30- 160 s, accuracy was less stable, between 30- 60% on average. Homogeneous trials (same number of pecks to the sample) produced the most accurate self-reports, between 70- 90% correct. Of the homogeneous trials, one peck followed by one peck to the samples produced higher accuracy than three pecks followed by three. Heterogeneous trials produced less accurate responding, between 40- 80% correct. The control condition decreased responding to the chance level, about 50%.

Overall, Kramer's (1982) data indicated that a pigeon's prior behavior can come to serve as a discriminative stimulus for subsequent behavior using a small number of pecks, and for a minute or longer. Pigeons have shown to respond accurately when reporting on two different response patterns within two different stimulus conditions. Responding was most accurate regarding most recent performance, when the response requirement was smaller (one peck vs. three pecks), and especially when the retention interval was closer to 0 s.

Summary

We may summarize the procedures and conclusions of the basic studies reviewed above as follows. First, the researchers trained subjects to engage in some baseline behavior. Then, the researchers examined the subjects' subsequent behavior to determine whether a feature of the subjects' prior baseline behavior exerted discriminative control over their subsequent behavior. The researchers concluded that for pigeons and rats, some feature of their prior behavior can often exert discriminative control over the subsequent behavior of those subjects, albeit in varying degrees and with varying implications for that subsequent behavior, depending on many details of the procedures that are employed.

The present research will further investigate the extent to which prior behavior is discriminative for subsequent behavior, but with a new procedure: a conditional discrimination task. Conditional discrimination tasks generate complex discriminative behavior; discriminative behavior depends on the relation between two or more stimuli. Conditional discrimination tasks reportedly yield "analogues of complex human performances" (MacKay, 1991). As such, analyzing and specifying the critical features within conditional discrimination tasks contributes to progress in research, application, and methodology, especially in the fields studying both human and non-human animals (e.g., Behavioral Pharmacology and Behavioral Neuroscience) (MacKay, 1991).

The conditional discrimination task is also known as a matching to sample (MTS) procedure, which is the terminology used in the present report. As originally developed, say for pigeons, the MTS procedure can use common visual stimuli projected on pecking keys for samples, comparison, and probe stimuli including colors (red, green), lines

(vertical, horizontal), or geometric forms (circles, triangles). In a MTS procedure as it is frequently employed, a subject is first presented with one of two stimuli, called the sample. After responding on the sample key, two concurrently available comparison stimuli are illuminated. The opportunity to earn reinforcement is conditional upon accurate responding on the comparison key that is designated as correct according to the procedure that is employed.

Thus, in the present research, pigeons first responded on an identity matching task, with either a red or green key as the sample, and red and green keys as comparisons. After performing on this task, the pigeons then responded on a probe trial or symbolic matching task, with circles and triangles as comparisons. Food reinforcement was provided (a) if the sample-comparison match in the preceding MTS task was red and the pigeon pecked the triangle rather than the circle, or (b) if the sample-comparison match in the preceding task was green and the pigeon pecked the circle rather than the triangle. In other words, baseline behavior was itself one MTS task, and the pigeon was then presented with a follow-up or probe trial, a type of symbolic matching trial, in which correct responding depended on how the subject had just responded on the preceding identity matching trial.

In the basic studies reviewed above, the sample was often some feature of the baseline behavior, such as its temporal properties or its pattern, rather than a visual stimulus. The comparison stimuli were visual stimuli, such as the colors mentioned above. The present research used the matching behavior on a conditional discrimination task, or visual stimuli on an identity MTS task as the baseline behavior, and the comparison stimuli were also visual stimuli. Procedurally, the present research differs

from and contributes to research in that pigeons were charged with recalling their previous behavior in response to visual stimuli versus temporal stimuli or its pattern. Given that pigeons have a phylogenetic predisposition to come under stimulus control of visual stimuli more so than the temporal properties of a behavioral stimulus, it was postulated that using visual stimuli to respond to would potentially impact pigeons' ability to subsequently report on prior baseline behavior. In addition, visual stimuli may potentially impact pigeons' MTS accuracy after their subsequent reporting on said behavior. In previous research, baseline accuracy on temporally-based behavior did not improve with the subsequent report on prior baseline behavior.

In the present research, the dependent measure was the percent correct responding to the comparison stimuli, also known as the discrimination index. Acquisition of the discrimination based on the sample is reflected in discrimination indices above chance, or .50, with higher discrimination indices reflecting better discrimination. Failure to acquire the discrimination is reflected in discrimination indices around chance, or .50.

There are several variations for the MTS procedure that were employed. When the sample is present at the same time as the comparisons, the procedure is called simultaneous matching to sample (SMTS). When the sample terminates and the comparisons appear immediately, the procedure is called 0-second delayed matching to sample (0-s DMTS). When there is a delay of n-seconds between the termination of the sample and the appearance of the comparisons, the procedure is called n-seconds delayed matching to sample (n-s DMTS), where n reflects the actual time duration in seconds. The interval of time between sample offset and comparison onset is called a retention interval. When the procedure involves responding to a red rather than a green

comparison, given a red sample, the procedure is called identity matching. When the procedure involves responding to a green rather than red comparison, given a red sample, the procedure is called oddity matching. When the procedure involves responding to a circle rather than a triangle, given a red sample, the procedure is called symbolic (or arbitrary) matching.

Throughout the present research, pigeons were required to respond to the sample and correct comparison, in both the identity matching and symbolic matching tasks, according to short FI schedules, in the range of FI 4-s to FI 15-s. Responding to the sample in the identity matching task ensured stimulus control by the sample, and responding to the comparisons in both tasks generated a sample of behavior that permitted meaningful conclusions (Urcuioli, 2011). In this procedure, responses to the correct comparison in the symbolic matching task produced food after the FI schedule was satisfied, whereas incorrect responses had no effect. Two questions were of interest in the present research: (a) Can the pigeons acquire a second conditional discrimination on the identity matching task (e.g., probe accuracy above chance)? (b) Will a conditional discrimination on the symbolic matching task facilitate the acquisition of the conditional discrimination on the identity matching task (e.g., improved MTS accuracy after probe implementation in phase two)?

Experiment #1 involved a SMTS task as the baseline behavior. Experiment #2 involved a 0-s DMTS task as the baseline behavior. Experiment #3 involved n-s DMTS tasks as the baseline behavior. Further details are below. Experimental conditions are outlined in Table 1.

Table 1

Experimental Conditions Indicating Number of Sessions in Phase 1 and 2 of Training

CONDITIONS		PIGEON			
VI 30-s ITI, FI 15-s sample, FI 8-s comp		**P- 172**	**P- 140**	**P- 141**	**P- 510**
Exp. # 1	SMTS, probe: FI 8 s	19/48	19/101	18/49	19/73
Exp. # 2	0s DMTS, probe: FI 8 s		17/15	20/51	14/33
Exp. # 3 ↓	1s DMTS, probe: FI 8 s		14/17		
	2s DMTS, probe: FI 8 s		13/30		
	5s DMTS, probe: FI 8 s		11/22		
	1s, 2s, 5s, DMTS, no probe			5, 5, 6/0	6, 6, 5/0
	8s DMTS, probe: FI 8 s			5/15	5/15
	8s DMTS, probe: FI 4 s		22/21		
	8s DMTS, probe: FI 2 s		0/18		
	12s DMTS, probe: FI 8 s		11/16	11/25	8/28
	12s DMTS, probe: FI 4 s			0/34	0/37
	12s DMTS, probe: FI 2 s			0/23	0/24
VI 15-s ITI, FI 8-s sample, FI 4-s comp					
	12s DMTS, probe: FI 2 s			8/30	22/20
	15s DMTS, probe: FI 2 s			11/12	10/11
	30 s DMTS, probe: FI 2 s			12/13	11/11

Note. Phase 1: baseline MTS/ Phase 2: MTS and probe

General Method

Subjects

Four naïve male pigeons (Columba livia; P-140, P-141, P-510, and P-172) served as subjects. The pigeons were maintained at approximately 75%-85% of their free-feeding weights. They were individually housed in a temperature-controlled colony room that was illuminated for 16 hours and dark for eight hours per 24 hour day. Water and grit was always available in their home cages. Sessions consisted of 72 trials, and were conducted six days per week under approximately 22 h of food deprivation each day.

Apparatus

Two standard three-key operant chambers for pigeons were employed. The chambers were enclosed in sound attenuating material with a ventilation fan to minimize external sounds. The interior dimensions of one chamber were approximately 32 cm (height) by 29 cm (width) by 29 cm (depth), and of the other approximately 36 cm (height) by 46 cm (width) by 35 cm (depth). On the front wall of each chamber were three circular response keys (2.5 cm in diameter) and a rectangular opening (5 cm by 6 cm) that provided access to an elevated food hopper. The response keys were mounted 26 cm above the floor. The center response key was centered on the wall, and the two side keys were 8.5 cm to the left and right of the center key. The keys required approximately 0.15 N to operate. The keys were illuminated from the rear with red, green, or white lights, or with a white triangle or circle on a dark surround, by means of a standard IEEE projector with 28-VDC lightbulbs (#1820, 3 W). The rectangular opening to the food hopper was centered on the wall, 8 cm above the floor. Conventional electromechanical

programming equipment, located in a room adjacent to the chambers, controlled events in
the chambers and recorded the data.

Procedure

A discrete-trial procedure was used throughout. In the first phase of training, there
was only one component per trial. In this component, the pigeons responded on an
identity MTS task with colors as both samples and comparisons. A trial began with the
illumination of a white center key, as an orienting stimulus. A single peck to the white
center key produced either a red or green sample on the center key. Responding to the
sample illuminated one side key red and the other green, assigned randomly across trials.
Mixed grain food reinforcement was provided when (a) given a red sample, the pigeons
pecked the red comparison, or (b) given a green sample, the pigeons pecked the green
comparison. Incorrect responding on the nonmatching side key had no effect. The
duration of the inter-trial interval (ITI) varied across the different conditions and is noted
in the various tables and descriptions below. In standard terminology, the task may be
more technically designated as an identity MTS task, which is the designation used
henceforth.

After acquiring the conditional discrimination during the MTS component, the
pigeons advanced to the second phase of training. In this phase, there were two
components per trial. The first component was an identity MTS task with red or green as
a sample, and red and green comparison side keys, as before. Correct responding on the
first, MTS component then immediately produced the second component, "the probe,"
rather than primary reinforcement. In standard terminology, the probe component may be
described as a symbolic MTS task. The sample in the probe component was the pigeon's

prior behavior: whether the pigeon had matched red or green sample-comparison stimuli in the preceding identity MTS component. The probe comparison stimuli were a white triangle and circle on a dark surround. The comparisons were presented as the side keys, their positions randomly assigned across trials. During the probe component, food reinforcement was provided when (a) given that the sample-comparison match in the preceding identity MTS component was red, pigeons responded to the triangle rather than the circle, and (b) given that the sample-comparison match in the preceding identity MTS component was green, pigeons responded to the circle rather than the triangle. Incorrect responding to a probe side key had no effect. An ITI was in effect.

Preliminary training. Each pigeon was given one day of preliminary magazine training to establish key pecking to the center white key. At first, key pecking was hand shaped. Next, key pecking was trained on continuous reinforcement. Lastly, pecks to the center white key were reinforced according to a VI 30-s schedule.

Experiment #1: Simultaneous Matching to Sample (SMTS)

Method

Subjects

Pigeons P-172, P-140, P-141, and P-510 served as subjects.

Procedure

Table 1 presents the phases of training for each pigeon, and the number of sessions in each phase. As described above, in phase one of Experiment #1, the pigeons were first presented with a white center key. A single peck to the center key immediately illuminated it either red or green, in random sequence. The red or green key represented the sample. Next, the pigeons responded to the sample on an FI 15-s schedule. After

satisfying the schedule requirement, one side key was illuminated red and the other

green, assigned randomly across trials. Both the center sample key and the comparison

keys were illuminated simultaneously (component one). Food reinforcement was

provided according to a FI 8-s schedule for a peck to the side key that matched the center

key. Incorrect responding on the nonmatching side key had no effect. A VI 30-s ITI was

in effect. The simultaneous matching to sample (SMTS) procedure was first introduced

without the probe component in order to provide a baseline measure of SMTS accuracy.

Phase one continued until stable MTS responding was demonstrated across at least five

sessions, as determined by visual inspection.

Next, in phase two of training, after stable responding had developed in phase

one, the "probe" component was added to see if the probe facilitated SMTS accuracy. In

the second component, immediately after the pigeons satisfied the matching requirement,

instead of primary reinforcement, one side key was illuminated with a white circle and

the other with a white triangle, assigned randomly across trials. Food reinforcement was

provided according to an FI 8-s schedule when (a) given that the sample-comparison

match in the preceding component was red, pigeons responded to the triangle, and (b)

given that sample-comparison match in the preceding component was green, pigeons

responded to the circle. Incorrect responses on the nonmatching side key had no effect. A

VI 30-s ITI was in effect. Phase two continued until stable MTS and probe responding

was demonstrated across at least five sessions, as determined by visual inspection.

A fading procedure (e.g., Terrace, 1963) in which the intensity of the color was

decreased as the intensity of the form was simultaneously increased was used to facilitate

the acquisition of probe discrimination in this phase of training. Instead of the correct

match producing only the white arbitrary form on the black background, the color

correlated with the form was also displayed on the key. Thus the white triangle that

correlated with the red key was superimposed on the red key, and the white circle that

correlated with the green key was superimposed on the green key. Over trials the

intensity of the color was gradually faded out, while the intensity of the white form was

faded in by means of a variable resistor. No fading procedure was necessary in

subsequent phases.

```
┌─ INTER-TRIAL INTERVAL (ITI)    VI 30 s ─┐
│                                          │
├─    ORIENTING STIMULUS          FR 1     │
│                                          │  COMPONENT 1
├─        SAMPLE                  FI 15 s  │
│                                          │
├─  SMTS ON COMPARISONS           FI 8 s ─┘
│
└─  PROBE ON COMPARISONS          FI 8 s ─┐ COMPONENT 2
```
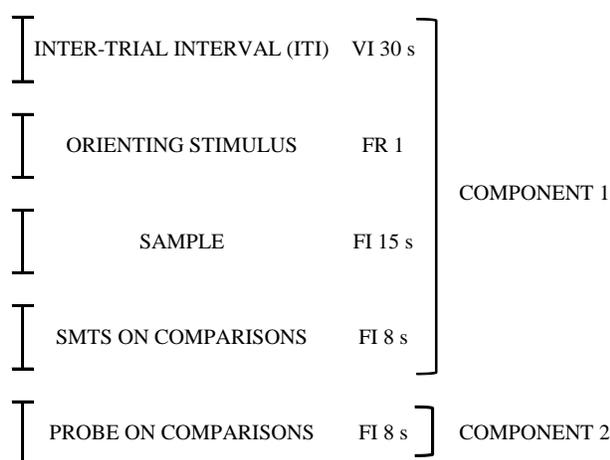
Figure 1: Outline of Experiment #1: SMTS

Results and Discussion

Figure 2 presents the discrimination indices for P-172, P-140, P-141, and P-510 in

Experiment #1. The indices are from the last five sessions in each phase, as in Kramer

(1982), Lattal (1975), and Shimp (1981, 1983). The indices are shown for the SMTS in

phase one of training, and then for both the SMTS and probe in phase two of training.

In panel 1, P-172's SMTS accuracy ranged from .85- .98. After the probe was added in

phase two, SMTS accuracy decreased to .78- .90. Probe accuracy ranged from .53- .77. In

panel 2, P-140's SMTS accuracy ranged from .77- .93. After the probe was added in
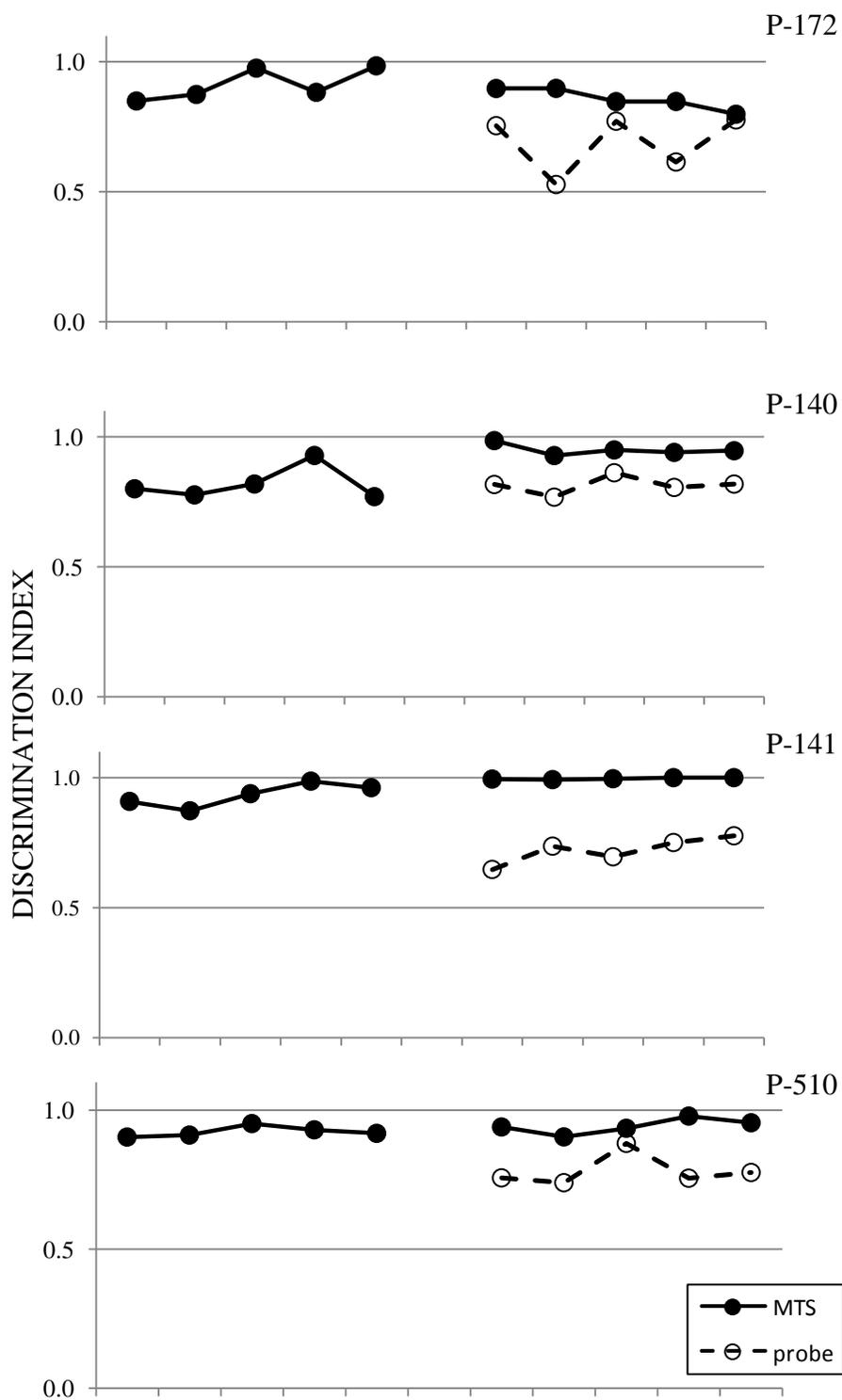
Figure 2: Experiment #1: SMTS- Discrimination indices for P-172, P-140, P-141, and P-510. The last 5 sessions from both the SMTS in phase 1, and the SMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, FI 8-s comparison stimuli, and FI 8-s probe stimuli were used.

phase two, SMTS accuracy increased and performance stabilized at .93- .99. Probe accuracy ranged from .77- .87. In panel 3, P-141's SMTS accuracy ranged from .87- .99. After the probe was added in phase two, SMTS accuracy increased and performance stabilized at .99- 1.0. Probe accuracy ranged from .65- .78. In panel 4, P-510's SMTS accuracy ranged from .90- .95. After the probe was added in phase two, SMTS accuracy maintained at .90- .98. Probe accuracy ranged from .74- .88.

Probe accuracy for all pigeons was between .53 and .87, in most instances well above chance, indicating the pigeons learned the probe discrimination. For P-172, the probe did not facilitate SMTS accuracy, as the pigeon's accuracy decreased slightly when the probe was added. For P-510, SMTS accuracy remained the same. However, for both P-140 and P-141, SMTS accuracy increased and stabilized when the probe was added.

Table 2 presents the primary data per trial for P-172, P-140, P-141, and P-510 in Experiment #1. The data are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The number of pecks per trial are presented for sample, SMTS comparison stimuli, and probe comparison stimuli across phases one and two of training. The data indicate that response rates to the sample key were approximately equal across the red and green stimuli. Response rates to the correct SMTS comparison stimuli and probe comparison stimuli were approximately equal, and response rates to the incorrect SMTS comparison stimuli and probe comparison stimuli were also approximately equal. Therefore, key color preference was not present, as indicated by similar response rates to each correct or incorrect color stimulus and to each form stimulus correlated with color.

Table 2

Experiment #1: SMTS, number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to SMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
P-172	phase 1	*	9	17	3	16	2	—	—	—	—
		*	9	15	0	15	1	—	—	—	—
		*	7	15	3	14	0	—	—	—	—
		*	10	14	0	14	0	—	—	—	—
		*	12	12	1	14	0	—	—	—	—
probe: FI 8 s	phase 2	3	3	5	0	4	1	11	5	7	1
		12	13	7	4	7	2	8	11	7	2
		2	3	5	1	4	1	12	4	9	2
		2	3	3	1	2	1	10	7	5	2
		2	2	4	1	4	0	10	3	7	2
P-140	phase 1	*	10	13	3	15	4	—	—	—	—
		*	11	12	3	14	5	—	—	—	—
		*	14	14	2	17	5	—	—	—	—
		*	13	11	1	19	1	—	—	—	—
		*	10	13	3	17	5	—	—	—	—
probe: FI 8 s	phase 2	4	6	5	0	5	0	5	1	5	1
		11	12	7	1	8	0	5	2	4	1
		4	5	4	0	6	0	5	1	4	0
		5	3	4	0	5	1	4	1	4	1
		2	4	4	0	6	0	4	1	3	1
P-141	phase 1	6	7	17	1	19	2	—	—	—	—
		6	6	17	3	18	2	—	—	—	—
		6	6	18	2	20	0	—	—	—	—
		6	6	16	0	18	0	—	—	—	—
		9	5	16	0	18	1	—	—	—	—
probe: FI 8 s	phase 2	6	2	6	0	9	0	8	3	7	5
		5	5	7	0	8	0	10	3	6	5
		5	4	5	0	9	0	10	2	8	6
		6	3	9	0	10	0	11	4	12	4
		8	8	9	0	10	0	9	2	10	4
P-510	phase 1	3	4	5	1	7	1	—	—	—	—
		8	8	6	0	8	1	—	—	—	—
		4	6	5	0	6	0	—	—	—	—
		7	9	6	0	7	1	—	—	—	—
		8	7	7	0	8	1	—	—	—	—
probe: FI 8 s	phase 2	5	5	4	0	4	0	9	3	9	3
		6	5	7	1	5	0	12	3	11	5
		4	*	5	0	4	0	13	2	13	2
		4	5	5	0	5	0	14	2	11	6
		2	3	3	0	4	0	12	5	13	2

Note. * = missing data

In Experiment #1, baseline SMTS accuracy was already high for all pigeons (ranging from .77- .99). The probe may not have been able to increase accuracy for two pigeons because their baseline SMTS performance may have already reached asymptote. Therefore in Experiment #2, the sample was removed during the MTS task in component one to analyze whether or not a decrease in MTS accuracy would occur, and again, whether or not the probe component in phase two would increase MTS accuracy. Changing the parameter of the SMTS to a 0-s delay MTS task may affect the rate at which the pigeons acquire and maintain the conditional MTS discrimination performance (MacKay, 1991), decreasing MTS accuracy which will allow an evaluation of the probe in phase two.

Experiment #2: 0-second Delayed Matching to Sample (0-s DMTS)

Method

Subjects

Pigeons P-140, P-141, and P-510 served as subjects[1].

Procedure

Table 1 presents the phases of training for each pigeon, and the number of sessions in each phase. Experiment #2 was similar to Experiment #1, except that in phase one, it used a 0-s DMTS task instead of a SMTS task. The 0-s DMTS differed from the SMTS procedure in that with 0-s DMTS, after the pigeon satisfied the FI 15-s schedule requirement on the sample, the sample went dark when the comparisons were illuminated. Thus with the offset of the sample, pigeons were required to respond to the comparison stimuli in the absence of the sample color. The pigeons were charged with "recalling" the sample stimulus color in order to correctly respond on the comparison

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[1] P-172 died during Experiment #2.

stimuli. The comparison keys were again illuminated red and green, assigned randomly across trials (component one). Food reinforcement was provided according to an FI 8-s schedule for responding on the side key that matched the center key. Incorrect responding on the nonmatching side key had no effect. A VI 30-s ITI was in effect. The 0-s DMTS procedure was first introduced without the probe component in order to provide a baseline measure of 0-s DMTS accuracy. Phase one continued until stable DMTS responding was demonstrated across at least five sessions, as determined by visual inspection.

Next, in phase two of training, after stable responding had developed in phase one, the probe component was added to see if the probe facilitated 0-s DMTS accuracy. In the second component, immediately after the pigeons satisfied the matching requirement, instead of food reinforcement, the side keys were illuminated with a circle and a triangle, assigned randomly across trials. Food reinforcement was provided according to an FI 8-s schedule if (a) the sample-comparison match in the preceding component was red and the pigeon responded to the triangle, or (b) the sample-comparison match in the preceding component was green and the pigeon responded to the circle. Incorrect responding on the nonmatching side key had no effect. Phase two continued until stable DMTS and probe responding was demonstrated across at least five sessions, as determined by visual inspection.

INTER-TRIAL INTERVAL (ITI)	VI 30 s	
ORIENTING STIMULUS	FR 1	
SAMPLE	FI 15 s	COMPONENT 1
RETENTION INTERVAL	0 s	
DMTS ON COMPARISONS	FI 8 s	
PROBE ON COMPARISONS	FI 8 s	COMPONENT 2
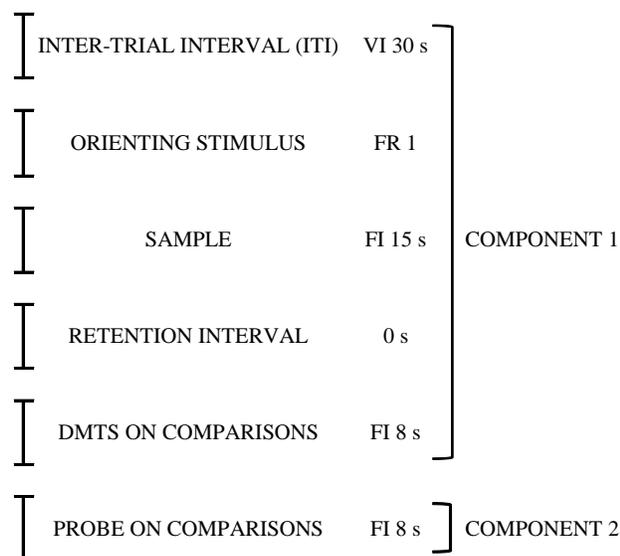
Figure 3: Outline of Experiment #2: 0-s DMTS

Results and Discussion

Figure 4 presents the discrimination indices for P-140, P-141, and P-510 in Experiment #2. The indices are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The indices are shown for the 0-s DMTS in phase one of training, and then for both the 0-s DMTS and probe in phase two of training.

In panel 1, P-140's 0-s DMTS accuracy ranged from .56- .71. After the probe was added in phase two, 0-s DMTS accuracy increased to .63- .79. Probe accuracy ranged from .56- .75. In panel 2, P-141's 0-s DMTS accuracy ranged from .82- .95. After the probe was added in phase two, 0-s DMTS accuracy maintained and performance stabilized at .87- .95. Probe accuracy ranged from .71- .78. In panel 3, P-510's 0-s DMTS accuracy ranged from .89- .93. After the probe was added in phase two, 0-s DMTS accuracy maintained at .86- .90. Probe accuracy ranged from .74- .86.
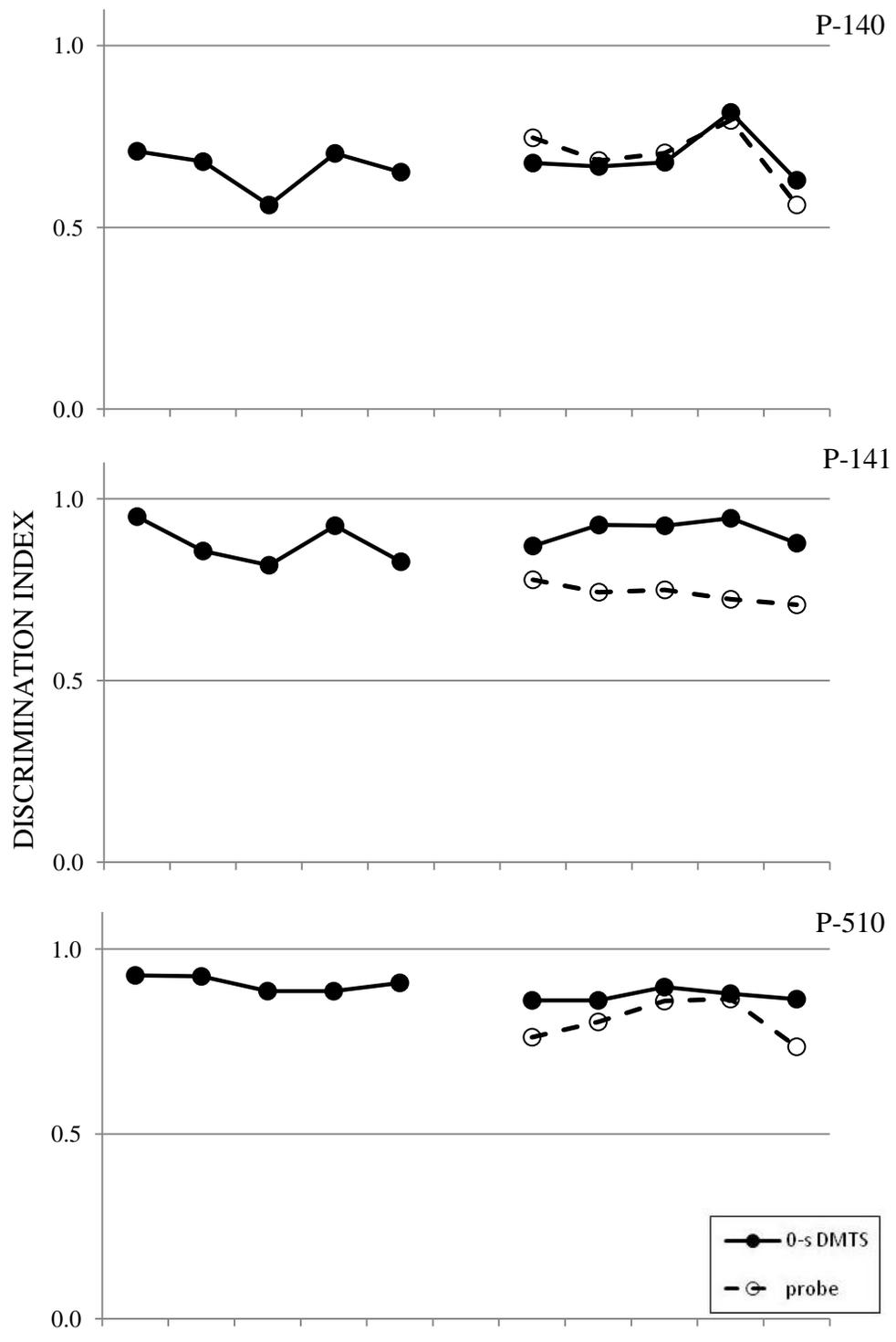
Figure 4: Experiment #2: 0-s DMTS- Discrimination indices for P-140, P-141, and P-510. The last 5 sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 0-s retention interval, FI 8-s comparison stimuli, and FI 8-s probe stimuli were used.

Probe accuracy for all pigeons was between .56 and .86, again in most instances well above chance, indicating the pigeons learned the probe discrimination. For P-141 and P-510, the probe did not facilitate 0-s DMTS accuracy, as the pigeons' 0-s DMTS accuracy remained the same when the probe was added. However, for P-140, 0-s DMTS accuracy increased when the probe was added.

Figure 5 presents discrimination indices from successive sessions across the three pigeons in Experiment #2. The indices are shown for the 0-s DMTS in phase one of training, and then for both the 0-s DMTS and probe in phase two of training. In panel 1, P-140's 0-s DMTS accuracy started to increase within six sessions of the addition of the probe in phase two. In panels 2 and 3, P-141 and P-510's 0-s DMTS accuracy did not increase with the addition of the probe in phase two.

Table 3 presents the primary data per trial for P-140, P-141, and P-510 in Experiment #2. The data are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The number of pecks per trial are presented for sample, 0-s DMTS comparison stimuli, and probe comparison stimuli across phases one and two of training. The data indicate that response rates to the sample key were approximately equal across the red and green stimuli. Response rates to the correct 0-s DMTS comparison stimuli and probe comparison stimuli were approximately equal, and response rates to the incorrect 0-s DMTS comparison stimuli and probe comparison stimuli were also approximately equal. Therefore, key color preference was not present, as indicated by similar response rates to each correct and incorrect color stimulus and to each form stimulus correlated with color.
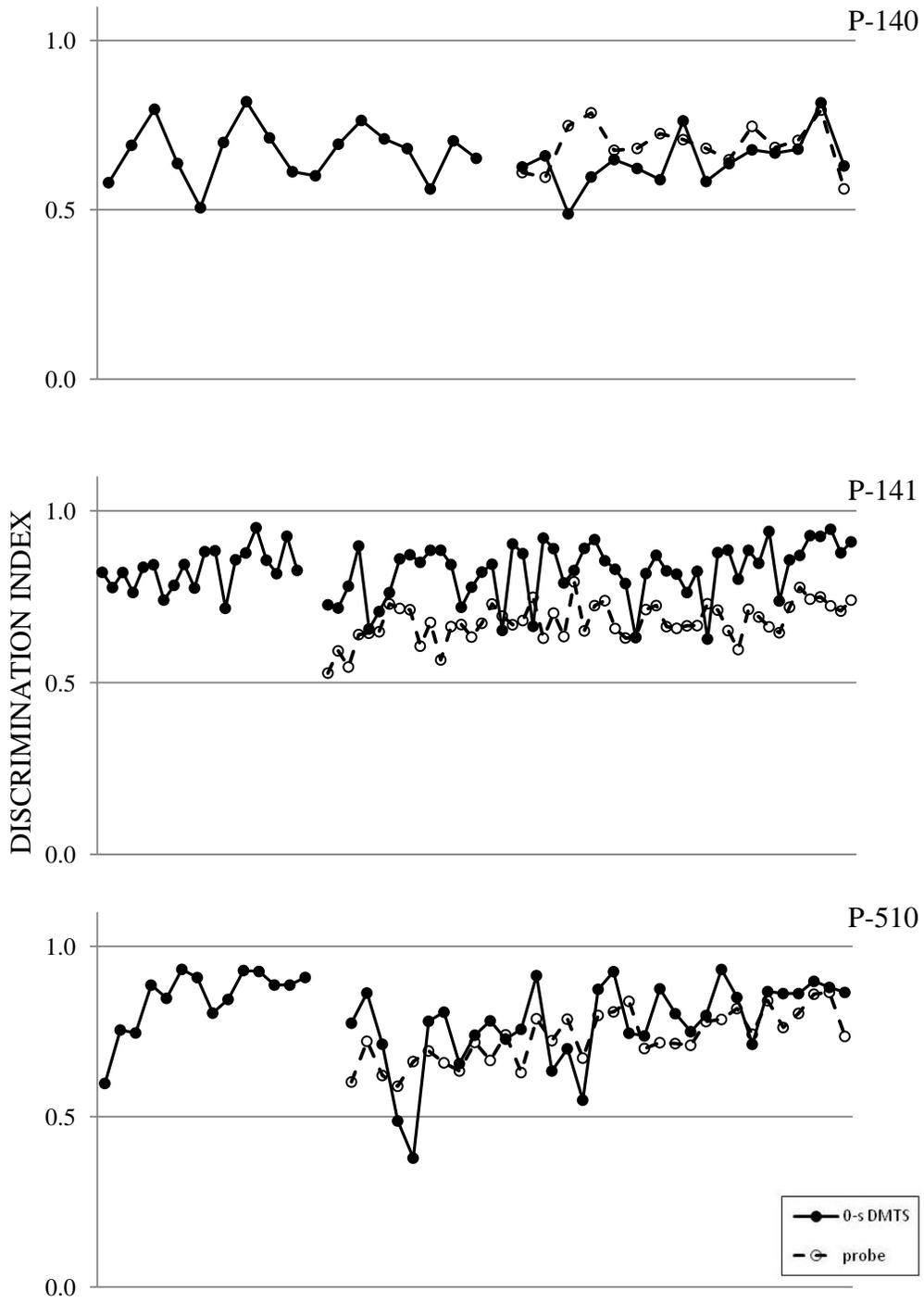
*Figure 5:* Experiment #2: 0-s DMTS- Discrimination indices for P-140, P-141, and P-510. Successive sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 0-s retention interval, FI 8-s comparison stimuli, and FI 8-s probe stimuli were used.

Table 3

Experiment #2: 0-s DMTS, number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to DMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
P-140	phase 1	6	7	11	4	14	7	—	—	—	—
		7	8	11	6	14	5	—	—	—	—
		15	20	19	8	15	19	—	—	—	—
		7	7	16	4	12	9	—	—	—	—
		6	8	17	3	11	14	—	—	—	—
probe: FI 8 s	phase 2	3	5	4	2	6	4	6	2	5	2
		11	13	10	7	13	4	5	3	6	2
		5	6	5	3	8	4	6	3	6	2
		5	7	10	1	8	3	7	3	6	0
		3	6	4	3	6	3	4	5	6	2
P-141	phase 1	13	15	13	1	21	1	—	—	—	—
		12	11	9	2	13	2	—	—	—	—
		20	21	13	3	19	4	—	—	—	—
		15	15	10	0	11	1	—	—	—	—
		13	12	9	1	12	3	—	—	—	—
probe: FI 8 s	phase 2	5	5	6	1	6	0	10	3	9	4
		7	5	5	1	5	0	9	1	7	4
		8	6	7	1	5	0	10	2	8	5
		4	5	5	1	6	0	9	3	8	5
		5	5	3	1	5	1	7	3	6	5
P-510	phase 1	7	6	20	1	19	2	—	—	—	—
		10	10	28	3	28	1	—	—	—	—
		7	6	24	4	26	3	—	—	—	—
		7	7	20	1	19	4	—	—	—	—
		10	11	29	4	33	3	—	—	—	—
probe: FI 8 s	phase 2	4	5	5	0	6	2	13	5	15	4
		3	3	5	0	6	1	14	5	17	3
		2	3	4	0	5	1	15	2	14	3
		2	3	5	1	5	1	16	3	17	3
		5	4	7	1	6	1	14	5	14	5

As was the case in Experiment #1, baseline 0-s DMTS accuracy was already high for the pigeons (ranging from .82-.95) in phase one of Experiment #2. The probe may not have been able to increase accuracy for the two pigeons because their baseline 0-s DMTS performance may have already reached asymptote. Therefore, in Experiment #3, the

retention interval (delay) between the sample and comparison stimuli was increased from a 0-s delay to an *n*-s delay, and the duration of the delay increased across conditions.

Changing the parameter of the DMTS from a 0-s delay to an *n*-s DMTS task, where *n* is an increasing time delay between the sample and comparison stimuli, should affect the terminal MTS accuracy (MacKay, 1991). There should be a decrease in MTS accuracy, especially with longer delay durations, which will allow an evaluation of the probe in phase two. Later conditions in Experiment #3 also decreased the schedule durations of the ITI, sample, comparisons, and probe. Decreasing the aforementioned schedule durations has been shown to not only affect the rate of the conditional MTS performance, but also to permit an analysis of the role these features and parameters play in DMTS accuracy (MacKay, 1991), thus permitting an even further evaluation of the probe in phase two.

Experiment #3: *n*-seconds Delayed Matching to Sample (*n*-s DMTS)

Method

Subjects

Pigeons P-140, P-141, and P-510 served as subjects.

Procedure

Table 1 presents the phases of training for each pigeon, and the number of sessions in each phase. Experiment #3 was similar to Experiment #2, except that in phase one, it used *n*-s retention interval (delay) DMTS tasks instead of a 0-s DMTS task. The *n*-s DMTS differed from the 0-s DMTS procedure in that with the *n*-s DMTS procedure, after the pigeon satisfied the FI 15-s schedule requirement on the sample, the offset of the sample stimulus produced an *n*-s retention interval. During the retention interval, an

n-seconds time delay was in effect prior to the onset of the comparison stimuli. As before, the pigeons were charged with "recalling" the sample stimulus color in order to correctly respond on the comparison stimuli. The retention intervals began at 1 s, and then were gradually increased over sessions to 2 s, 5 s, 8 s, and 12 s. After the retention interval had elapsed, the comparison keys were again illuminated red and green, assigned randomly across trials (component one). Food reinforcement was provided according to an FI 8-s schedule for responding on the side key that matched the center key. Incorrect responding on the nonmatching side key had no effect. A VI 30-s ITI was in effect. The *n*-s DMTS procedure was first introduced without the probe component in order to provide a baseline measure of *n*-s DMTS accuracy. Phase one continued until stable DMTS responding was demonstrated across at least five sessions, as determined by visual inspection.

Next, in phase two of training, after stable responding had developed in phase one, the probe component was added to see if the probe facilitated *n*-s DMTS accuracy. In the second component, immediately after the pigeons satisfied the matching requirement, instead of food reinforcement, the side keys were illuminated with a circle and a triangle, assigned randomly across trials. Food reinforcement was provided according to an FI 8-s schedule if (a) the sample-comparison match in the preceding component was red and the pigeon responded to the triangle, or (b) the sample-comparison match in the preceding component was green and the pigeon responded to the circle. Incorrect responding on the nonmatching side key had no effect. A VI 30-s ITI was in effect. Phase two continued until stable DMTS and probe responding was demonstrated across at least five sessions, as determined by visual inspection.

```
┤  INTER-TRIAL INTERVAL (ITI)    VI 30 s  ┐
                                          │
┤     ORIENTING STIMULUS          FR 1    │
                                          │
┤         SAMPLE                  FI 15 s │  COMPONENT 1
                                          │
                                   1 s,   │
┤      RETENTION INTERVALS          2 s,  │
                                   & 5 s  │
                                          │
┤    DMTS ON COMPARISONS          FI 8 s  ┘

┤    PROBE ON COMPARISONS         FI 8 s  ┐ COMPONENT 2
                                          ┘
```

Figure 6: Outline of Experiment #3: 1-s, 2-s, and 5-s DMTS

For P-140, once the retention interval reached an 8-s delay, responding on the probe was reduced from a FI 8-s reinforcement schedule to FI 4-s, and then FI 2-s, to counteract extinction effects with the longer FI 8-s schedule. In the next condition, P-140's retention interval was lengthened to a 12-s delay, and responding on the probe was increased back up to the original FI 8-s reinforcement schedule.

For both P-141 and P-510, when the retention intervals were 1 s, 2 s, and 5 s, *n*-s DMTS accuracy was still very high, so the probe was not added as baseline DMTS accuracy was near or at asymptote. In the next condition, with an 8-s retention interval, DMTS accuracy decreased, so the probe component was added in phase two, as per the normal procedure. Once the retention interval reached 12-s, responding on the probe was first reinforced according to the FI 8-s schedule, but the schedule was then reduced to FI 4-s, and then FI 2-s, to counteract extinction effects with the longer FI 8-s schedule.

INTER-TRIAL INTERVAL (ITI)   VI 30 s

ORIENTING STIMULUS   FR 1

SAMPLE   FI 15 s   COMPONENT 1

RETENTION INTERVALS   8 s & 12 s

DMTS ON COMPARISONS   FI 8 s

PROBE ON COMPARISONS   FI 8 s, FI 4 s, & FI 2 s   COMPONENT 2
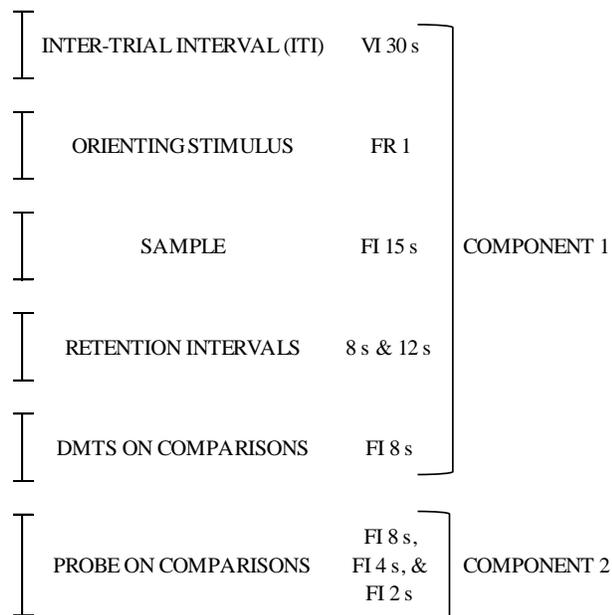
Figure 7: Outline of Experiment #3: 8-s and 12-s DMTS

All three pigeons completed the DMTS conditions with 1 s through 12 s retention intervals in Experiment #3, but pigeons P-141 and P-510 continued to further parameter changes. Due to the positive effects of reducing the probe schedules on pigeons' probe accuracy, further schedule reductions were in effect, and both DMTS and probe accuracy were again tested. In these further analyses, 12-s, 15-s, and 30-s retention intervals were used. The DMTS and probe components were procedurally the same as they had been across the previous experiments. The schedule changes included: (a) the schedule on the sample was reduced from FI 15-s to FI 8-s, (b) the schedule on the DMTS comparison stimuli was reduced from FI 8-s to FI 4-s, (c) the schedule on the probe stimuli was reduced from FI 8-s to FI 2-s, and (d) the ITI was reduced from VI 30-s to VI 15-s. Such changes should counteract any potential extinction effects with the longer schedules, as well as provide more immediate feedback as to self-accuracy on the DMTS and probe. For both P-141 and P-510, following phase two in the 30-s retention interval condition,

phase one (baseline) was repeated to assess if the probe had any lasting influence on DMTS accuracy.

INTER-TRIAL INTERVAL (ITI)   VI 15 s

ORIENTING STIMULUS   FR 1

SAMPLE   FI 8 s   COMPONENT 1

RETENTION INTERVALS   12 s, 15 s, & 30 s

DMTS ON COMPARISONS   FI 4 s

PROBE ON COMPARISONS   FI 2 s   COMPONENT 2
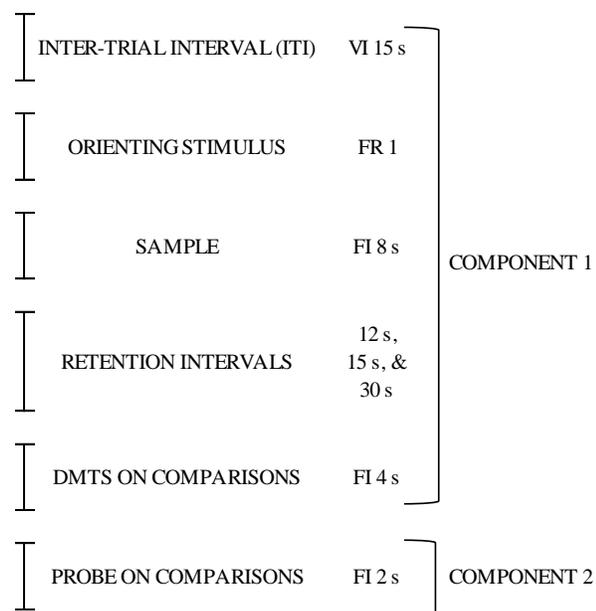
Figure 8: Outline of Experiment #3: 12-s, 15-s, and 30-s DMTS

Results and Discussion

P-140: 1-s, 2-s, 5-s, 8-s*, and 12-s DMTS with VI 30-s ITI, FI 15-s sample, FI 8-s comparisons, and FI 8-s probe (*= with both a FI 4-s and FI 2-s probe). Figure 9 presents the discrimination indices for P-140 in Experiment #3. The indices are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The indices are shown for the *n*-s DMTS in phase one of training, and then for both the *n*-s DMTS and probe in phase two of training.

In panel 1, P-140's indices are from conditions with 1-s, 2-s, and 5-s retention intervals, and an FI 8-s schedule in effect during comparisons in probe. When the retention interval was 1-s, DMTS accuracy ranged from .45- .67. After the probe was
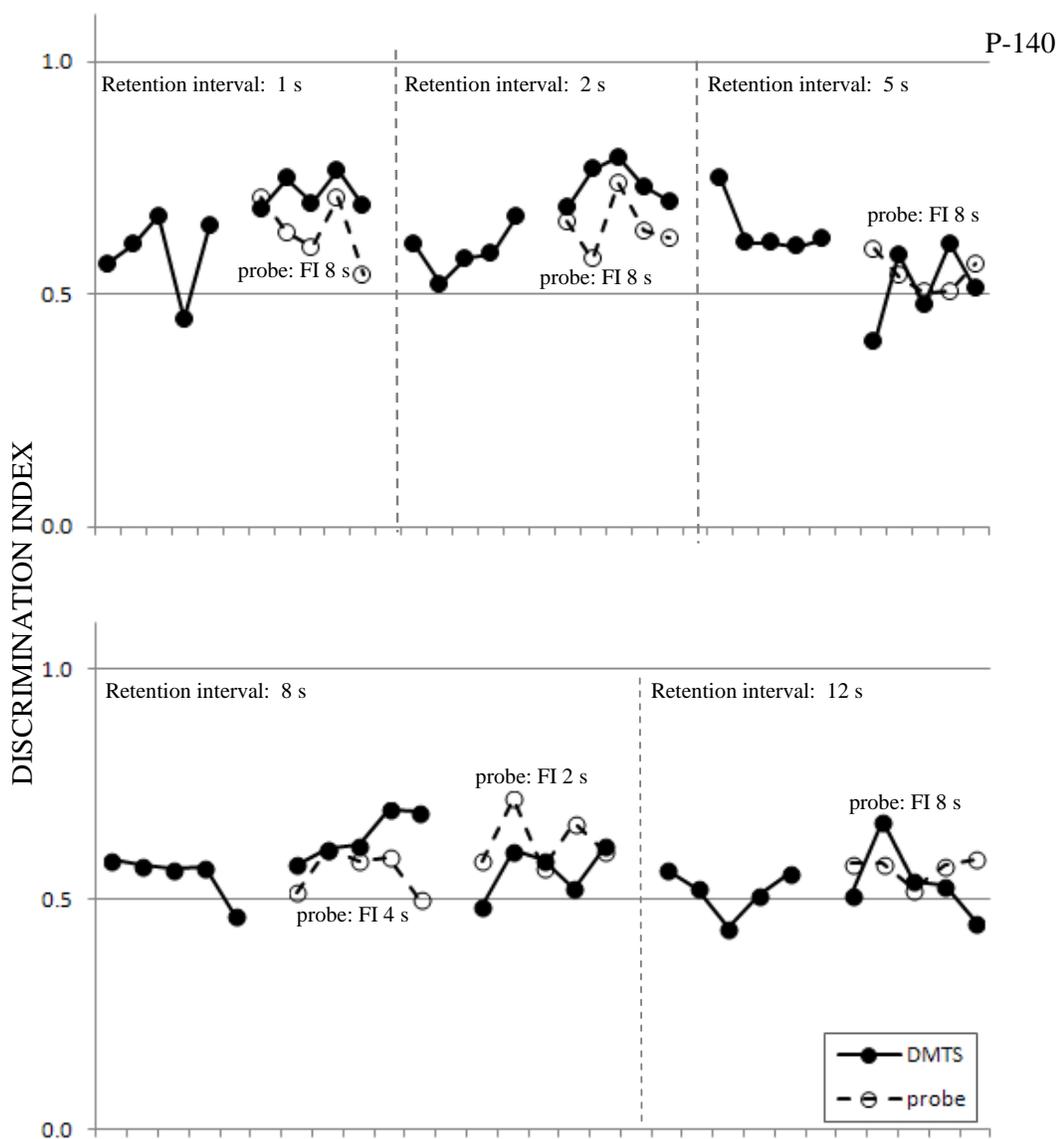
Figure 9: Experiment #3: *n*-s DMTS- Discrimination indices for P-140. The last 5 sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 1-s, 2-s, 5-s, 8-s, and 12-s retention intervals, FI 8-s comparison stimuli, and varied FI probe stimuli were used.

added in phase two, DMTS accuracy increased to .69- .77. Probe accuracy ranged from

.54- .71. When the retention interval was 2-s, DMTS accuracy ranged from .52- .67.

After the probe was added in phase two, DMTS accuracy increased to .69- .79. Probe

accuracy ranged from .58- .74. When the retention interval was 5-s, DMTS accuracy

ranged from .60- .75. After the probe was added in phase two, DMTS accuracy decreased to .40- .61. Probe accuracy ranged from .50- .60.

In panel 2, the indices are from conditions with 8-s and 12-s retention intervals. With the 8-s retention interval, FI 4-s and FI 2-s schedules were in effect during comparisons in probe. With the 12-s retention interval, the FI 8-s schedule in effect during comparisons in probe was reinstated. When the retention interval was 8-s, DMTS accuracy ranged from .47- .58. After the FI 4-s probe was added in phase two, DMTS accuracy increased to .58- .70. FI 4-s probe accuracy ranged from .50- .61. After the FI 4-s probe was decreased to an FI 2-s probe, DMTS accuracy remained higher than baseline at .49- .62. FI 2-s probe accuracy ranged from .58- .72. When the retention interval was 12-s, DMTS accuracy ranged from .45- .67. After the FI 8-s probe was added in phase two, DMTS accuracy slightly increased to .51- .67. Probe accuracy ranged from .52- .59.

P-140's probe accuracy was between .50 and .74 across conditions, again in most instances well above chance, indicating the pigeon learned the probe discrimination. For this pigeon, the probe facilitated DMTS accuracy when the retention intervals were 1-s, 2-s, and 12-s, with FI 8-s schedules in effect during probe, and when the retention interval was 8-s with an FI 4-s schedule in effect during probe. When the retention interval was 5-s with an FI 8-s schedule during the probe, the probe did not facilitate DMTS accuracy, as the pigeon's DMTS accuracy decreased when the probe was added. Figure 10 presents discrimination indices from successive sessions for P-140 in Experiment #3. The indices are shown for the *n*-s DMTS in phase one of training, and

then for both the *n*-s DMTS and probe in phase two of training. In panel 1, when the

retention interval was 1-s, DMTS accuracy increased as soon as the probe was added in
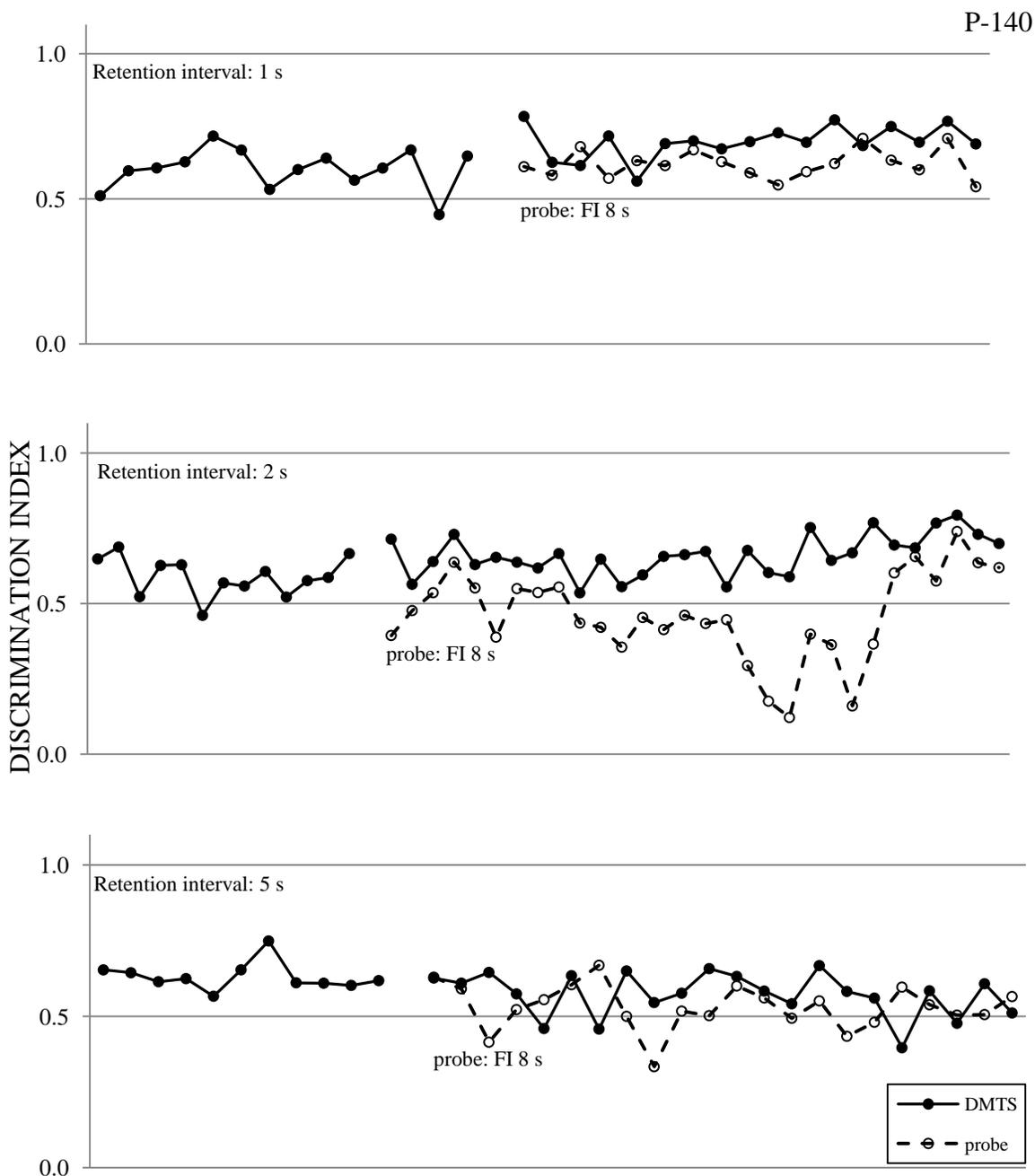
Figure 10: Experiment #3: *n*-s DMTS- Discrimination indices for P-140. Successive sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 1-s, 2-s, 5-s, 8-s, and 12-s retention intervals, FI 8-s comparison stimuli, and varied FI probe stimuli were used.
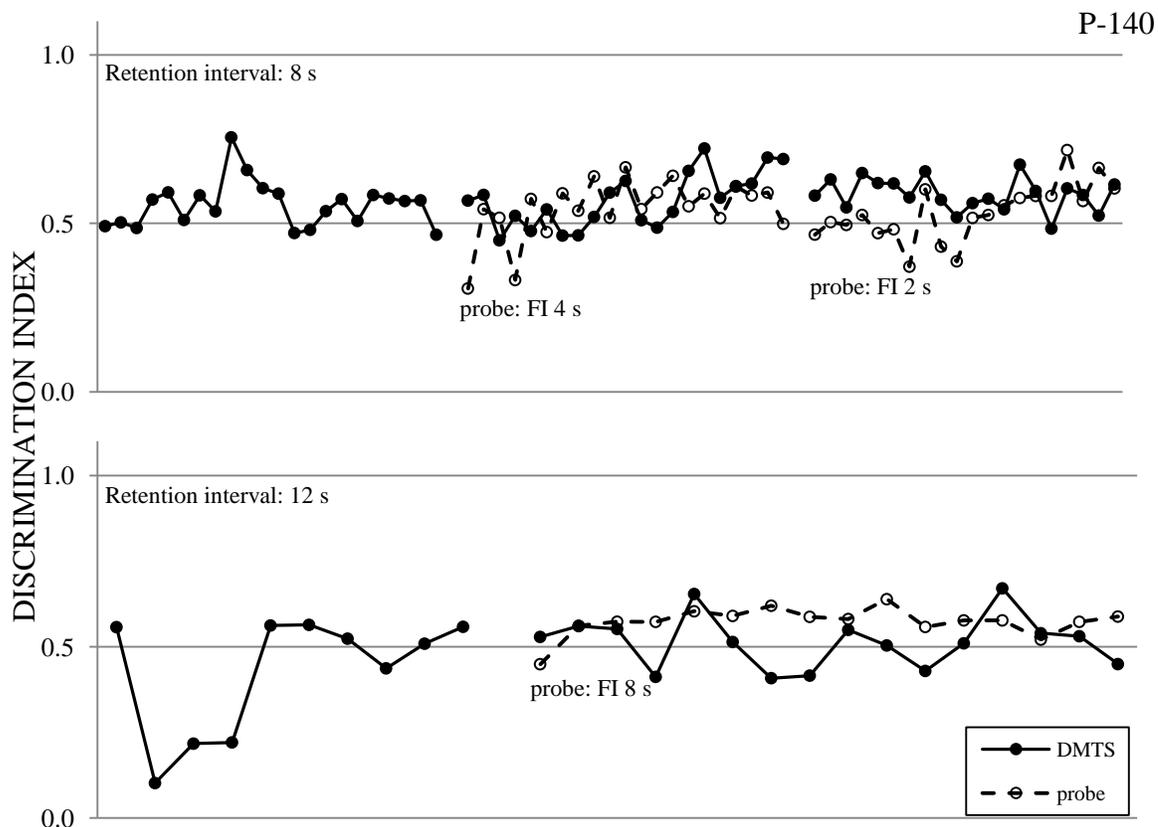
*Figure 10 (cont.):* Experiment #3: *n*-s DMTS- Discrimination indices for P-140. Successive sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 1-s, 2-s, 5-s, 8-s, and 12-s retention intervals, FI 8-s comparison stimuli, and varied FI probe stimuli were used.

phase two. In panel 2, when the retention interval was 2-s, DMTS accuracy increased

soon after the probe data separated from the DMTS data, after about ten sessions with the

probe. In panel 3, when the retention interval was 5-s, DMTS accuracy did not increase

with the addition of the probe. In panel 4, when the retention interval was 8-s and the FI

4-s schedule was in effect during probe, DMTS accuracy increased after about seven

sessions with the probe; DMTS accuracy did not increase with the FI 2-s schedule during

probe. In panel 5, when the retention interval was 12-s, DMTS accuracy increased

steadily with the addition of the probe.

P-141 and P-510: 1-s, 2-s, 5-s, 8-s, and 12-s* DMTS with VI 30-s ITI, FI 15-s sample, FI 8-s comparisons, and FI 8-s probe (*= with FI 8-s, FI 4-s, and FI 2-s probes). For both P-141 and P-510, when the retention interval was 1-s, 2-s, and 5-s, baseline *n*-s DMTS accuracy ranged from .80-.89. With such accurate discrimination indices in phase one, the probe was not added as DMTS accuracy was at or near asymptote. The probe was added in the 8-s and 12-s retention interval conditions since DMTS accuracy was reduced with the longer delay durations.

Figure 11 presents discrimination indices for P-141 and P-510 in Experiment #3, across the 8-s and 12-s retention interval conditions. The indices are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The indices are shown for the *n*-s DMTS in phase one of training, and then for both the *n*-s DMTS and probe in phase two of training.

In panel 1, P-141's indices are from conditions with 8-s and 12-s retention intervals. With the 8-s retention interval, an FI 8-s schedule was in effect during comparisons in probe. With the 12-s retention interval, FI 8-s, FI 4-s, and FI 2-s schedules were in effect during comparisons in the probe. When the retention interval was 8-s, DMTS accuracy ranged from .64- .73. After the FI 8-s probe was added in phase two, DMTS accuracy decreased to .53- .72. Probe accuracy ranged from .57- .69. When the retention interval was 12-s, DMTS accuracy ranged from .54- .64. After the FI 8-s probe was added in phase two, DMTS accuracy maintained at .44- .69. FI 8-s probe accuracy ranged from .44- .50. After the FI 8-s probe was decreased to an FI 4-s probe, DMTS accuracy increased to .62- .95. FI 4-s probe accuracy ranged from .44- .78. After
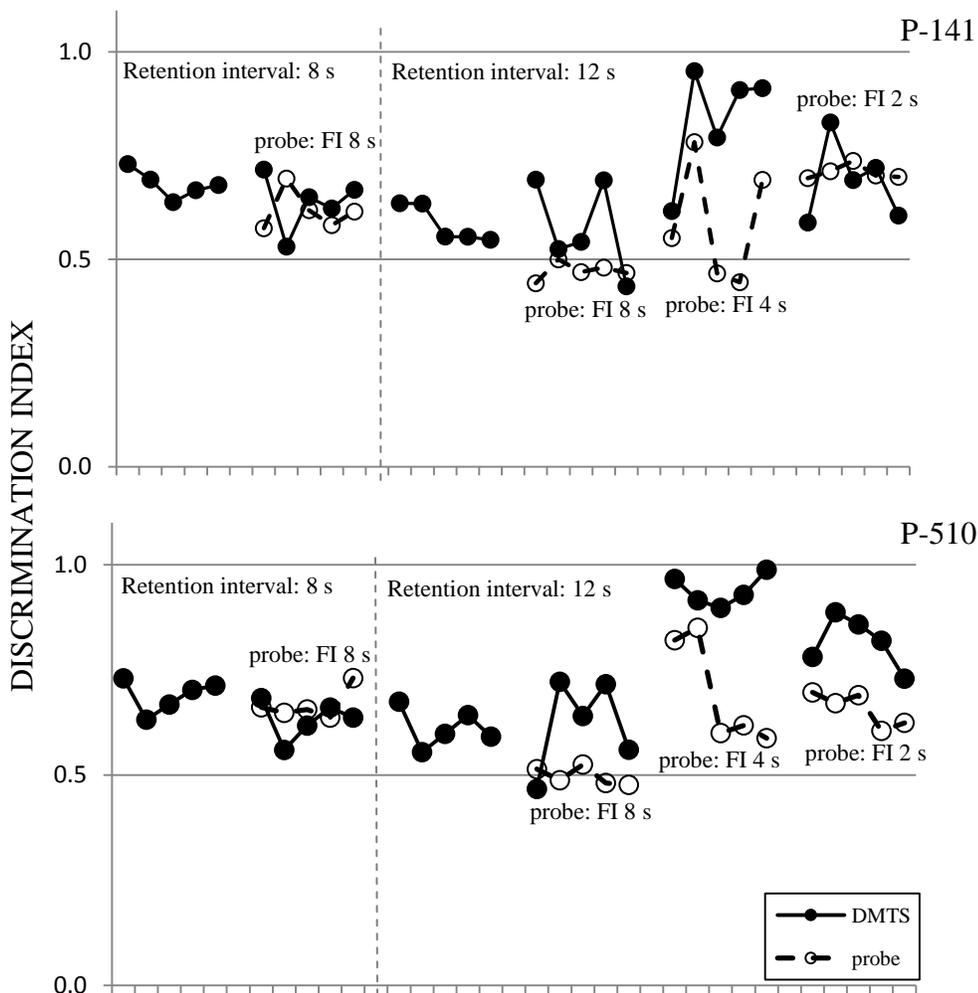
Figure 11: Experiment #3: *n*-s DMTS - Discrimination indices for P-141 and P-510. The last 5 sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 8-s and 12-s retention intervals, FI 8-s comparison stimuli, and varied FI probe stimuli were used.

the FI 4-s probe was decreased to an FI 2-s probe, DMTS accuracy remained higher than

baseline at .59- .83. FI 2-s probe accuracy ranged from .70- .74.

In panel 2, P-510's indices are from conditions with 8-s and 12-s retention

intervals. With the 8-s retention interval, an FI 8-s schedule was in effect during

comparisons in probe. With the 12-s retention interval, FI 8-s, FI 4-s, and FI 2-s

schedules were in effect during comparisons in probe. When the retention interval was

8-s, DMTS accuracy ranged from .63- .73. After the FI 8-s probe was added in phase

two, DMTS accuracy decreased to .56- .68. Probe accuracy ranged from .64- .73. When

the retention interval was 12-s, DMTS accuracy ranged from .55- .67. After the FI 8-s

probe was added in phase two, DMTS accuracy maintained at .47- .72. FI 8-s probe

accuracy ranged from .48- .53. After the FI 8-s probe was decreased to an FI 4-s probe,

DMTS accuracy increased to .90- .99. FI 4-s probe accuracy ranged from .59- .85. After

the FI 4-s probe was decreased to an FI 2-s probe, DMTS accuracy remained higher than

baseline at .73- .89. FI 2-s probe accuracy ranged from .61- .70.

Both pigeons' probe accuracy was between .44 and .85 when the retention

intervals were 8-s and 12-s. Probe accuracy was at chance during the 12-s retention

interval with an FI 8-s probe. When the probe schedule was reduced from FI 8-s to FI 4-s

and then FI 2-s, probe accuracy increased to above chance, indicating the pigeons learned

the probe discrimination more so with the shorter schedules. The probe did not facilitate

an increase in DMTS accuracy after it was added when the retention interval was 8-s with

an FI 8-s schedule during the probe. However, when the retention interval was 12-s with

FI 4-s and FI 2-s schedules in effect during probe, the probe did facilitate DMTS

accuracy, as the pigeon's DMTS accuracy increased when the probe was added. In other

words, probe accuracy clearly facilitated DMTS accuracy when the probe schedule was

shorter (FI 4-s and FI 2-s versus FI 8-s).

Figure 12 presents discrimination indices for pigeons P-141 and P-510 in

Experiment #3. The indices are from the pigeons' successive sessions with the 8-s and

12-s retention intervals. The indices are shown for the *n*-s DMTS in phase one of

training, and then for both the *n*-s DMTS and probe in phase two of training.
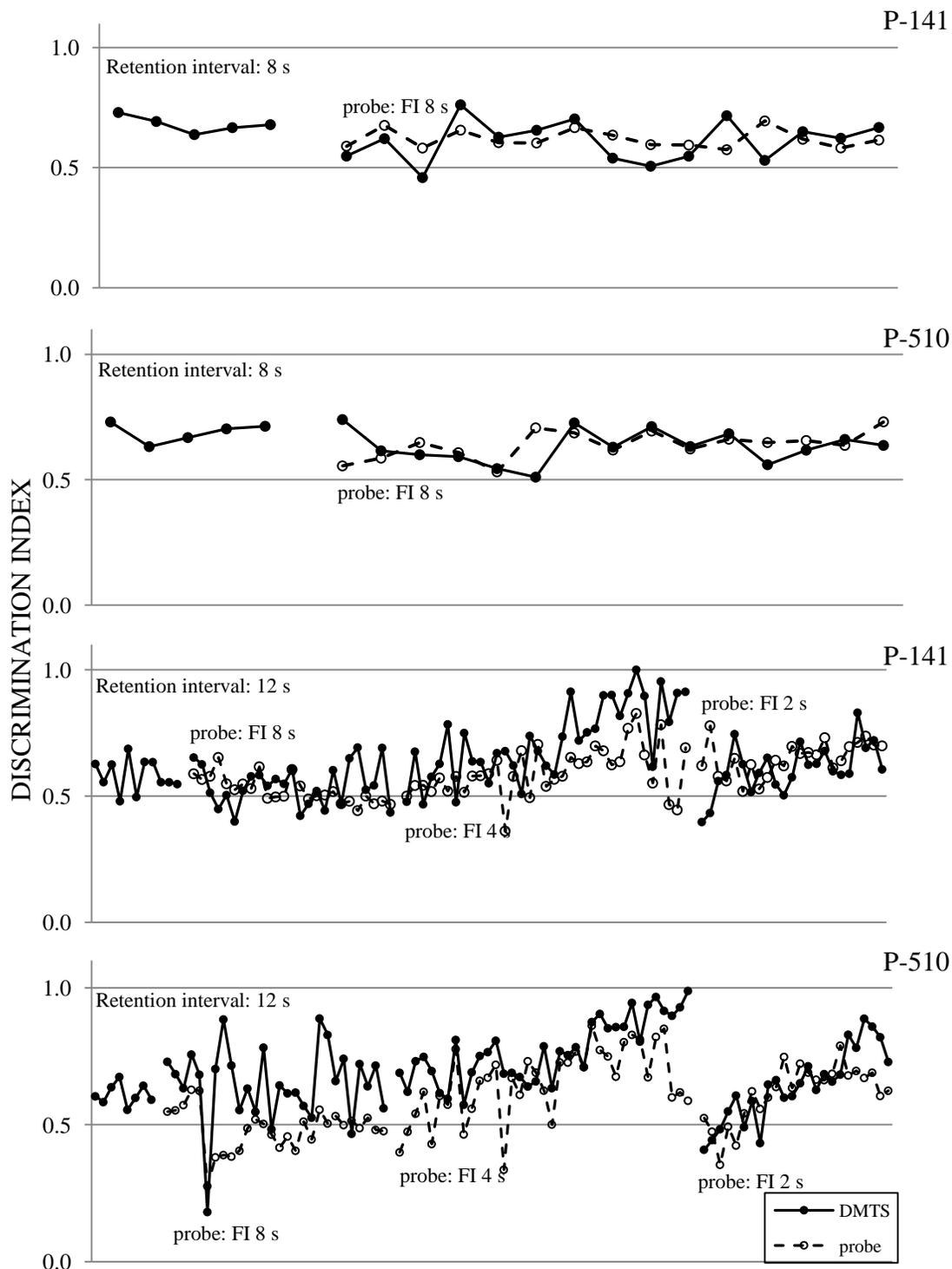
Figure 12: Experiment #3: *n*-s DMTS - Discrimination indices for P-141 and P-510. Successive sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 30-s ITI, FI 15-s sample, 8-s and 12-s retention intervals, FI 8-s comparison stimuli, and varied FI probe stimuli were used.

In panels 1 and 2 for both pigeons, when the retention interval was 8-s, DMTS accuracy did not increase with the addition of the probe in phase two. In panel 3 for P-141, when the retention interval was 12-s and the FI 4-s schedule was in effect during probe, DMTS accuracy increased after the DMTS data start to separate from the probe data, following the eleventh session with the probe. With the FI 2-s schedule in effect during probe, DMTS accuracy increased after the third session. In panel 4 for P-510, when the retention interval was 12-s, DMTS accuracy increased immediately with the FI 8-s and FI 4-s schedules in effect during probe. With the FI 2-s schedule in effect during probe, DMTS accuracy increased after the thirteenth session with the probe.

P-141 and P-510: 12-s, 15-s, and 30-s DMTS with VI 15-s ITI, FI 8-s sample, FI 4-s comparisons, and FI 2-s probe. Figure 13 presents discrimination indices for P-141 and P-510 in Experiment #3, across the 12-s, 15-s, and 30-s retention interval conditions. The indices are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The indices are shown for the *n*-s DMTS in phase one of training, and then for both the *n*-s DMTS and probe in phase two of training, with a return to phase one of training during the 30-s retention interval condition only.

In panel 1, P-141's indices are from conditions with 12-s, 15-s, and 30-s retention intervals. When the retention interval was 12-s, DMTS accuracy ranged from .55- .62. After the probe was added in phase two, DMTS accuracy increased to .58- .68. Probe accuracy ranged from .68- .82. When the retention interval was 15-s, DMTS accuracy ranged from .54- .66. After the probe was added in phase two, DMTS accuracy maintained at .54- .68. Probe accuracy ranged from .75- .81. When the retention interval was 30-s, DMTS accuracy ranged from .53- .61. After the probe was added in phase two,
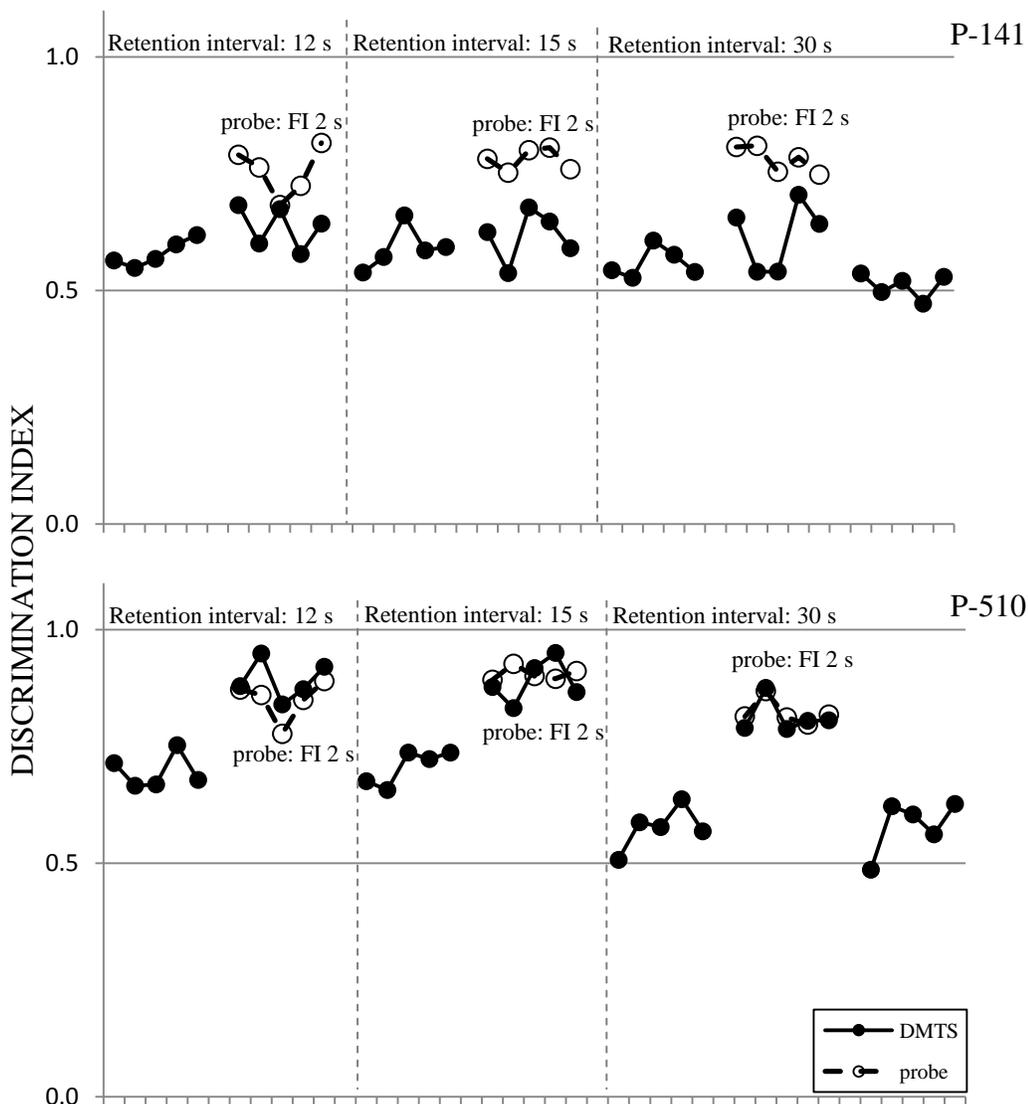
Figure 13: Experiment #3: *n*-s DMTS - Discrimination indices for P-141 and P-510. The last 5 sessions from both the DMTS in phase 1, the DMTS and probe in phase 2, and reversal to phase 1 (* only) are shown. A VI 15-s ITI, FI 8-s sample, 12-s, 15-s, and 30-s (*) retention intervals, FI 4-s comparison stimuli, and FI 2-s probe stimuli were used.

DMTS accuracy increased to .54- .70. Probe accuracy ranged from .75- .81. After phase

one was repeated in this condition only, DMTS accuracy immediately reduced to less

than baseline levels at .47- .56.

In panel 2, P-510's indices are from conditions with 12-s, 15-s, and 30-s retention

intervals. When the retention interval was 12-s, DMTS accuracy ranged from .67- .75.

After the probe was added in phase two, DMTS accuracy increased to .84- .95. Probe

accuracy ranged from .78- .89. When the retention interval was 15-s, DMTS accuracy

ranged from .66- .74. After the probe was added in phase two, DMTS accuracy increased

to .83- .95. Probe accuracy ranged from .89- .93. When the retention interval was 30-s,

DMTS accuracy ranged from .51- .64. After the probe was added in phase two, DMTS

accuracy increased to .79- .88. Probe accuracy ranged from .80- .87. After phase one was

repeated in this condition only, DMTS accuracy immediately reduced to less than

baseline levels at .49- .63.

Probe accuracy for both pigeons was between .68 and .93 across conditions, well

above chance, indicating the pigeons learned the probe discrimination. For P-141, the

probe did not facilitate an increase in DMTS accuracy when the retention interval was

15-s. However, the probe did facilitate DMTS accuracy when the retention intervals were

12-s and 30-s. For P-510, the probe facilitated DMTS accuracy across all retention

intervals.

Figure 14 presents discrimination indices for pigeons P-141 and P-510 in

Experiment #3. The indices are from the pigeons' successive sessions with the 12-s and

15-s retention intervals. The indices are shown for the n-s DMTS in phase one of

training, and then for both the n-s DMTS and probe in phase two of training. In panel 1

for P-141, when the retention interval was 12-s, DMTS accuracy began to increase

slowly from the second session with the probe. In panel 2 for P-510, when the retention

interval was 12-s, DMTS accuracy increased immediately after the probe was added. In

panel 3 for P-141, when the retention interval was 15-s, DMTS accuracy did not increase,

but maintained across sessions after the probe was added. In panel 4 for P-510, when the
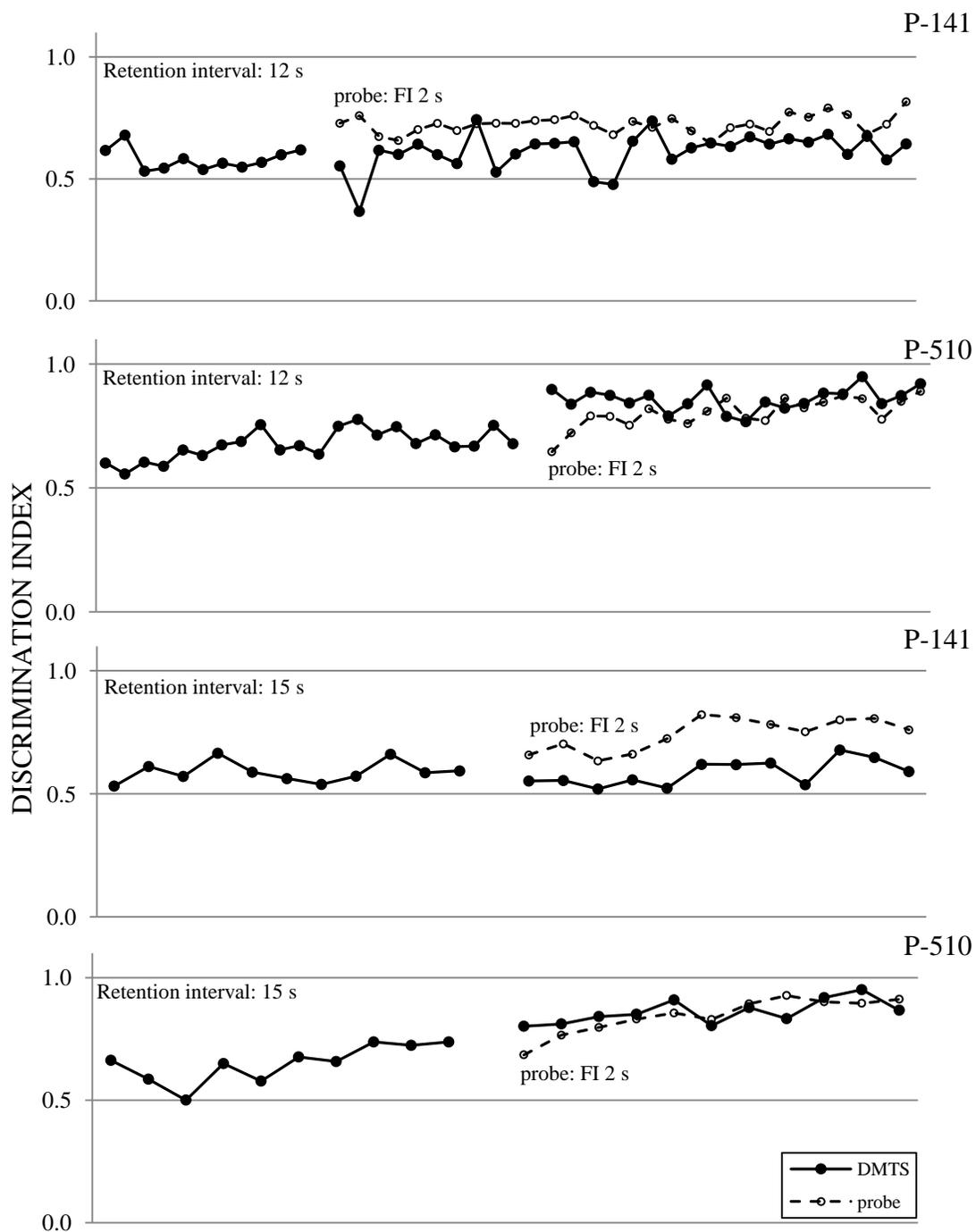
Figure 14: Experiment #3: *n*-s DMTS - Discrimination indices for P-141 and P-510. Successive sessions from both the DMTS in phase 1, and the DMTS and probe in phase 2 are shown. A VI 15-s ITI, FI 8-s sample, 12-s and 15-s retention intervals, FI 4-s comparison stimuli, and FI 2-s probe stimuli were used.

retention interval was 15-s, DMTS accuracy increased immediately after the probe was added.

Figure 15 presents discrimination indices for P-141 and P-510 in Experiment #3. The indices are from the pigeons' successive sessions with the 30-s retention interval. The indices are shown for the *n*-s DMTS in phase one of training, for both the *n*-s DMTS and probe in phase two of training, and then a return to phase one of training. In panel 1 for P-141, DMTS accuracy began to increase slowly from the fifth session with the probe. In panel 2 for P-510, DMTS accuracy increased immediately after the probe was added.
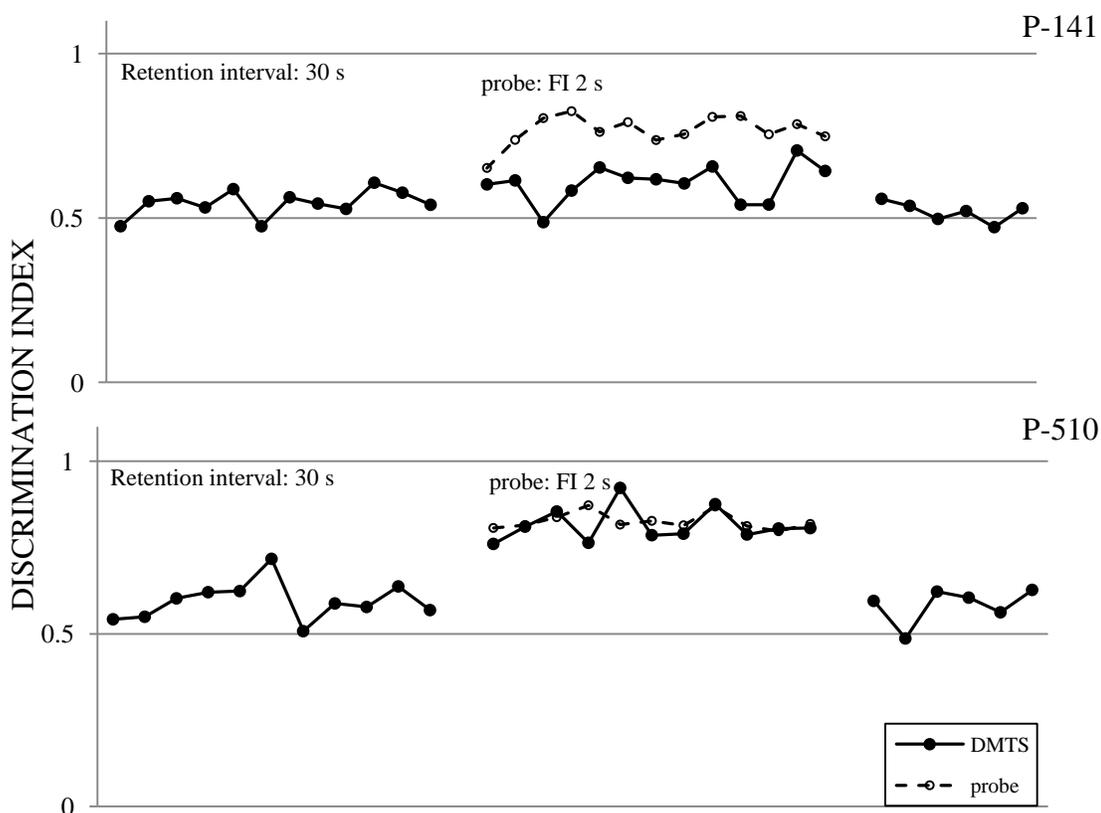
Figure 15: Experiment #3: *n*-s DMTS - Discrimination indices for P-141 and P-510. Successive sessions from both the DMTS in phase 1, the DMTS and probe in phase 2, and reversal to phase 1 are shown. A VI 15-s ITI, FI 8-s sample, 30-s retention interval, FI 4-s comparison stimuli, and FI 2-s probe stimuli were used.

Tables 4 through 6 present the primary data per trial for P-140, P-141, and P-510 in Experiment #3. The data are from the last five sessions in each phase, as in Kramer (1982), Lattal (1975), and Shimp (1981, 1983). The number of pecks per trial are presented for sample, n-s DMTS comparison stimuli, and probe comparison stimuli across phases one and two of training. The data indicate that response rates to the sample key were approximately equal across the red and green stimuli. Response rates to the correct n-s DMTS comparison stimuli and probe comparison stimuli were approximately equal, and response rates to the incorrect n-s DMTS comparison stimuli and probe comparison stimuli were also approximately equal. Therefore, key color preference was not present, as indicated by similar response rates to each correct and incorrect color stimulus and to each form stimulus correlated with color.

Table 4

Experiment #3: n-s DMTS, P-140 number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to DMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
1 s DMTS	phase 1	4	4	22	8	13	19	—	—	—	—
		9	7	40	15	25	28	—	—	—	—
		4	4	23	6	14	12	—	—	—	—
		6	4	17	15	10	19	—	—	—	—
		7	6	15	6	12	9	—	—	—	—
probe: FI 8 s	phase 2	4	4	7	3	7	4	5	2	5	2
		2	3	10	3	10	3	5	4	5	2
		3	4	5	3	7	3	5	4	3	2
		10	11	14	5	18	4	5	3	5	1
		4	5	9	5	11	4	5	5	3	1
2 s DMTS	phase 1	8	11	18	17	22	9	—	—	—	—
		9	9	17	16	18	16	—	—	—	—
		8	7	21	9	13	16	—	—	—	—
		8	6	18	8	13	14	—	—	—	—
		6	8	18	9	17	8	—	—	—	—
probe: FI 8 s	phase 2	8	8	8	6	12	3	6	3	7	3
		5	5	9	1	9	4	8	7	4	1
		6	6	8	2	8	3	9	4	6	1
		6	6	10	3	11	5	6	4	5	2
		7	9	9	3	9	5	6	5	4	1
5 s DMTS	phase 1	8	11	28	7	23	11	—	—	—	—
		10	14	29	11	22	23	—	—	—	—
		6	8	28	14	36	28	—	—	—	—
		5	8	23	7	13	19	—	—	—	—
		5	8	24	12	29	20	—	—	—	—
probe: FI 8 s	phase 2	3	3	5	9	4	5	5	4	6	4
		5	7	10	13	19	7	7	8	6	2
		6	5	13	4	7	21	6	7	4	3
		4	5	11	5	23	18	6	8	5	2
		5	7	9	8	9	10	6	5	5	3
8 s DMTS	phase 1	8	8	20	11	17	15	—	—	—	—
		7	8	17	14	19	13	—	—	—	—
		5	6	18	12	17	14	—	—	—	—
		5	4	22	6	11	22	—	—	—	—
		4	4	15	22	18	15	—	—	—	—
probe: FI 4 s	phase 2	7	7	10	10	14	7	6	6	5	4
		3	5	7	8	16	6	6	5	6	2
		3	3	8	9	10	2	6	4	4	3
		5	6	11	4	11	6	5	4	4	3
		5	6	12	3	11	8	7	9	4	2
probe: FI 2 s	phase 2	3	2	7	13	14	7	3	3	4	3
		6	7	10	10	18	7	4	3	5	0
		5	6	9	8	14	8	3	2	1	1
		3	3	9	10	15	12	3	3	3	0
		3	3	10	8	15	8	3	4	4	0
12 s DMTS	phase 1	4	3	9	6	11	10	—	—	—	—
		5	8	14	13	15	14	—	—	—	—
		0	5	16	11	10	24	—	—	—	—
		3	4	16	12	17	21	—	—	—	—
		4	6	17	16	26	17	—	—	—	—
probe: FI 8 s	phase 2	3	3	7	3	6	10	11	10	6	1
		3	3	10	3	10	7	11	12	8	2
		3	4	7	3	5	7	10	15	9	1
		3	3	7	6	7	6	9	13	11	1
		4	5	10	7	6	14	11	12	9	1

Table 5

Experiment #3: n-s DMTS, P-141 number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to DMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
1 s DMTS	phase 1	8	10	11	0	11	2	—	—	—	—
		11	9	11	4	15	5	—	—	—	—
		7	8	12	1	19	4	—	—	—	—
		13	14	11	0	21	0	—	—	—	—
		12	11	11	1	16	1	—	—	—	—
2 s DMTS	phase 1	10	14	10	2	19	2	—	—	—	—
		7	8	9	3	13	4	—	—	—	—
		9	9	10	2	11	2	—	—	—	—
		10	10	8	0	13	1	—	—	—	—
		10	9	11	1	14	1	—	—	—	—
5 s DMTS	phase 1	5	6	5	0	8	3	—	—	—	—
		8	7	8	2	11	4	—	—	—	—
		9	7	8	2	9	2	—	—	—	—
		9	8	7	0	11	3	—	—	—	—
		8	8	6	1	9	3	—	—	—	—
8 s DMTS	phase 1	10	6	6	2	6	3	—	—	—	—
		9	7	7	3	6	2	—	—	—	—
		7	6	9	5	8	4	—	—	—	—
		5	6	5	2	6	4	—	—	—	—
		8	5	6	2	6	3	—	—	—	—
probe: FI 8 s	phase 2	3	3	4	2	5	2	6	3	5	5
		4	3	4	3	5	5	7	3	7	3
		5	4	5	3	7	3	6	3	6	4
		3	3	4	2	5	4	6	3	6	5
		3	3	3	0	4	3	5	2	5	4
12 s DMTS	phase 1	7	8	6	3	9	5	—	—	—	—
		6	6	7	3	9	6	—	—	—	—
		5	10	6	3	9	9	—	—	—	—
		11	9	8	6	8	6	—	—	—	—
		8	7	7	5	8	8	—	—	—	—
probe: FI 8 s	phase 2	2	5	3	2	5	1	2	3	5	4
		3	4	3	2	4	4	2	2	2	2
		2	3	5	5	4	3	3	3	2	3
		3	3	4	1	5	3	2	2	2	2
		3	4	3	3	4	6	4	3	2	4
probe: FI 4 s	phase 2	13	11	8	1	10	1	5	2	3	3
		12	11	6	1	13	0	6	1	5	2
		9	7	5	2	7	0	2	1	1	2
		7	7	4	1	9	0	2	2	1	2
		11	11	7	1	9	0	4	2	4	2
probe: FI 2 s	phase 2	5	4	2	2	6	4	3	1	3	1
		3	5	2	1	6	1	3	1	3	1
		5	5	3	3	5	1	3	1	3	1
		5	4	3	2	4	1	3	1	2	1
		4	5	3	3	4	2	3	2	3	1

Table 5 (cont.)

Experiment #3: n-s DMTS, P-141 number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to DMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
12 s DMTS	phase 1	3	4	2	1	4	4	—	—	—	—
		4	4	3	2	3	4	—	—	—	—
		3	3	3	1	4	4	—	—	—	—
		5	7	2	0	6	6	—	—	—	—
		4	5	3	1	3	2	—	—	—	—
probe: FI 2 s	phase 2	3	3	3	1	6	4	4	1	4	1
		3	3	3	1	5	5	3	1	4	1
		3	3	3	1	6	3	3	1	3	2
		4	4	3	2	3	3	4	2	5	2
		4	4	3	1	5	4	5	1	5	1
15 s DMTS	phase 1	4	5	3	2	5	5	—	—	—	—
		4	4	3	2	4	4	—	—	—	—
		7	6	4	2	5	3	—	—	—	—
		5	5	3	2	4	3	—	—	—	—
		5	4	4	2	3	3	—	—	—	—
probe: FI 2 s	phase 2	3	4	2	0	6	4	4	2	4	1
		3	4	2	1	5	6	5	1	4	2
		3	3	3	2	4	2	4	1	4	1
		3	3	3	1	5	4	4	1	4	1
		3	2	4	3	4	3	4	1	5	2
30 s DMTS	phase 1	3	4	4	3	4	3	—	—	—	—
		4	4	5	5	2	2	—	—	—	—
		3	3	5	3	4	2	—	—	—	—
		3	3	5	4	4	2	—	—	—	—
		3	3	5	4	2	3	—	—	—	—
probe: FI 2 s	phase 2	3	4	3	2	6	4	5	1	6	1
		4	4	4	3	5	4	5	1	5	1
		4	3	3	2	6	6	4	1	4	2
		2	3	4	2	4	1	4	1	4	2
		3	3	3	3	3	1	4	2	5	2

Table 6

Experiment #3: n-s DMTS, P-510 number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to DMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
1 s DMTS	phase 1	6	3	13	6	12	4	—	—	—	—
		4	3	15	2	15	2	—	—	—	—
		4	5	14	1	16	4	—	—	—	—
		4	4	14	0	17	3	—	—	—	—
		3	3	13	2	14	3	—	—	—	—
2 s DMTS	phase 1	3	3	13	2	13	3	—	—	—	—
		2	2	12	1	13	3	—	—	—	—
		3	2	11	3	12	3	—	—	—	—
		3	3	14	2	12	1	—	—	—	—
		6	5	14	2	13	2	—	—	—	—
5 s DMTS	phase 1	2	3	12	4	13	5	—	—	—	—
		2	2	9	3	12	7	—	—	—	—
		2	2	9	2	10	5	—	—	—	—
		3	2	10	3	10	4	—	—	—	—
		12	11	14	3	20	10	—	—	—	—
8 s DMTS	phase 1	4	2	7	1	13	7	—	—	—	—
		3	2	9	6	10	4	—	—	—	—
		2	3	9	4	12	6	—	—	—	—
		2	2	10	4	12	5	—	—	—	—
		2	2	8	2	11	6	—	—	—	—
probe: FI 8 s	phase 2	2	2	5	1	7	4	12	6	11	6
		2	2	4	2	4	3	13	6	11	7
		3	2	6	4	4	2	13	5	12	8
		2	4	6	3	5	3	12	7	11	6
		3	3	5	3	7	4	13	6	13	4
12 s DMTS	phase 1	2	3	10	4	13	7	—	—	—	—
		2	4	9	7	10	8	—	—	—	—
		2	2	10	6	10	7	—	—	—	—
		4	3	10	5	12	7	—	—	—	—
		4	3	9	6	10	8	—	—	—	—
probe: FI 8 s	phase 2	2	3	2	2	2	3	3	2	3	3
		2	2	4	1	4	2	3	4	3	3
		2	2	3	1	5	4	8	5	7	8
		2	3	4	1	6	4	3	4	3	3
		2	2	3	2	4	4	4	4	4	4
probe: FI 4 s	phase 2	3	5	15	1	10	0	7	2	7	1
		4	5	15	2	10	1	8	2	8	1
		2	4	15	1	11	2	2	1	1	1
		2	3	17	2	11	0	2	1	1	1
		2	3	17	0	14	0	1	1	2	1
probe: FI 2 s	phase 2	2	2	5	2	5	1	4	2	5	1
		2	2	5	1	5	1	3	3	6	0
		1	2	6	1	5	1	4	3	4	1
		2	2	7	2	5	1	3	4	5	1
		2	2	6	2	4	2	3	3	4	1

Table 6 (cont.)

Experiment #3: n-s DMTS, P-510 number of pecks per trial

		PECKS PER TRIAL to SAMPLE		PECKS PER TRIAL to DMTS				PECKS PER TRIAL to PROBE			
		RED	GREEN	C-RED	I-RED	C-GREEN	I-GREEN	C- ▲	I- ▲	C- ●	I- ●
12 s DMTS	phase 1		2	7	2	5	3	—	—	—	—
		2	2	7	3	4	2	—	—	—	—
		2	1	7	3	4	2	—	—	—	—
		1	1	6	2	4	2	—	—	—	—
		2	2	6	2	5	4	—	—	—	—
probe: FI 2 s	phase 2	2	2	6	1	6	1	5	1	5	0
		2	2	6	0	6	0	5	1	5	0
		2	2	5	0	5	2	4	2	5	1
		2	2	6	1	5	1	4	1	5	0
		2	2	7	1	6	1	5	1	5	0
15 s DMTS	phase 1	2	1	6	4	4	1	—	—	—	—
		2	2	8	4	3	1	—	—	—	—
		1	2	7	2	4	2	—	—	—	—
		2	2	7	3	4	1	—	—	—	—
		2	2	6	2	5	2	—	—	—	—
probe: FI 2 s	phase 2	2	2	7	1	5	1	6	1	6	0
		2	2	6	1	5	2	6	1	6	0
		2	2	6	0	4	1	6	1	6	0
		1	2	6	0	5	0	6	1	5	0
		1	2	7	1	5	0	7	1	6	1
30 s DMTS	phase 1	1	1	4	4	2	2	—	—	—	—
		1	1	5	3	3	2	—	—	—	—
		1	1	5	4	3	1	—	—	—	—
		1	1	5	3	2	1	—	—	—	—
		1	2	5	4	4	3	—	—	—	—
probe: FI 2 s	phase 2	1	1	6	1	4	1	5	1	5	1
		1	1	5	1	4	1	5	1	6	0
		2	2	5	1	3	1	5	2	6	1
		1	2	5	1	3	1	6	2	6	1
		1	2	5	1	5	1	5	2	6	0

Summary and General Concluding Discussion

The present results demonstrate that adding a probe component clearly improved previous MTS behavior. MTS behavior can become discriminative for subsequent probe responding, which improved overall accuracy in both MTS and probe components, as well as increased primary reinforcement for subjects. The improved prior behavior was then reduced to baseline levels when the probe component was removed, indicating the probe component was the mechanism for the improved MTS accuracy.

In Experiments #1 and #2, the sample stimulus was either present with the comparison stimuli (Experiment #1: SMTS) or was removed immediately (0-s retention interval) prior to the onset of the comparison stimuli (Experiment #2: 0-s DMTS) in component one. In phase two, the probe stimuli were added immediately after the offset of the comparison MTS stimuli. The probe stimuli were arranged to ask the pigeons, "Do you recall what color stimuli you previously matched in phase one?" Under such conditions in Experiments #1 and #2, probe accuracy indicated that the pigeons learned the probe discrimination, at a level that was well above chance. Therefore, in component two, pigeons were able to report on the probe keys what comparison key color was matched with the sample key color in component one.

Across these conditions in Experiments #1 and #2, the probe in phase two either maintained or increased accuracy. Because baseline MTS accuracy appeared to be already at asymptote for the pigeons, it was necessary to change the various schedule parameters associated with the MTS task. These changes were necessary to permit an evaluation of the probe, and to permit an analysis of the role these features and

parameters play in MTS accuracy. Without making these changes, it would be erroneous to state that the probe had any absolute effect on prior MTS behavior.

In Experiment #3, the sample stimulus was removed and an *n*-seconds retention interval was in effect prior to the onset of the comparison stimuli in component one. In phase two, the probe stimuli were added immediately after the offset of the comparison DMTS stimuli. As was the case in Experiments #1 and #2, in Experiment #3, the probe stimuli were arranged to ask the pigeons, "Do you recall what color stimuli you previously matched in phase one?"

P-140 performed dissimilarly from the other two pigeons on the probe stimuli. When the retention intervals were 1-s and 2-s, the pigeon learned the probe discrimination well above chance. When the retention intervals were 5-s, 8-s, and 12-s, the pigeon learned the probe discrimination at or above chance. In an analysis of successive sessions (see Figure 10), panel 2 shows that when the retention interval was 2-s, probe accuracy fell below chance, across the span of 15 sessions, but then recovered to above chance for the remainder of that condition. Generally, across conditions probe accuracy was about .50 to .65, even throughout the longer retention interval conditions. Probe accuracy maintained in this range even when the retention interval was 8-s and schedule on the probe was reduced (from FI 8-s in previous conditions) to FI 4-s and then FI-2 s; therefore, in this condition, reducing the probe schedule did not affect probe accuracy. Overall, during phase two across conditions, P-140 was able to report on the probe keys what comparison key color was matched with the sample key color in component one, even across longer retention intervals.

For P-140, when the retention intervals were 1-s, 2-s, 8-s (probe schedule: FI 4 s), and 12-s, the probe component increased MTS accuracy in phase two. When the retention interval was 8-s (probe schedule: FI 2 s), the probe component maintained MTS accuracy in phase two. However, when the retention interval was 5-s, the probe component did not increase MTS accuracy in phase two.

Figure 16 presents four bar charts depicting all pigeons' data across all conditions. The bars are the average of the last five sessions in each phase. The bars are shown for the MTS in phase one of training, and then for both the MTS and probe in phase two of training. In panel 2, P-140's bars show that across all conditions, the probe discrimination was above chance. The bars also show that across all conditions, MTS accuracy increased in phase two as a result of adding the probe, except when the retention interval was 5-s and when the retention interval was 8-s with a probe schedule of FI 2-s.

For P-140, it is not clear why this pigeon's MTS accuracy would increase across all conditions except when the retention interval was 5-s and when the retention interval was 8-s with a probe schedule of FI 2-s. The relation between probe implementation on MTS accuracy is uncertain with this pigeon considering its accuracy increased during longer schedule parameters, such as when the retention interval was 12-s with a probe schedule of FI 8-s and its accuracy decreased during shorter schedule parameters, such as when the retention interval was 5-s. Despite these outliers, the data indicate that across the varying retention intervals and probe schedules, most DMTS conditions have similar probe and MTS data paths, and the pigeon learned the probe discrimination. The probe component then increased MTS accuracy in phase two.
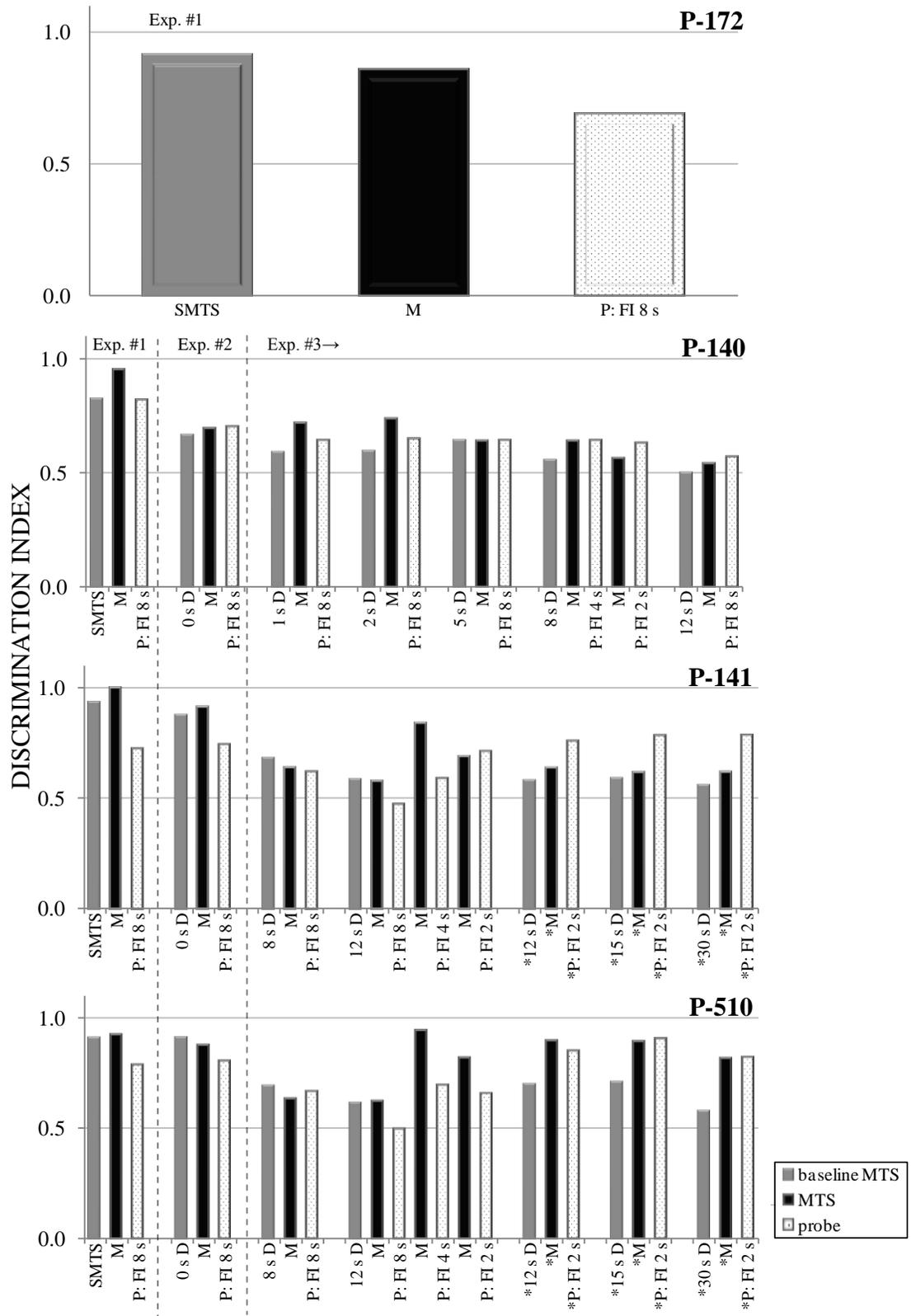
Figure 16: Bar charts for P172, P140, P141, and P510 across all conditions. The average of the last 5 sessions from both the MTS in phase 1, and the MTS and probe in phase 2 are shown.

For P-141 and P-510, when the retention intervals were 8-s and 12-s (probe schedule: FI 4 s and FI 2 s) and the schedules on the ITI, sample, and comparisons were longer, the pigeons learned the probe discrimination well above chance. During phase two of these conditions, the pigeons were able to report on the probe keys, what comparison key color was matched with the sample key color in component one. For both pigeons, probe accuracy was maintained at or below chance when the retention interval was 12-s (probe schedule: FI 8 s). In this condition, the pigeons were not able to adequately report on the probe keys in phase two, what comparison key color was matched in component one. However, when the retention intervals were 12-s, 15-s, and 30-s and the schedule durations of the ITI, sample, and comparisons were shorter, the pigeons learned the probe discrimination well above chance. The pigeons were able to report on the probe keys in phase two, what comparison key color was matched in component one. Therefore, when the retention intervals were shorter, and when the retention interval were longer but the schedules in effect on the keys were shorter, the pigeons were able to report on their previous MTS behavior.

For P-141 and P-510, when the retention intervals were 8-s and 12-s and the schedules on the ITI, sample, comparisons, and probe were longer (probe schedule: FI 8 s), the probe component maintained MTS accuracy. However, when the retention interval was 12-s and the schedules on the ITI, sample, comparisons, were longer but the schedules on the probe were shorter (probe schedules: FI 4 s and FI 2 s), the probe component increased MTS accuracy for both pigeons. The probe component also increased MTS accuracy for both pigeons when the retention intervals were 12-s, 15-s, and 30-s and the schedules on the ITI, sample, comparisons, and probe (probe schedule:

FI 2 s) were shorter. Therefore, with a shorter schedule in effect during the probe, as well as with shorter schedules in effect during the ITI, sample, and comparisons, MTS and probe accuracy increased for both of these pigeons.

For P-141, in an analysis of successive sessions (see Figures 12, 14, and 15), the addition of the probe in phase two increased prior DMTS accuracy only when the retention interval was 12-s and the schedule on the probe was shorter (probe schedule: FI 4 s and FI 2 s). During the other retention intervals and probe schedules, the addition of the probe in phase two increased DMTS accuracy only slightly above baseline. Therefore for this pigeon, the probe did improve MTS accuracy at least to some degree, and with the removal of the probe, MTS accuracy was again reduced.

For P-510, in an analysis of successive sessions (see Figures 12, 14, and 15), the addition of the probe in phase two increased prior DMTS accuracy during all conditions, except when the retention intervals were 8-s and 12-s (probe schedule: FI 8 s). During these conditions, the retention interval was considered long for a pigeon, and schedule on the probe was also long (FI 8 s). When the schedule parameters were reduced, especially on the probe (FI 4 s and/or FI 2 s), the addition of the probe in phase two immediately increased DMTS accuracy, even with longer retention intervals. Therefore for this pigeon, the probe improved MTS accuracy, and with the removal of the probe, MTS accuracy was again reduced.

In Figure 16, the bars across all conditions in panel 3 for P-141 and panel 4 for P-510 show the probe discrimination well above chance, except when the retention interval was 12-s with a probe schedule of FI 8-s. For both pigeons, when an FI 8-s probe schedule was in effect, probe accuracy decreased with each delay increase in DMTS. Yet

as soon as the probe schedule in effect was reduced to FI 4-s and then FI 2-s, probe accuracy increased with each increase in DMTS. Therefore, probe accuracy decreased until the probe schedule in effect was reduced, which had a positive effect on probe accuracy, even with the longer retention intervals. The bars also show an increase in MTS accuracy in phase two as a result of adding the probe across all conditions, except for when the retention intervals were 8-s and 12-s with the FI 8-s probe schedule. Probe and MTS accuracy data paths across both pigeons were similar. Also, when the retention intervals were 12-s, 15-s, and 30-s and the schedules on the ITI, sample, comparisons, and probe (probe schedule: FI 2 s) were shorter, across these three phases the bars repeat the same data pattern, despite the increase in retention intervals. Such data indicate that reducing the FI schedule parameters did in fact counteract any potential extinction effects with the longer schedules, as well as provide more immediate self-feedback as to accuracy on the DMTS and probe.

Therefore, overall the probe component clearly improved the accuracy of MTS behavior. The present results demonstrate that a subject can respond on the basis of whether or not it previously selected a colored comparison stimulus and that such responding is a function of the schedule of reinforcement that maintain behavior, across different retention intervals.

Previous studies that examined self-awareness in non-human animals used some feature of baseline behavior such as its temporal property or pattern as the sample (Eisler, 1984; Killeen, 1978, 1981; Killeen & Smith, 1984; Kramer, 1982; Lattal, 1975; Maki, 1979; Reynolds, 1966; and Shimp 1891, 1983). The present research used visual stimuli on an identity MTS task as the baseline behavior. The present research using visual

stimuli as baseline behavior improved and contributed to the basic research on self-awareness because although the previous studies demonstrated that prior baseline behavior could become discriminative for subsequent reporting, such studies did not demonstrate an improvement in prior baseline behavior. Improvements in prior behavior show an evolutionary advantage to self-reporting because without the improvement in prior behavior, the self-report is merely an observation without a behavior changing function. And, although some may regard temporal baseline tasks as a clearer indication of organismic action because the organisms report on a specific temporal feature of their own behavior versus a previous stimulus (as in MTS tasks), the temporal discrimination tasks were commonly confounded because of the relative asynchronicity between said responding and stimulus change. The argument that MTS tasks are not an indication of organismic action is unfruitful since both baseline accounts are behavior strengthened and manipulated by reinforcement. Also, the previous researchers used temporal baseline tasks primarily because the organisms could display a response requirement as the critical feature (Kramer, 1982). Of course, MTS tasks include a complex conditional response requirement. Lastly, in previous studies, the accuracy on baseline and subsequent reporting was commonly a decreasing function of the log retention interval (e.g., Kramer, 1982). In the present research, it appears promising that the probe component on visual tasks paired with shorter feedback schedules remedied inaccurate reporting due to extinction effects with the longer schedules.

MTS tasks reveal varying degrees of adaptation to the demands the reinforcement contingency places on correct MTS behavior. This represents an increased self-awareness on the MTS task, or at least to the colored stimuli in the MTS, that has been facilitated by

the probe condition. The probe key choice behavior can be regarded as a nonverbal commentary by the pigeons on the topic of their own MTS behavior (e.g., Shimp, 1981, 1983). The present use of the conditional MTS task as prior baseline behavior used to evaluate the effects of subsequent reporting on the probe extends information about the discriminative properties of behavior. Thus, adding probe trials to attempt to increase not only self-awareness of previous behavior, but also the accuracy of previous behavior itself, appears promising. The probe trials functioned to ask "Do you recall what color stimuli you previously matched in phase one?" Such effective procedures could arguably be designed for use with humans.

As mentioned previously, individuals that demonstrate mental health needs (e.g., those with Depression), inappropriate responding (e.g., those with Autism), or who tend to be labeled according to the DSM-IV-TR (American Psychiatric Association, 2000) are less successful at environmental awareness. Such individuals often demonstrate a repetitive lack of self-awareness of their previous and current behavior, or the contingencies under which their behavior occurs (Kohlenberg & Tsai, 2007). And, such concerns can severely limit their access to primary and secondary reinforcement, maintain their current behavior on negative reinforcement paradigms, interfere with behavior acquisition, and result in overall health problems or health decrement due to other factors (e.g., taking medication, limited autonomy). Most individuals would reason to benefit from discrimination trials to improve self-awareness, including but not limited to individuals with: post-stroke; neurological or head damage such as Traumatic Brain Injury; health concerns such as HIV, Multiple Sclerosis, Osteoporosis; and academic and

social behavior of school-aged children in classrooms (Rosenbaum & Drabman, 1979) to name a few.

Commonly, individuals with the above concerns carry with them diagnostic recommendation for increased social interactions, clarity and awareness of self, awareness of the environment, and communication (American Psychiatric Association, 2000). Behavior analysts attempt to address an adequate range of socially important behaviors (Critchfield & Kollins, 2001) in settings including hospitals, residential and treatment programs, as well as in offices and the homes. Generalization of skill development across settings and people is only one of the practical difficulties that presents when we attempt to negotiate with the world outside of the controlled setting.

Training that contributes to making prior behavior discriminative for subsequent behavior would promote "self-care and self-direction" (Chudley, 2004). For many of the aforementioned concerns, methods that demonstrate an improvement in self as context over awareness, management, monitoring, and control, have shown to improve the behavior of concern to some degree (e.g., Woods et al., 1996). An example of such a technology is a habit reversal treatment program (Azrin & Nunn, 1973) designed with multiple treatment components. Typical treatment components include: vocal response descriptions of the behavior of concern, vocal response of when the response has been detected to occur, identification of antecedents, self-monitoring, data collection and analysis, and context specific awareness training. Simplified versions commonly include at least the self-monitoring and/ or self-awareness component (e.g., Finney, Rapoff, Hall, & Christopherson, 1983; Miltenberger & Fuqua, 1985; Miltenberger, Fuqua, & McKinley, 1985; Sharenow, Fuqua, & Miltenberger, 1989; Wagaman, Miltenberger, &

Arndorfer, 1993; Woods et al., 1996). Awareness training generally attempts to increase awareness of under what conditions the response occurs and its various topographical descriptions (Woods et al., 1996). Such components have been shown to be at least minimally effective across a wide range of behaviors, including paper recycling (Witmer & Geller, 1976), increased exercise (Van Houten, Hill, & Parsons, 1975), and sports performance (Mellalieu, Hanton, & O'Brien, 2006). A development of "self -" aims at understanding and explaining the stimuli that evoke one's experiences (Kohlenberg & Tsai, 2007). It requires practicing an observing of one's own behavior, and attending to the consequences that are commonly produced (Linehan, 1993).

The present research could inform the applied community of the necessity of immediate and frequent reporting on previous behavior as key for effective self-report. In the present research, when the schedule of reinforcement on the probe was reduced, pigeons' accuracy on the report and previous behavior improved. Individuals may also exhibit accuracy on self-report, and most importantly, improved previous behavior by providing immediately reinforced trials in which they report on their most recent behavior, versus reporting behavior of concern at a future time.

The two questions of interest in the present research were: (a) Can the pigeons acquire a second conditional discrimination on the identity matching task (e.g., probe accuracy above chance)? And, (b) will a conditional discrimination on the symbolic matching task facilitate the acquisition of the conditional discrimination on the identity matching task (e.g., improved MTS accuracy after probe implementation in phase two)? The use of a visual identity MTS task in phase one followed by a visual arbitrary probe task in phase two with pigeons produced positive results to both of the aforementioned

questions. The procedure appears promising as a means for assisting individuals with

mental health needs to better come under the discriminative control of the outcomes of

their own prior behavior.

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