

IMITATION OF TARGET SEQUENCES IN PIGEONS

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By
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CERTIFICATION OF APPROVAL

IMITATION OF TARGET SEQUENCES IN PIGEONS

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DEDICATION

I dedicate this thesis to my wife who has supported me throughout this entire process and encouraged me all along the way. You stood by my side through the ups and downs until the very end. I could not have endured this project without you. I also dedicate this thesis to my mom and dad for all they have done for me. You both have taught me to work hard and endure life's obstacles no matter how difficult. Thank you very much and I love you both. Lastly, I dedicate this thesis to my daughter in the hopes that you will strive to achieve all of your goals as you grow up, knowing that your mom and I will always be by your side to support you.

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ABSTRACT

An alternating treatments design was used to examine the target sequence acquisition between pigeons being exposed to a model performing a four-target key peck sequence versus a control condition (no model). Model pigeons demonstrated a four-target key peck sequence in the presence of observer pigeons, after which the observer birds had opportunities to peck at the same keys. Four-target sequences were reinforced if it matched the model sequence observed. The control condition required a different four-target sequence, but did not include a model bird. Results showed one bird performing slightly better in the model condition, two birds performing better in the control condition, and one bird showing no differentiation between conditions. Study limitations and future research suggestions are discussed.

Keywords: imitation, model, observational learning

INTRODUCTION/LITERATURE REVIEW

The ontogenetic history of a particular organism is filled with environmental interactions that gradually give rise to unique patterns of responding, which contribute to the organism's total fitness in terms of warding off or evading predators, locating food sources, and sexual reproduction. Over the course of a lifetime an organism can come to display a vast and extensive behavioral repertoire, which can require much time and effort to amass. A portion of the learning can be said to occur via direct contact with environmental contingencies. Another mode of learning, which is the focus of the present research, is achieved through imitation.

Imitation is defined as the extent to which an organism can reproduce an observed response from that of another organism, usually a member of the same species, or conspecific. An advantage of an organism having the capacity to learn behavioral responses through imitation is a decrease in the time it takes to learn a response, thus being able to adapt to environmental surroundings more quickly. Much of human learning is achieved through observational learning with instances being detectable as early as infancy (Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1977). However, as humans develop, language becomes more prominent and complex, making imitation a rather difficult area to research. Therefore, the remaining content will focus on imitation observed in nonhuman organisms.

Research in the field of imitation has been explored with a wide range of organisms including cats (John, Chesler, Bartlett, & Victor, 1968; Thorndike, 1898), orangutans (Custance, Whiten, & Bard, 1995), rats (Del Russo, 1971), dogs (Pongracz, Miklosi, Kubiny, Gurobi, Topal, & Csanyi, 2001; Thorndike, 1898) marmosets (Voelkl & Huber, 2000), rhesus monkeys (Warden & Jackson, 1935), squirrels (Weigle & Hanson, 1980), and birds (Zentall, 2004). Typical experimental procedures include having a model demonstrate a particular task, usually in a proficient manner, in the presence of a naïve learner who afterwards has an opportunity to perform the modeled task. Studies involving imitation require tightly controlled conditions to ensure that the model's behavior can clearly be observed by the learner and responses be easily measured, which is why nonhumans have been used extensively throughout this subject area.

This study will focus on observational learning in pigeons. Observational learning has been studied among various species of birds and different factors have been isolated and manipulated to further explore the controlling variables of imitative behavior (see Zentall, 2003; Zentall, 2012). For example, Epstein (1984) conducted a study where a pigeon had an opportunity to observe another pigeon in an adjacent operant chamber peck at various items on the chamber wall (e.g. ping-pong ball, rope, plastic disc). Baseline measures showed low responding to the items when no other pigeon was present. When a model pigeon was placed adjacent to the observer pigeon and pecked at a specific item, the observer pigeon's responding to the identical item increased above baseline levels, even after the removal of the model

pigeon. The variable identified in the study, which contributed to the increase in responding, was the presence and actions of the model bird. One suggestion for future research was to examine whether an observer bird would imitate a model bird pecking at an object among an array of objects and shift responding to a different object if done so by the model. Epstein's study is just one along with others which have isolated specific variables and observed their effects on imitation. A summary of the other research follows.

Motivating Operations

The extent to which imitation occurs, given varying levels of food deprivation, was examined by Dorrance and Zentall (2001) using Japanese quail. Two experimental chambers separated by Plexiglas were arranged side by side, each including a feeding hopper and a treadle. Quail assigned as models were trained to either step or peck the treadle for food reinforcement, after which observer quail were given an opportunity to respond in the same manner as their respective model. Observer quail were separated into one of four groups (satiated-immediate, hungry-immediate, satiated-delayed, hungry-delayed). Groups denoted as 'immediate' were placed in the testing chamber as soon as the model was finished, while groups denoted as 'delayed' waited 30 minutes until testing. 'Satiated' birds were fed 15 minutes before the observation period and 'hungry' birds were food deprived for 23 hours at the time of observation.

The results showed that the 'hungry' groups had a higher proportion of treadle responses matching the responses of the observed model than the 'satiated' groups

regardless of whether the testing was immediate or delayed, suggesting that altered motivating operations at the time of observation and testing may contribute to imitation. In other words, as food deprivation increases during observational opportunities, so does the probability that imitation will occur.

Model Proficiency

Another topic that has been researched focuses on whether the proficiency of the model's performance is crucial to learning the imitative response. Templeton (1998) arranged three groups of observer starlings, which were exposed to a model who performed at three different levels of proficiency during a discrimination task that involved opening one of two container lids differentiated by color patterns. The three groups either observed the model picking the correct container every time, never picking the correct container, or picking the correct container 50% of the time. Contrary to traditional beliefs about model proficiency during observation, the group that observed only incorrect responses learned the discriminations with a higher accuracy than birds that observed highly proficient or mediocre models. Similar results were found using pigeons (Vanayan, Robertson, & Biederman, 1985) suggesting the importance of not only observing correct responses, but incorrect responses as well.

Observation of Reinforced Behavior

While observing incorrect responses may be useful, observation of reinforced responding seems to be an important factor also. Akins and Zentall (1998) used Japanese quail in determining whether observing reinforced responding increased

imitation. Three groups of quail observed a model respond to a treadle where responses either produced food reinforcement, no food reinforcement, or the model was fed separate from treadle responses. The results revealed an increase in imitative responding with the quails that observed the model being reinforced. Quails that did not observe reinforcement being delivered for responding showed no above-chance imitation.

Operant Variability

Prior to a target response being shaped to its final form, much behavioral variability exists in terms of topography, rate, latency, etc. until some form of reinforcement is introduced. This reinforcing consequence “selects” a response class that more closely approximates the target response. Research that studies imitation seek to exploit the aforementioned variables (e.g. motivating operations) to contribute to the shaping process, ultimately developing a definitive target response. Other areas of research seek to embrace variability itself in terms of manipulating environmental variables to control differing levels of response variability.

Allen Neuringer has pioneered much of the behavioral literature regarding response variability, publishing numerous studies and reviews (Neuringer, 2002; Neuringer, 2004). His research on the topic has typically involved treating response variability as an operant, which can be controlled by consequences and brought under stimulus control (see Page & Neuringer, 1985) similar to other behavioral dimensions (e.g. rate). Neuringer has explored the concept of operant variability in both animals and humans. Some areas of research have included operant learning in rats and

pigeons (Neuringer, 1993; Neuringer, Deiss, & Olson, 2000), creativity in pigeons (Cherot, Jones, & Neuringer, 1996), depression (Hopkinson & Neuringer, 2003), ADHD (Hunziker, Saldana, & Neuringer, 1996), and autism (Miller & Neuringer, 2000).

To our knowledge, observational learning has not been addressed in combination with response variability in teaching complex behaviors. The current study seeks to incorporate the research of Neuringer, Deiss, and Olson (2000) and the notion of reinforcing varied responses to increase the likelihood of emitting a desired target response. In that study, three groups of rats were reinforced on a fixed-ratio 1 schedule (FR1) for responding to two levers, left and right, in a particular five-step sequence (e.g. LRLLR). One of the three groups was provided additional reinforcement for producing *variable* (i.e. infrequent) five-step sequences on a VI 1' schedule. The second group was additionally reinforced for producing *any* five-step sequence on a VI 1' schedule. The third group was given no additional reinforcement other than for the target sequence only. Rats in the *variable* condition emitted the five-step target sequence at a higher percentage relative to the other two groups where either the target sequence was not acquired or responding extinguished altogether.

The research provides evidence for the idea that variability itself can be treated as a separate dimension of behavior, which is subject to the effects of reinforcement that can be used to facilitate the acquisition of a target response. However, the literature lacks research in combining response variability with observational learning in shaping complex responding.

Present Study

The current study focused on pigeons learning a four-response target sequence in different observational conditions. Birds were either exposed to a model demonstrating a target sequence in an adjacent operant chamber or exposed to an empty operant chamber. After the observation period ended, birds had an opportunity to learn the target sequence.

METHODS

Subjects

Six King Hubbard pigeons were used in the study and were maintained at 80% of their free-feeding body weight. All pigeons had exposure to the experimental chambers used in the study. Food was received during experimental sessions and birds had free access to water in their home cages. Extra food was provided in the event that a pigeon did not receive all of the food during an experimental session or if its weight dropped below 80% of the established free-feeding body weight. They were housed in a 16/8 hour light/dark cycle.

Apparatus

Four operant chambers were used in the study. Each chamber included a food hopper, house light, and an intelligence panel comprised of three response keys situated above the food hopper, all of which were capable of being illuminated. Experimental chambers were arranged so that the observer chamber was facing the model chamber, which was separated by a Plexiglas partition. In each model chamber, the far left and right response keys were used to ensure maximum discriminability for the observer birds (see Figure 1).

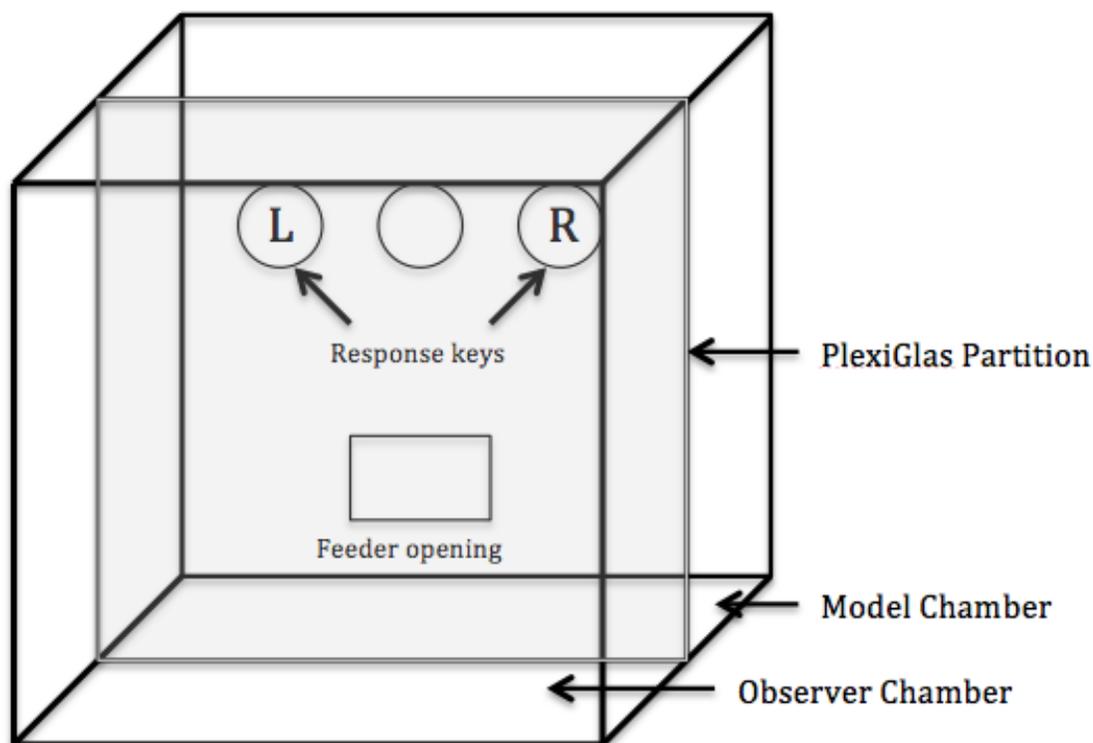


Figure 1. A graphic depiction of the apparatus setup.

Fans operated on the back of the operant chambers for ventilation purposes, which also served to mask extraneous noise.

Procedures

Preliminary training. Two birds served as models during the study. Each bird was initially trained to eat food from a raised hopper and subsequently trained to peck at a white, illuminated key to produce food. The illuminated keys were white during the preliminary training until target sequence training was introduced. Model birds were shaped to peck at both left (L) and right (R) response keys by providing 4 s of food reinforcement for emitting a single response to only one key, which was randomly presented in both left and right positions. After single-key response

training occurred, each model bird was required to emit an alternating response (e.g. LR or RL). Once birds received the maximum amount of 45 reinforcers during a session, model birds began to learn one of the two, four-responses sequences. Model A was assigned to learn sequence A (RLRR) and model B was assigned to learn sequence B (LRL), which served as the target responses for the observer birds during testing. Sequence A was based on Neuringer (2000) and on acquisition difficulty. Sequence B is just a mirror image to control for the number of switchovers between the left and right keys.

Training the four-response target sequences was shaped by introducing their component sequences which birds were required to master before continuing on to the next (i.e. LR, LRL, LRL or RL, RLR, RLRR). Initially, birds were trained on the first two components of the sequence (i.e. the LR response for the target sequence LRL). A trial began by illuminating both left and right keys with a particular color (red or green), depending on the target sequence being trained. Responses that matched the first two components of the target sequence were presented with food for 4 s and followed by a 2 s ITI, after which a new trial began. Any other two-response combination initiated an 8 s time-out sequence (i.e. lights out) followed by the presentation of a new trial. The criterion for moving on to learn the three-response sequence was target responding over 50%. Training the three-response and four-response sequence was structured the same as the two-response training, except that additional responses were required (i.e. the LRL response for the target sequence LRL). The criterion for mastering each sequence remained the same with target

responding over 50%. After model birds mastered their respective sequence, testing began with the observer birds.

Concurrently, four birds serving as observers proceeded through the same preliminary training procedures as the model birds (hopper training, single key-peck training, alternating key-peck training), which ended just before being exposed to the four-response target sequences. When observer birds received the maximum amount of reinforcers during alternate key peck training, they were randomly assigned into one of two experimental conditions.

Experimental conditions and design. An alternating treatments design was used. Each observer bird experienced either the model or control condition every day for the duration of the study. The model and control conditions were randomly assigned with the rule that no condition be experienced for more than two consecutive sessions. An example of how the conditions were scheduled is displayed in Table 1.

Table 1

Example of alternating conditions

Sessions	Bird #67	Bird #69	Bird #58	Bird #68
Session 1	Model B	Control	Model A	Control
Session 2	Control	Model B	Control	Model A
Session 3	Control	Model B	Model A	Control

Note. Birds #58 and #68 alternated between model A and control conditions. Birds #67 and #69 alternated between model B and control conditions.

It is also important to note that the keys being pecked during testing conditions were illuminated one of two different colors depending on the sequence being tested (sequence A - red, sequence B - green).

The control condition was similar to the model condition with the exception of the model and the observation period. Instead, the observer birds were placed directly into the model chamber and given 30 minutes on the alternate sequence.

Observer birds were randomly assigned either to model A ($n = 2$) or model B ($n = 2$). Each of the two sequences was modeled by either model A (sequence A) or model B (sequence B) (see Table 2).

Table 2

Experimental conditions for pigeons

Model Birds/Sequence	Model Condition	Control Condition
Bird #56 - Sequence A (RLRR)	Birds #58 and #68	Birds #67 and #69
Bird #72 - Sequence B (LRLl)	Birds #67 and #69	Birds #58 and #68

Note. Sequence A was modeled by Bird #56 and sequence B was modeled by Bird #72.

Birds were counterbalanced across sequence A and sequence B.

There were two experimental conditions in which the observer birds were either exposed to a model bird (model condition) or an empty chamber (control condition). In the model condition, an observer bird was placed in a separate chamber facing the model chamber with a Plexiglas partition in between the two chambers. Depending on the experimental condition, model bird A or B was placed

in the model chamber and target sequences were reinforced with 4 s of food, followed by a 3 s ITI and a new trial. Incorrect sequences were followed by an 8 s time out where all lights were turned off, followed by the presentation of a new trial. The observation period lasted for 10 minutes, after which the model bird was taken out of the chamber and replaced with the observer bird for an additional 30 minutes, or if the maximum amount of reinforcers were received. During this time, observer birds received food for pecking the same target sequence as the model bird and a time out for incorrect sequences.

Dependent measures. The number of sessions/trials during pre-training and observation, variability of target and non-target responses/sequences for both model and observer birds, and frequency of target sequences were used as dependent measures in the study.

RESULTS

The outcome of the study revealed that one observer bird had acquired more target sequences in the model condition, two other observer birds acquired more target sequences in the control condition, and one bird had similar levels of acquisition in both conditions. The individual performances of each bird will be discussed.

Model Birds. Birds 56 and 72 served as model birds A and B, respectively, throughout the study. The completion of preliminary training took 80 sessions for bird 56 and 41 sessions for bird 72.

During the demonstration sessions for observer bird 58, model bird 56 emitted the target sequence an average of 48.1 % of sequences across a total of 20 sessions, with target frequencies ranging from 0 to 24 within a session. In the presence of observer bird 68, model bird 56 emitted the target sequence an average of 47.1 % of sequences across a total of 18 sessions, with target frequencies ranging from 8 to 31 within a session. The range of target percentage in the presence of bird 58 and 68 was 0% - 62% and 22% - 74% respectively. Overall, the target sequence had the highest frequency among all possible sequences for both observer birds (see Figure 2 and 3).

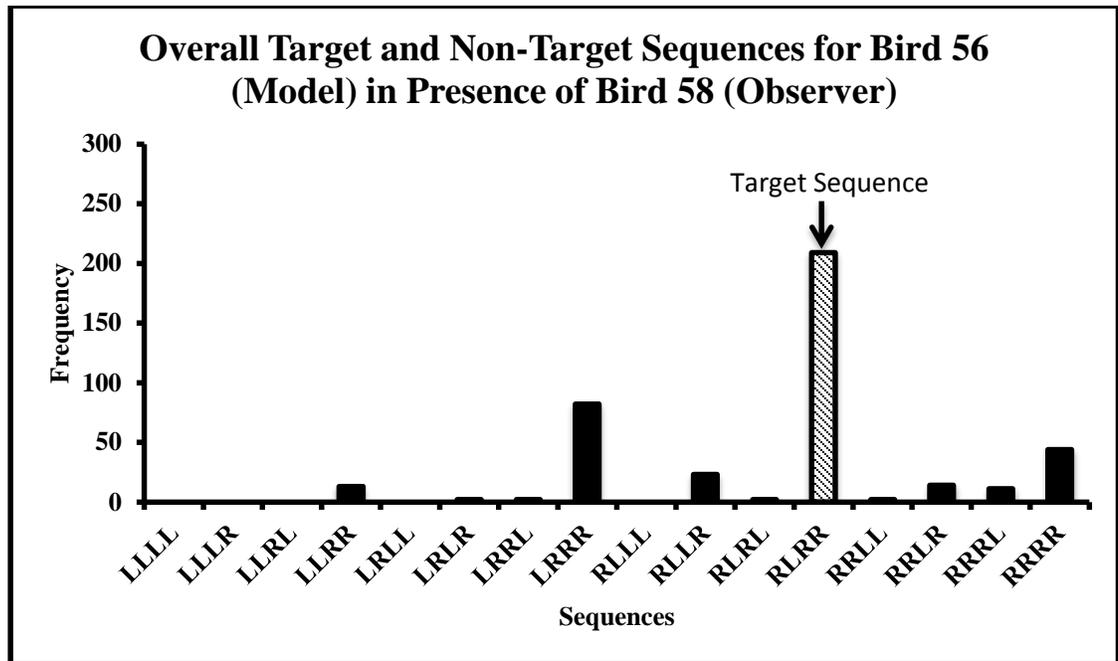


Figure 2. Overall target (RLRR) and non-target sequences performed by bird 56 (model) in the presence of bird 58 (observer).

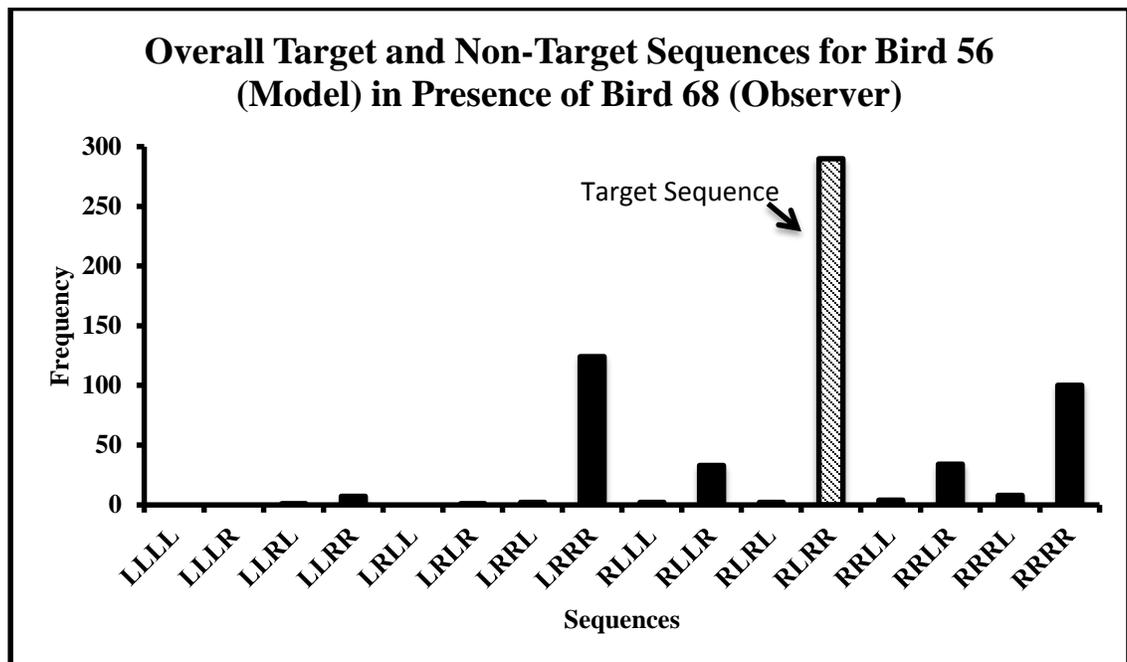


Figure 3. Overall target (RLRR) and non-target sequences performed by bird 56 (model) in

the presence of bird 68 (observer).

Error sequences were examined among the model birds to look at any existing patterns. The next two sequences that had the highest frequency after the target sequence were LRRR and RRRR respectively.

During the demonstration sessions for observer bird 67, model bird 72 emitted the target sequence an average of 29.5 % of sequences across a total of 17 sessions, with target frequencies ranging from 0 to 35. In the presence of observer bird 69, model bird 72 emitted the target sequence an average of 27.5% of sequences across a total of 20 sessions, with target frequencies ranging from 2 to 42. The range of target percentage in the presence of bird 67 and 69 was 0% - 54% and 5% - 66% respectively. Total frequency of the target sequence was also higher than non-target sequences for both observer birds (see Figure 4 and 5).

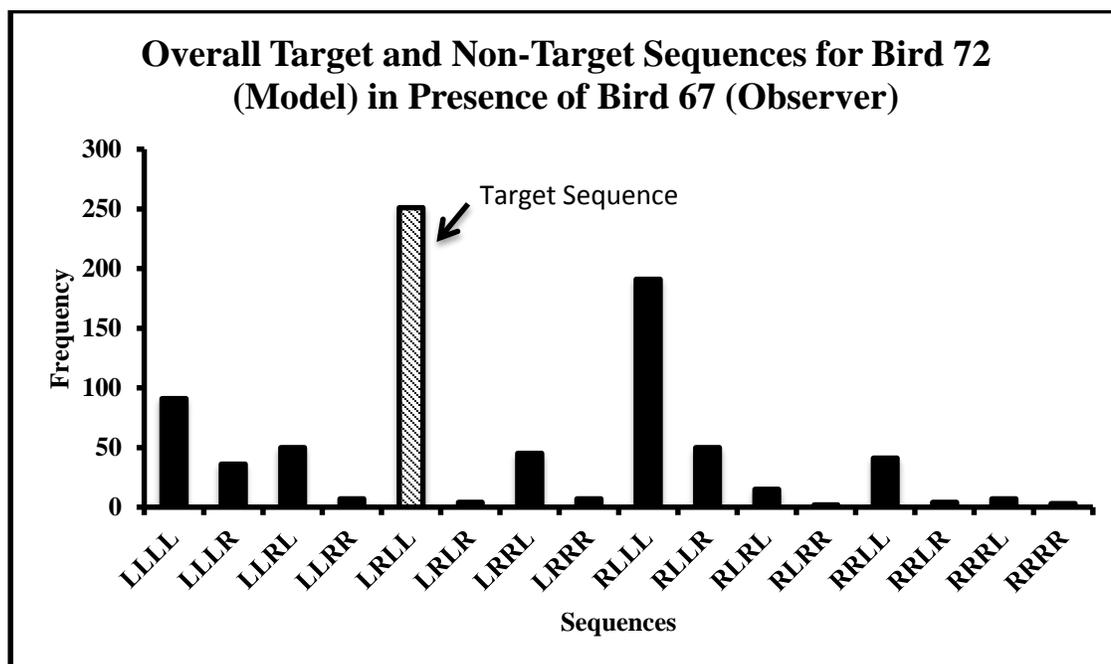


Figure 4. Overall target (LRLl) and non-target sequences performed by bird 72 (model) in the presence of bird 67 (observer).

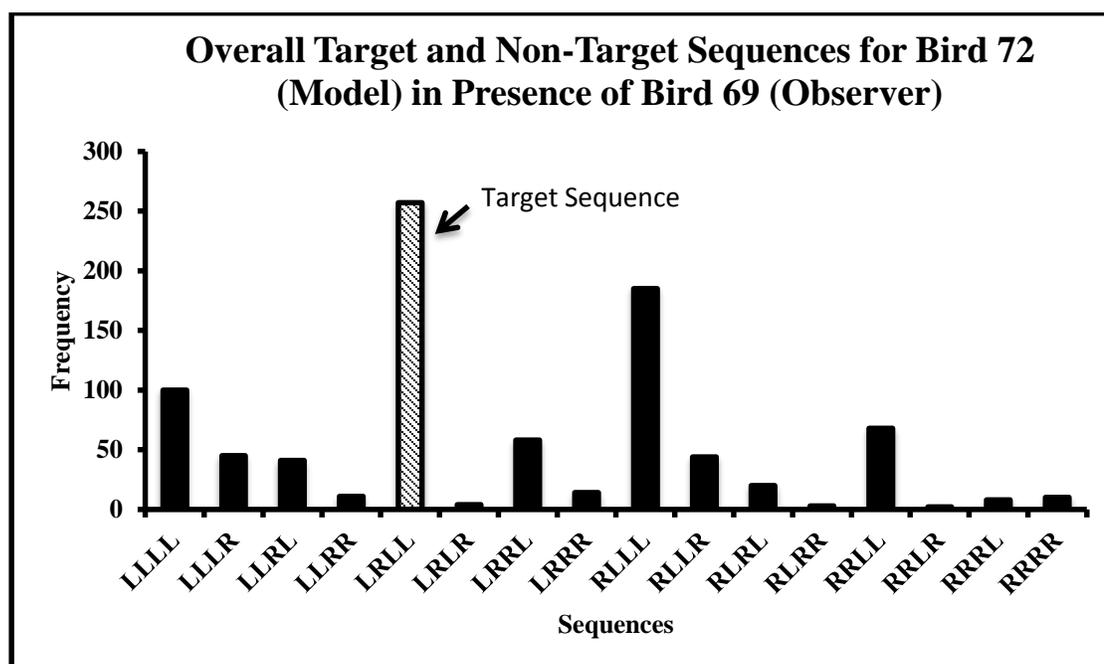


Figure 5. Overall target (LRLl) and non-target sequences performed by bird 72 (model) in the presence of bird 69 (observer).

The top two error sequences with the highest frequency after the target sequence were RLLL and LLLL. Interestingly, the two error sequences are mirror images of the top two errors for bird 56 (e.g. LRRR and RRRR).

The number of target sequences acquired by each model bird for all sessions was superimposed onto the performances of each respective observer bird in Figures 6, 9, 12, and 15.

Observer Birds. Birds 58, 67, 68, and 69 served as observer birds throughout the study. Birds 58 and 68 observed bird 56 modeling sequence A (RLRR) and birds 67 and 69 observed bird 72 modeling sequence B (LRL).

Bird 58 completed 20 total sessions of observing sequence A being modeled and then responded under the same conditions as the model, and 18 total sessions of testing on sequence B without a history of observing a model doing the same sequence. In the first three sessions there was an increasing trend in target frequencies in the control condition, which subsequently fell to low, stable levels for the remainder of the sessions. Frequency levels in the model condition began lower than the control condition in the first three sessions, but increased to a higher level for the next two sessions. Subsequent sessions displayed a decreasing trend similar to levels observed in the control condition until session 23 when levels increased and remained with mild variability until the end of the study. Overall, this bird showed better performance in the model condition. Data displaying target frequencies are displayed in Figure 6.

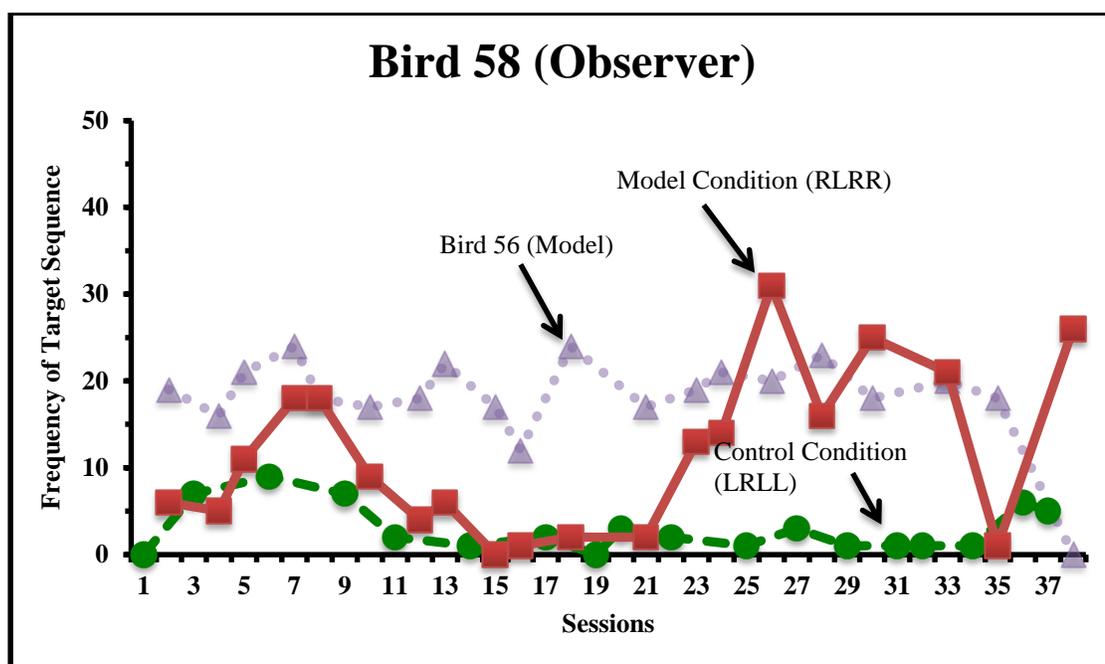


Figure 6. Frequency of target sequences for model (RLRR) and control (LRL) conditions for bird 58 (observer). Includes target frequencies for bird 56 (model) during model condition sessions.

Error sequences were examined in both conditions for bird 58 (see Figure 7 and 8).

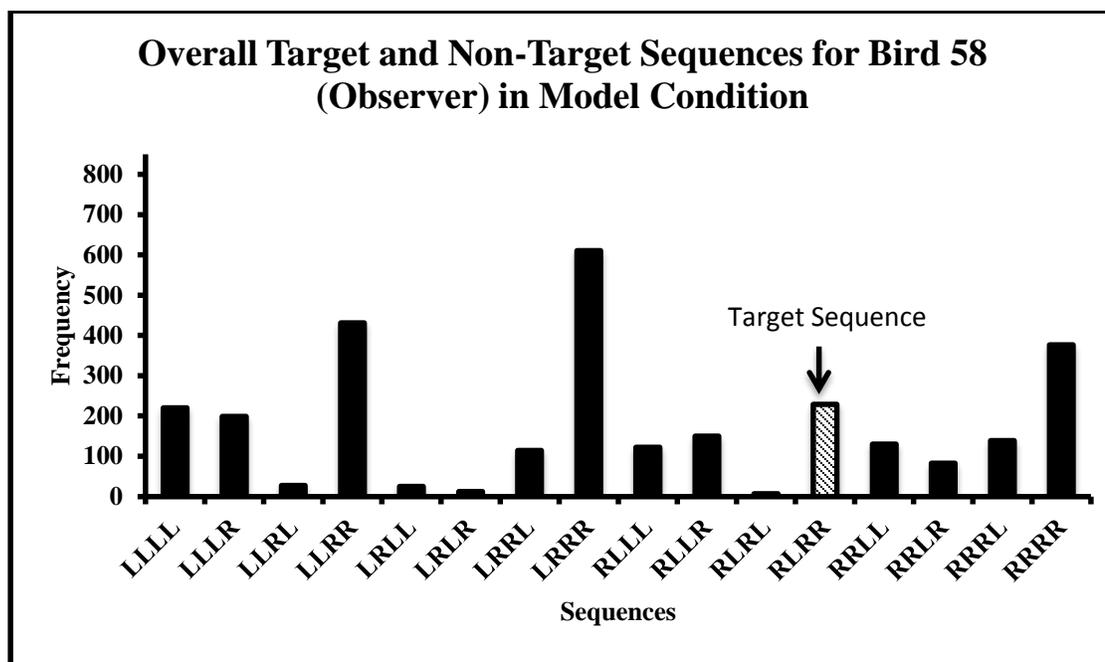


Figure 7. Overall target (RLRR) and non-target sequences performed by bird 58 (observer) w/ bird 56 modeling the target sequence.

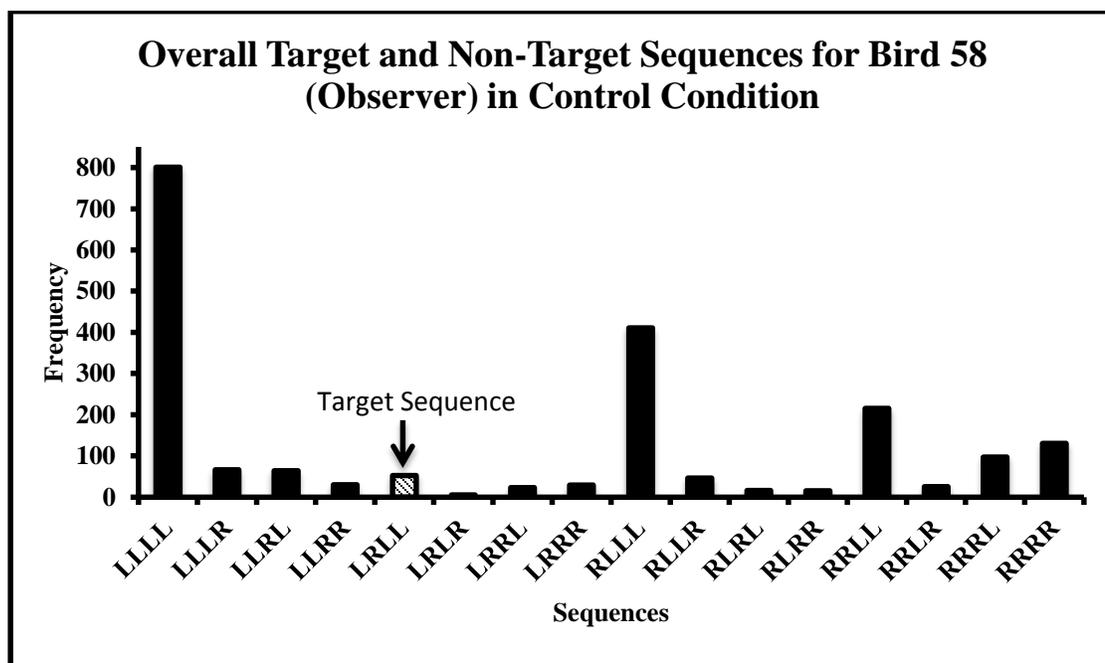


Figure 8. Overall target (LRLR) and non-target sequences performed by bird 58 (observer)

w/ no model bird demonstrating the target sequence.

The top three non-target sequences with the highest frequency in the model condition were LRRR, LLRR, and RRRR, respectively, comprising of 49.3% of all sequences. In the control condition the top three non-targets were LLLL, RLLL, and RRLL, respectively, comprising of 70.5% of all sequences. The target sequence in the model and control condition had the fourth and eighth overall highest frequency, respectively, among all possible sequences. There were not any noticeable patterns with the two target sequences emerging as a predominant error in either condition (i.e. the target sequence RLRR did not appear in high frequency in the LLLL condition as a non-target or vice versa).

Bird 68 observed bird 56 model sequence A. The model condition had a total of 18 sessions and control condition had a total of 18 sessions. From the first session, acquisition levels were maintained at a higher level for the control condition than the model condition with moderate variability and minor overlap throughout the majority of the study. Session 8 was the only point where data paths overlapped. Data displaying target frequencies are displayed in Figure 9.

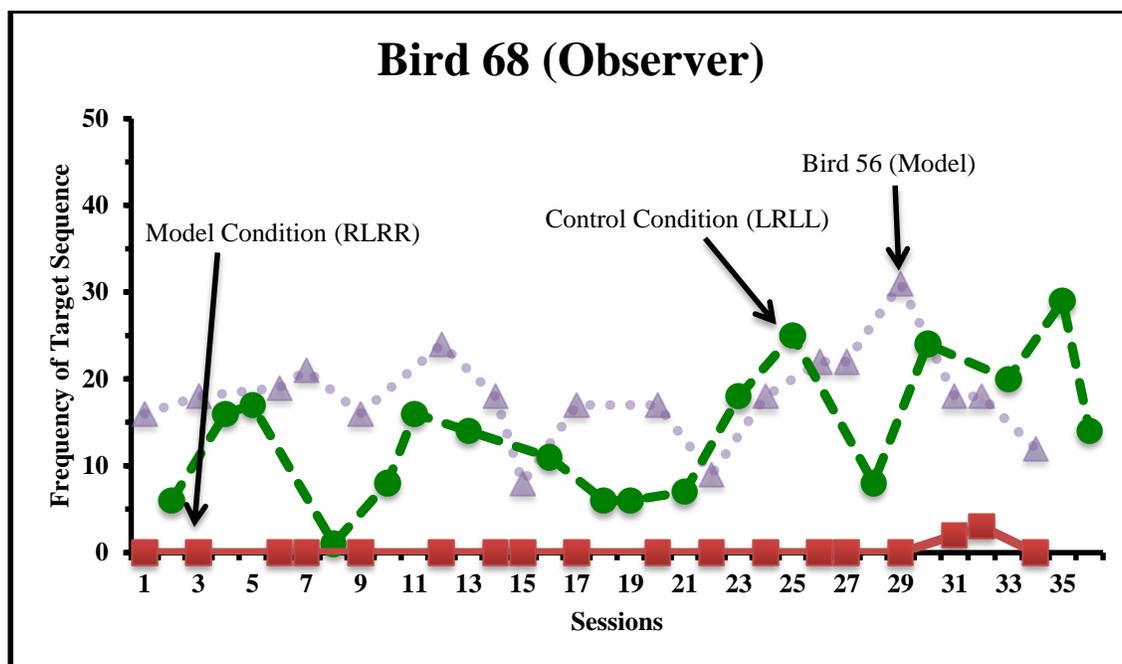


Figure 9. Frequency of target sequences for model (RLRR) and control (LRL) conditions for bird 68 (observer). Includes target frequencies for bird 56 (model) during model condition sessions.

Error sequences were examined in both conditions for bird 68 (see Figure 10 and 11).

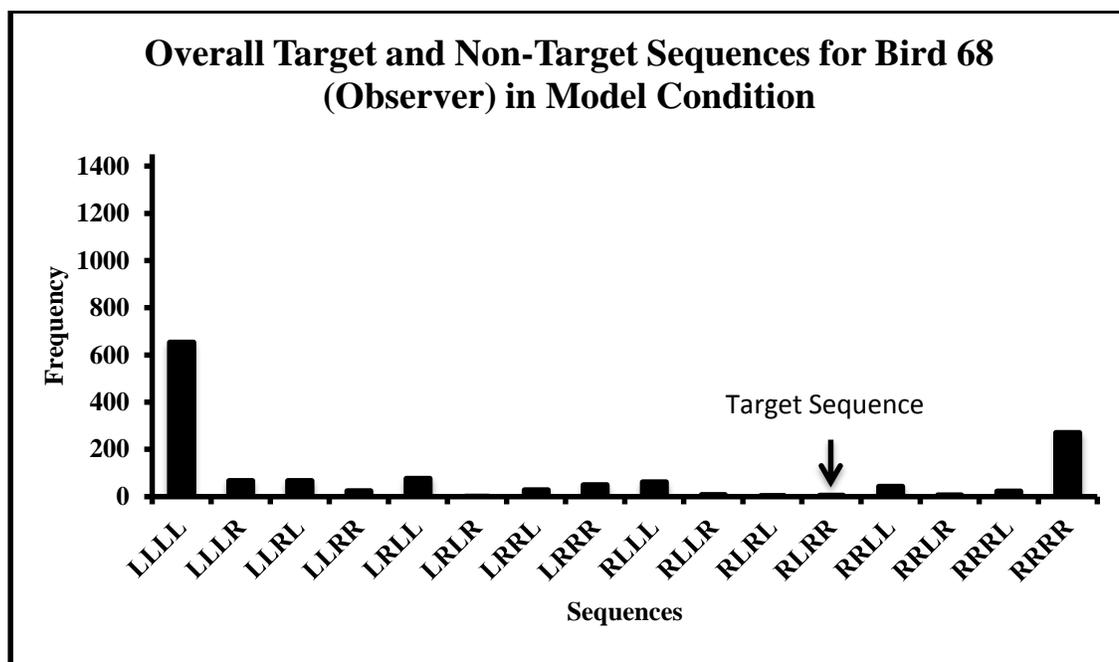


Figure 10. Overall target (RLRR) and non-target sequences performed by bird 68 (observer) w/ bird 56 modeling the target sequence.

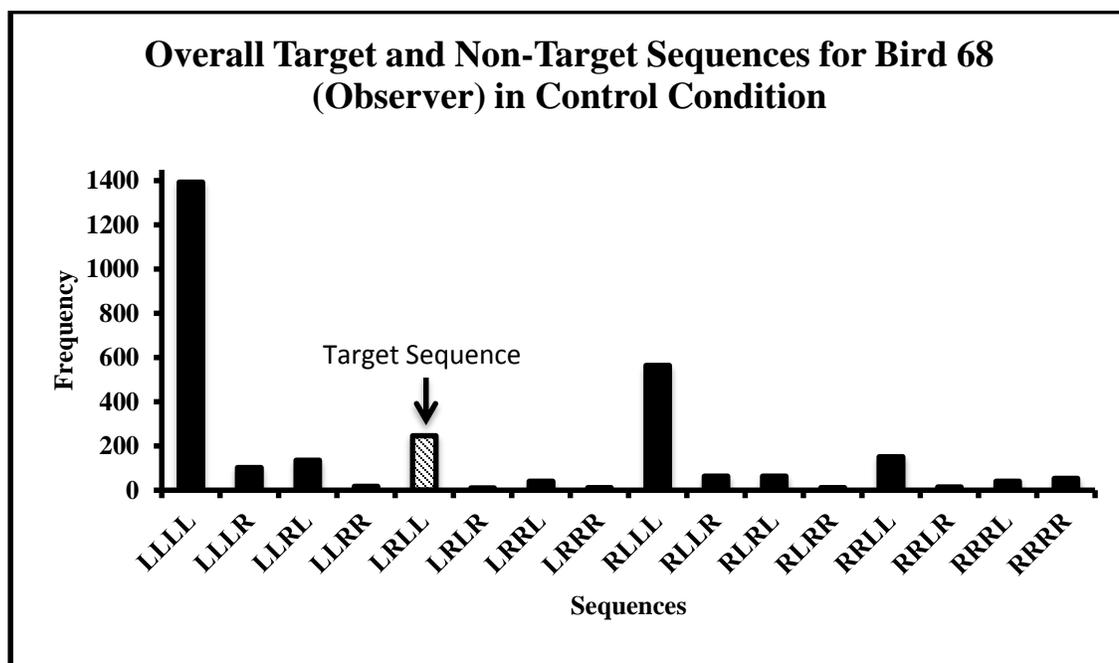


Figure 11. Overall target (LRLR) and non-target sequences performed by bird 68 (observer)

w/ no model bird demonstrating the target sequence.

The top three non-target sequences with the highest frequency in the model condition were LLLL, RRRR, and LRLL, respectively, comprising of 72.3% of all sequences. In the control condition the top three non-targets were LLLL, RLLL, and RRLL, respectively, comprising of 75.5% of all sequences. The target sequence in the model and control condition had the fourteenth and third overall highest frequency, respectively, among all possible sequences. There were not any noticeable patterns with the two target sequences emerging as a predominant error in either condition.

Bird 67 observed bird 72 model sequence B. There was a clear separation between data paths throughout the study with the control condition displaying higher acquisition. Session 10 was the only session that contained an overlapping data point. There were four total sessions in which bird 67 maxed out with 45 reinforcers in the control condition. Total sessions for sequence A and B were 19 and 17 respectively. Data displaying target frequencies are displayed in Figure 12.

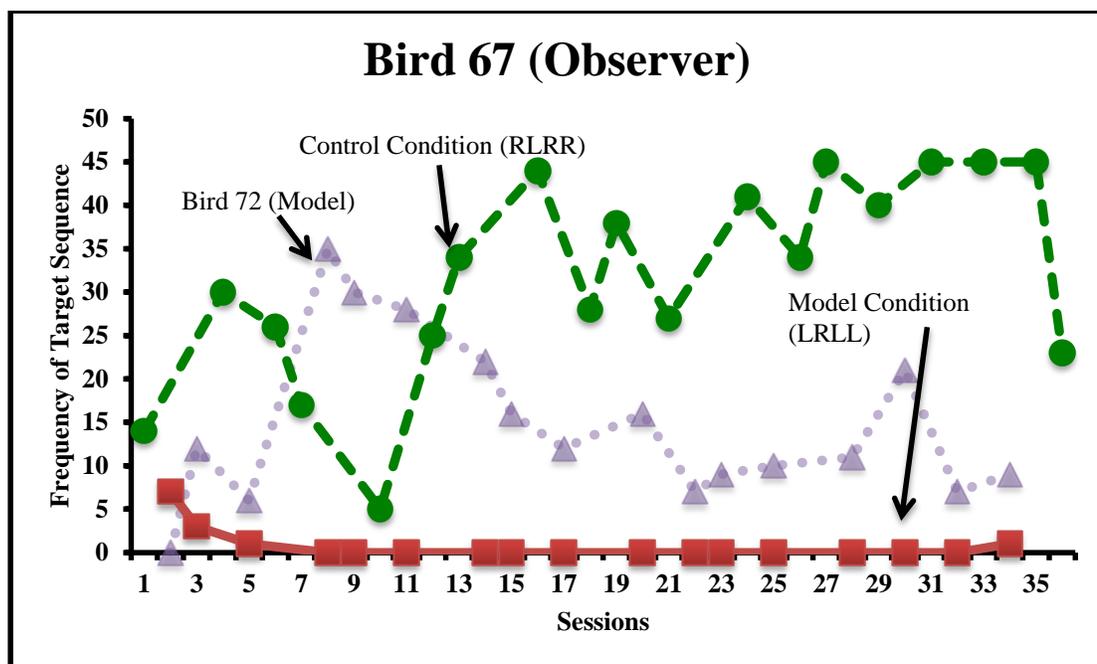


Figure 12. Frequency of target sequences for model (LRL) and control (RLRR) conditions for bird 67 (observer). Includes target frequencies for bird 72 (model) during model condition sessions.

Error sequences were examined in both conditions for bird 67 (see Figure 13 and 14).

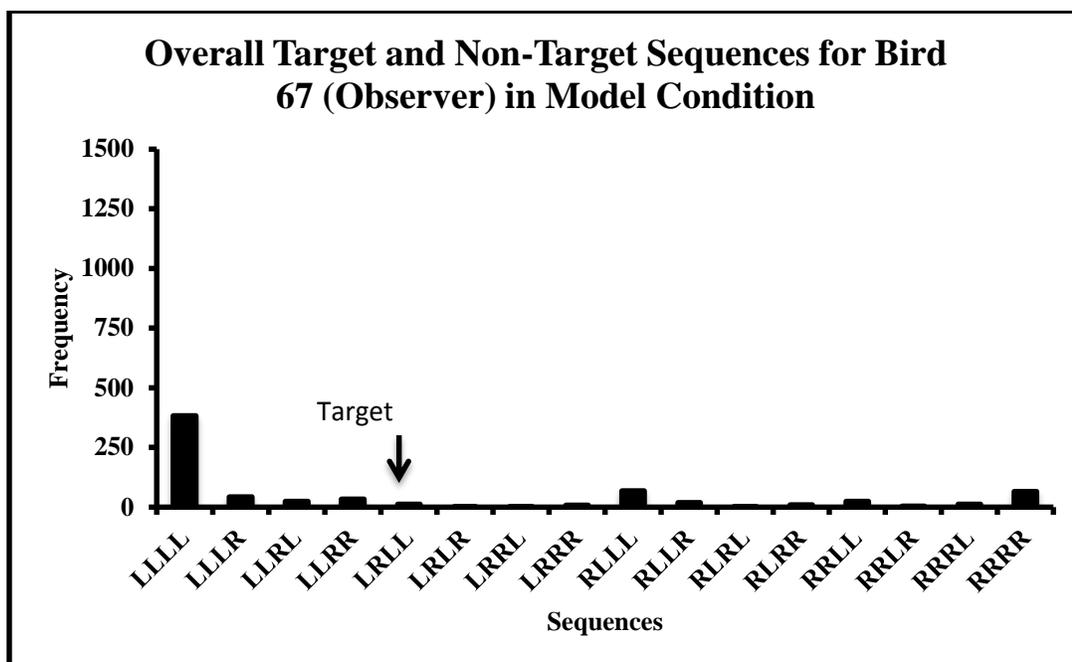


Figure 13. Overall target (LRLI) and non-target sequences performed by bird 67 (observer) w/ bird 72 modeling the target sequence.

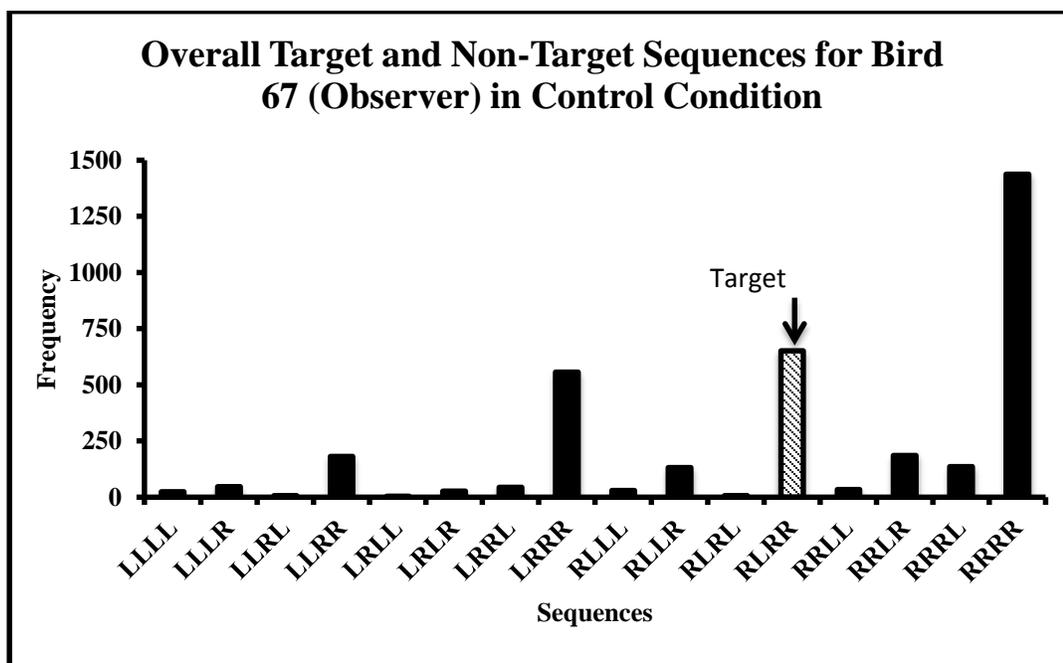


Figure 14. Overall target (RLRR) and non-target sequences performed by bird 67 (observer)

w/ no model bird demonstrating the target sequence.

The top three non-target sequences with the highest frequency in the model condition were LLLL, RLLL, and RRRR, respectively, comprising of 73% of all sequences. In the control condition the top three non-targets were RRRR, LRRR, and RRLR, respectively, comprising of 75.6% of all sequences. The target sequence in the model and control condition had the ninth and second overall highest frequency, respectively, among all possible sequences. There were not any noticeable patterns with the two target sequences emerging as a predominant error in either condition.

Bird 69 observed bird 72 model sequence B. The average frequency of the modeled sequence was 23 and 23.2 for the non-modeled sequence. The average percentage of the modeled sequence was 13% and 14% for the non-modeled sequence. There was an upward trend for the first ten sessions, which then turned into a downward trend for another ten sessions. The remaining sessions were moderately variable, showing no differentiation. Total sessions for sequence A and B were 17 and 19 respectively. Data displaying target frequencies are displayed in Figure 15.

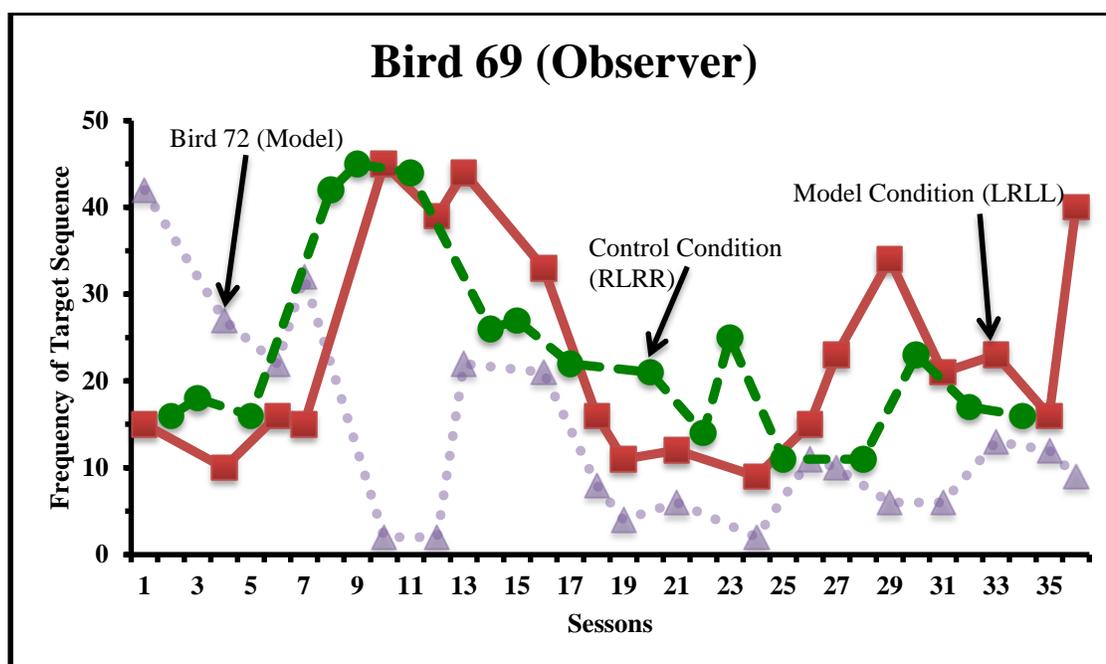


Figure 15. Frequency of target sequences for model (LRL) and control (RLRR) conditions for bird 69 (observer). Includes target frequencies for bird 72 (model) during model condition sessions.

Error sequences were examined in both conditions for bird 69 (see Figure 16 and 17).

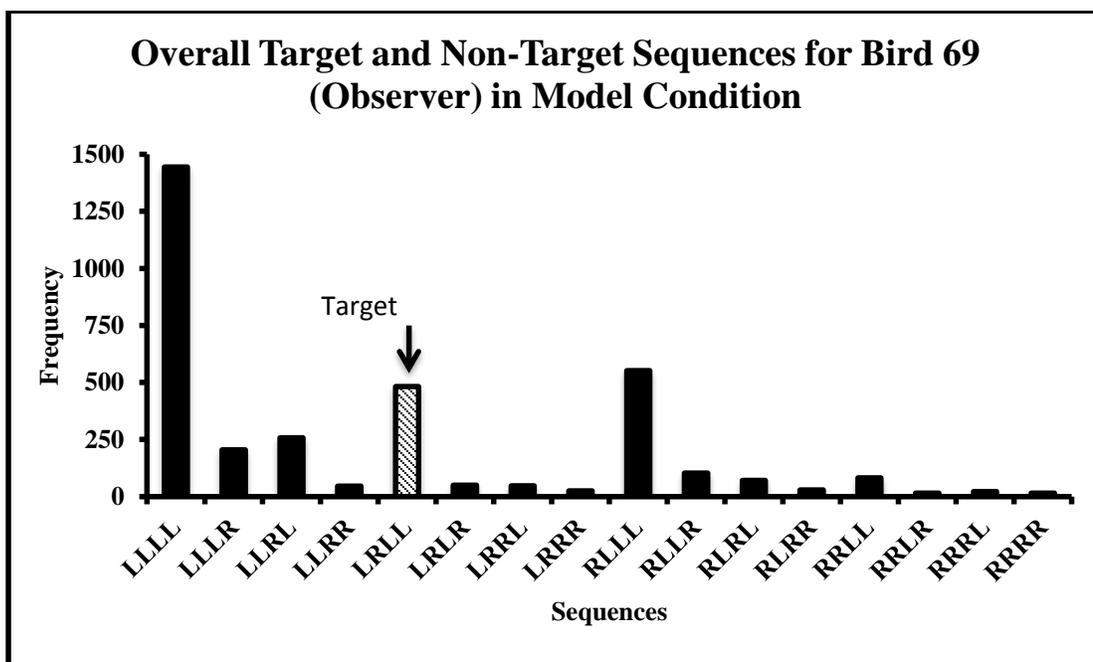


Figure 16. Overall target (LRLl) and non-target sequences performed by bird 69 (observer) w/ bird 72 modeling the target sequence.

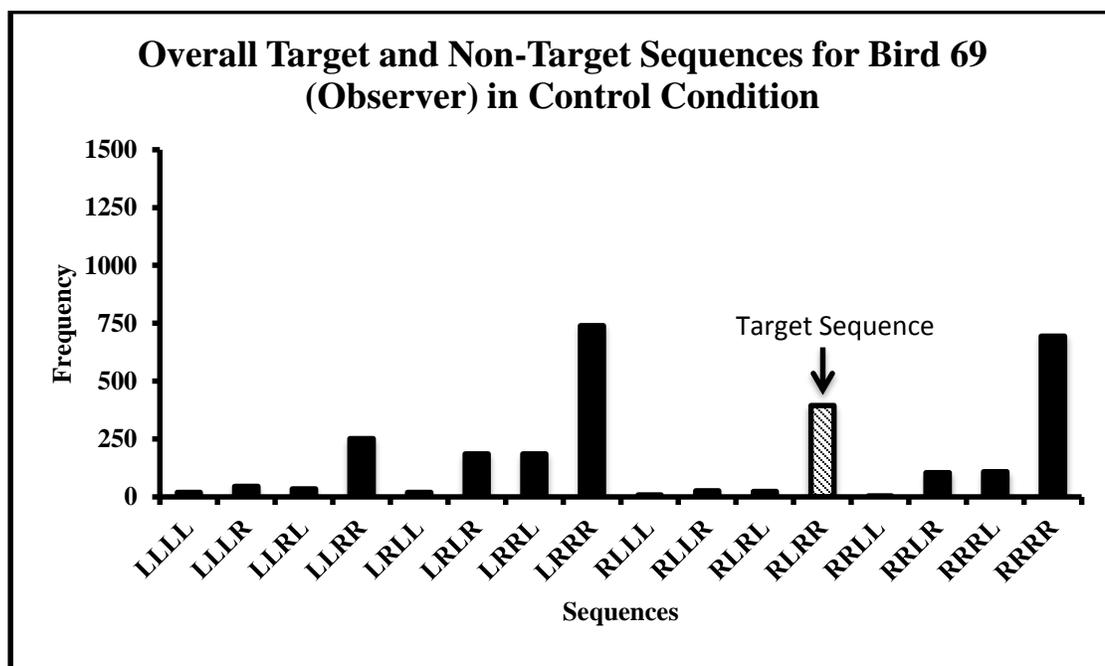


Figure 17. Overall target (RLRR) and non-target sequences performed by bird 69 (observer)

w/ no model bird demonstrating the target sequence.

The top three non-target sequences with the highest frequency in the model condition were LLLL, RLLL, and LLRL, respectively, comprising of 72% of all sequences. In the control condition the top three non-targets were LRRR, RRRR, and LLRR, respectively, comprising of 64.2% of all sequences. The target sequence in the model and control condition both had the third overall highest frequency among all possible sequences. There were not any noticeable patterns with the two target sequences emerging as a predominant error in either condition.

DISCUSSION

The present findings revealed no significant differences in acquisition rates when pigeons observed another pigeon model a pecking sequence and when they did not observe a model. Half of the observer pigeons acquired the control sequences faster than the modeled sequences, while the other half either showed slightly better performance in the model condition or no differentiation between the two conditions.

In the current study, pigeons were exposed to another bird being reinforced for pecking a particular sequence, which in earlier studies indicated an improved acquisition rate of the target response (Akins and Zentall, 1998). However, this effect was only marginally supported by two out of the four birds in the study, suggesting that other factors may have impacted the degree to which the target sequence was learned. One particular study (McGregor et al, 2006) had pigeons observe model pigeons either peck or step on a horizontal plate in which no food reinforcement was delivered. After the observation period, the observers had an opportunity to respond to the horizontal plate. The researchers found that even though the model birds were not presented with food for responding to the horizontal plate in a particular way, the observer birds had a higher proportion of responding that matched what was observed. A follow-up experiment within the same study also found that the imitative responding in the observer birds was not affected by the density of food reinforcement delivered to the model birds (e.g. CRF vs. VI). That is, the observer

birds had a higher proportion of responding that matched the model regardless of whether the model received food reinforcement on a dense or intermittent schedule.

Although accuracy of target sequences was a main dependent variable in the current study, analyses of error sequences provided interesting response patterns that may help explain observed performances. With respect to the target sequence RLRR, three out of the four observer birds made the same two errors in their top three non-target sequences, RRRR and LRRR, as the model bird for that target sequence (bird 56). As for the other target sequence LLLL, all four observer birds had the same top two errors, LLLL and RLLL, as the model bird for that target sequence (bird 72). One notable similarity between these two sets of error patterns is that they are the exact reversal of each other (i.e. the reversal of RRRR/LRRR is LLLL/RLLL). The two errors either perseverate on one key (e.g. RRRR) or include one-key changeover pattern (LRRR). In fact, the top two errors made by all birds include either a perseveration error or a one-key changeover error. Increased response effort in changing over between keys multiple times may have reduced the frequency of “elaborate” errors (e.g. LRLR). Neuringer, Deiss, and Olson (2000) also observed common errors that included perseveration or lack of changeover. Machado (1997) mentioned attributing sequence errors to faulty stimulus control due to elapsed time or extended responses. In other words, the longer the response sequence, the more difficult it is to retain appropriate stimulus control for longer sequence patterns.

One potential confound in the current study was the performance variability observed among the model birds. Bird 56 had a higher average target frequency and

percentage than Bird 72 for both observer birds (47.1% and 48.1% versus 27.6% and 29.5% respectively). The criteria required for a model bird to be labeled ‘proficient’ were not upheld during observation periods, thus allowing more incorrect sequences to occur. Past research (Vanayan, Robertson, & Biederman, 1985; Templeton, 1998) suggested that observing incorrect responses was just as important as observing correct responses, but that effect was not prominent in the current study given that the majority of the sequences observed in any given session were incorrect. Interestingly, two observer birds performed better in the condition with no opportunity to observe correct or incorrect sequences, suggesting that adequate stimulus control was not obtained in the model conditions regardless of proficiency. Another explanation could be that too many errors were observed and prevented the detection of reinforced target responses (since the reinforcement came after the target sequence was emitted and the bird might have missed what the model bird had just done). Perhaps a higher proficiency rate among the model birds could have increased the total number of reinforcers observed for the target sequences, resulting in improved imitative performances.

During the model condition, birds were quickly transferred to the other side of the chamber after the observation period. This involved opening the chamber door, extracting the model bird, sliding open the Plexiglas divider, coaxing the observer bird to the other side, closing the Plexiglas divider, and finally closing the chamber door. The transfer process was not conducted with the control condition, thus not being exposed to the same stimulus changes. Lacking control of these factors poses

potential confounds which may have affected how birds performed in one condition versus the other.

Another limitation may be linked to stimulus saliency in terms of the visibility of the illuminated stimuli and the model pecking at each individual disc. The far left and far right discs were used in order to maximize discriminability during the demonstration phases, but the visibility of the pecking patterns may have been obstructed due to the experimental setup. Observer birds were placed in a chamber behind the model birds during observation periods, as opposed to a side-by-side apparatus used in other studies (e.g. Epstein, 1984). Additionally, upon each peck of the disc the illuminating light briefly turned off and came back on to enhance the discriminative properties of pecking the disc, but that feature may also have been hidden by the positioning of the model pigeon.

The pecking characteristics of the model birds may also have had an effect. Upon direct observation, when the model birds pecked at a particular key, at times they pecked too lightly to make the mechanical connection necessary to record a response. This led to multiple “failed” response attempts within a trial and repetitive pecking, which likely increased the overall number of incorrect sequences observed. Data were not collected on these “failed” attempts to determine if one model bird emitted more than the other and whether that correlated with different response patterns by the observer pigeons.

Given the findings of the current study, suggestions for future research include various extensions or modifications based on the encountered limitations. A different

approach to examining the imitation of extended target sequences could be by observing how acquisition of a final target sequence (e.g. LRLL) progresses from smaller units of the final target sequence (e.g. LR, LRL). Observations of model birds could start at earlier stages and systematically build up to the final target sequence, comparing performances to a different sequence progression in a control condition. Not only could comparisons be made between the model and control conditions throughout the study, but it could also shed light on research pertaining to whether pigeons can be ‘taught’ to learn how to imitate conspecifics.

Another aspect of the study that could be altered is the observation time. The current study allowed a ten-minute observation before allowing birds to respond to stimuli, which was consistent with other research. Previous studies have allowed shorter observation times such as five minutes (e.g. Akins & Zentall, 1998) and 25-30 seconds (e.g. Templeton, 1998) and longer sustained periods of up to 30 minutes (e.g. Epstein, 1984). Longer times may lead to a higher proportion of correct responding observed given that the proficiency of the model is high and can maintain throughout the duration of the demonstration. However, satiation was a variable that needed to be controlled for, thus requiring a limited observation time. Future research could manipulate observation times and conduct parametric analyses to see the effect on response acquisition.

Task complexity also may have played a role in the decreased acquisition of the target sequences. A four-response sequence may have been too difficult of a response and requiring more effort compared to other research that used simpler, less effortful

responses such as stepping or pecking a treadle (e.g. Dorrance & Zentall, 2001). The different sequences may also not have been topographically distinct enough as compared to a stepping or pecking response. The acquisition of lengthy responses sequences have been studied in terms of using concurrent reinforcement procedures to help with identifying ways of facilitating the acquisition (e.g. Neuringer, Deiss, & Olson, 2000). Given that the difficulty of the sequence increases with additional responses, there exist many possible sequence combinations, some of which may be perseverated on regardless of contacting reinforcement. All of the birds in the current study had at least two non-target sequences that had a noticeably higher frequency than other non-targets. Future research could possibly combine the notion of reinforced variability with imitation procedures and look at whether adding concurrent reinforcement for varied responding improves acquisition among modeled or non-modeled sequences.

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