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# Every Other, Every Time - Rat Imitative Pattern Learning

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EVERY OTHER, EVERY TIME - RAT IMITATIVE PATTERN LEARNING

by

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Submitted in Partial Fulfillment

of the requirements for the degree of

Bachelor of Arts

in

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Abstract

Keshen (2011) showed that rats better learned to find visually-distinctive food locations arranged in a circle after watching an expert demonstrator rat forage in the setting. Phillips (2013) failed to find a similar imitative effect when 6 of 12 visually-identical food towers, also arranged in a circle, were consistently baited, but in a random pattern. The present experiment was designed to determine whether rats could display imitative learning using a more-regular pattern. Eight rats were assigned to be either demonstrators or observers. The experimental arena contained 12 identical food towers in a circular formation with every other tower baited. In Phase 1, the demonstrators were free to forage for 50 trials. In Phase 2, the observers were given the opportunity to forage for 20 trials, always after observing an expert demonstrator forage. During their 20 trials, the observers performed better than the demonstrators had during their first 20 trials.

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To Dr. Cole, where do I even begin. I am almost at a loss for words, something we all know happens very infrequently. I can't imagine how my academic career would be without him and quite frankly, I wouldn't want to. He has been an immense source of inspiration and allowed me to recognize my own potential, far surpassing what I thought possible. The amount of expertise and knowledge he passed down to me is unparalleled and I will be eternally grateful. As you may or not have known, I have been dubbed "Little Cole" which I hold as one of the highest compliments and true honour. Thank you for being such an incredible advisor and role model. I will always cherish the memories of working alongside you.

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demanding and pushing me to work hard. To my brothers Matthew and Johnny, thank you guys for always looking out for me and putting up with my little brotherness. I know that if I ever needed anything, you'd be there at the drop of a hat.

I am so proud of my time at Huron and will never forget the knowledge and experiences I gained from it. Thank you to everyone that has helped me along the way.

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Introduction

The ability to learn through imitation enables an animal to thrive in their current environment or survive in a new one by watching an experienced conspecific interact with stimuli formerly unknown to the naïve animal (Galef, 2002). Imitative learning occurs when a naïve observer performs a novel behaviour following the observation of another organism performing that same behaviour (Zentall, 1988). This is a useful skill for an animal to have and it may become more important as many species are beginning to lose their natural habitats (Seamans, & Gutiérrez, 2007). Although numerous studies have examined imitative learning in non-human animals, many researchers disagree on the implications of the findings and whether non-human animals are capable of imitative learning. Researchers such as Morgan (1900) argued that imitative learning is a uniquely human capability and that non-human animals are only capable of imitation that is instinctive. To further this argument, Morgan indicated that there are two basic types of imitation: *instinctive imitation* and *reflective imitation*. The latter was characterized by deliberate and intentional thoughts, mental processes that Morgan deemed too sophisticated for non-human animals. Therefore, any type of imitation performed by a non-human animal would be, according to him, instinctive.

Like Morgan, Thorndike was reluctant to believe that imitative learning would be possible in any non-human animals. Additionally, Thorndike also identified multiple "pseudo-imitative" processes that were considered simpler versions of the true imitation which could only be practiced by humans (Thorndike, 1911). These contentions likely derived from earlier studies by Thorndike that failed to show imitative behaviour in monkeys. For example, Thorndike (1901) permitted a monkey to observe a demonstrator conspecific complete a problem-box task and later allowed the observer to attempt the same task. No evidence of true imitation was

reported but the findings were later opposed by Kinnaman (1902). The study conducted by Kinnaman assessed the problem-solving abilities of two rhesus monkeys (*Macacus mulattus*), one male and one female. The male monkey was placed in a test arena with a box containing food. The food only became accessible by correctly manipulating various latches. The correct latch manipulation was demonstrated to the male monkey by an experimenter. However, the monkey failed to learn the correct method from the demonstration and instead learned gradually by trial and error. Once the male had successfully completed the trials, a trial in which the male and the female monkey were simultaneously allowed in the test area took place. At this point, the female did not know the correct manipulation of the latches but the male did. Once the trial commenced, the male successfully obtained the food reward while the female was present. In all subsequent trials, the female correctly manipulated the latches and gained her food rewards. To ensure this finding was not due to chance, a different type of latch was used in a new set of trials. As in the previous trials, the female monkey learned the new match manipulation upon observing the male's success. It was argued that the demonstration for the male monkey was unsuccessful because the demonstration was coming from a non-conspecific animal which provided an insufficient model for imitative learning.

The findings from Kinnaman (1902) suggest that non-human animals are capable of imitative learning but the significance of this ability was not discussed. While researchers such as Thorndike and Morgan might have argued that the female monkey did not display true imitation, Romanes might have disagreed and might have suggested that imitative learning plays an integral role in the development of behaviour in animals. Romanes argued that imitative behaviours are simply behaviours that resulted from social interaction, and therefore, are not uniquely human (Romanes, 1884). However, Kinnaman argued that the ability to alter behaviour

due to a social interaction displays intelligence and intent. The findings from Kinnaman (1902) would have been interpreted as intelligent and intended behaviour adjustment by the female monkey and this type of behaviour would ultimately contribute to the survival of the species.

Primate imitative learning has been demonstrated for several evolutionarily advantageous tasks such as tool manufacture and food selection (Jouventin, Pasteur, & Cambefort, 1970; Wimpenny, Weir, Clayton, Rutz, & Kacelnik, 2009). The ability of baboons (*Mandrillus sphinx*) to discriminate between noxious and edible foods and to learn this discrimination by observing a conspecific's food selection was examined by Jouventin, Pasteur, and Cambefort (1970). The demonstrator baboons were to select one of two slices of banana, one regular slice and one with an altered bitter taste to represent the potentiality of noxiousness. The two slices were made distinguishable using coloured dye and varied across demonstrators, but remained consistent throughout for each demonstrator. For example, red banana slices denoted a bitter banana slice for one demonstrator and a normal tasting slice for another. After observing the demonstrator make their food selection, the observer made its own decision between two banana slices with the same colours as the demonstration. The results showed that the observers selected the same slice as their demonstrator and thus supported previous evidence of observational learning in primates. Additionally, the findings suggest that baboons can use imitative learning for evolutionarily adaptive behaviours such as food selection.

However, the ability to select food is insufficient for survival if an animal is unable to find or obtain food in the first place. The research by Sanz and Morgan (2009) found that chimpanzees could learn to manufacture tools through imitation when gathering honey from hives. However, it was unclear if chimpanzees would learn better from imitation than individual trial and error in the case of a new challenge or an alteration to the task at hand. Based on these

findings, and other previous research (Jouventin et al., 1970), animals with a close evolutionary history to that of humans appear to have the ability to learn by imitation even on tasks as complex as tool manufacture. Though these findings do not answer the question of whether animals lower on the phylogenetic scale are capable of imitative learning.

A large body of literature suggests that several mammals are capable of imitative learning with the common example being the ability to learn birdsongs among some avian species. Similar to human speech, young songbirds begin life unable to sing, but rapidly gain this skill by listening to and imitating the mature songs of conspecifics surrounding them (Brainard, & Doupe, 2002). Additionally, some avian species such as Swamp Sparrows (*Melospiza georgiana*) are unable to learn songs they do not hear during their first year of life (Marler, & Peters, 1988). Although many researchers associate imitative learning in avian species with song production, other tasks such as tool manufacture in New Caledonian crows (*Corvus moneduloides*) may rival that of primates (Wimpenny et al. 2009).

Lahti, Moseley, and Podos (2011) experimentally altered recordings of Swamp Sparrow songs obtained by a nearby population. Ten song models were constructed for the birds with trill rates artificially altered using signal software. Two of the 10 training songs were constructed at the natural trill rate from a recorded song of a nearby Swamp Sparrow population, whereas the remaining eight were modified to range from 4.6 to 11.7 Hz. Swamp Sparrows nestlings were taken from a reserve in Western Massachusetts between five and seven days after hatching and were hand reared by the researchers. During their sensitive period for song acquisition, birds were housed in a walk-in acoustic isolation chamber for daily song training. Once the birds were old enough to make adequate vocalizations, they were recorded for 3 hours in the morning twice per week. Overall, the birds imitated the training songs, but not with equal accuracy for all 10

songs. The songs that the birds most-accurately replicated had trill rates equal to, or more rapid than, the natural song from which they were derived. Additionally, as the trill rate was reduced from the original trill rate of the song, the accuracy of the imitation decreased as well. The reduced trill rate finding was not associated with the inability of the birds to learn by imitation, but rather due to those vocalizations being too unlike natural vocalizations from the species however, this was only when the deviation was in a downwards rate and not when it was upwards.

As mentioned earlier, avian species have displayed imitative learning in tasks other than birdsong which includes a visual discrimination task from Biederman, Robertson, and Vanayan (1986). During their study, demonstrator pigeons (*Columba livia*) were presented pairs of visual stimuli such as triangles and dots. If the demonstrator selected the stimulus designated as S+, it was given access to grain whereas selecting the S- stimulus resulted in a 20-s time out. After being given an opportunity to watch a demonstrator complete the discrimination task, the observer was given the opportunity to discriminate between the stimuli. There was also a group of control pigeons that did not have an observational opportunity. The results indicated that pigeons that observed a conspecific demonstrator perform the discrimination task prior to their own opportunity, outperformed the non-observing pigeons on the same task, thereby supplying more evidence with respect to the various imitative learning capabilities of avian species.

The outlined studies and the entertaining imitative vocalizations of parrots have produced widespread knowledge of imitation abilities in avian species. But, a species often studied by psychologists with widespread capabilities unbeknownst to the general public is the rat (*Rattus norvegicus*). Many early studies involving rats required them to press a lever in an operant-conditioning chamber to obtain a food reward (Skinner, 1936). More-recent studies have

indicated that rats are faster at learning to press the lever or bar after watching an experienced conspecific correctly perform the same task (Corson, 1967; Jacoby & Dawson, 1969). Jacoby and Dawson (1969) modified a standard operant-conditioning chamber by moving the lever above the food receptacle and adding a clear Plexiglas partition that enabled an observer to watch a demonstrator rat press the lever and then consume the subsequent food reward. Two rats were randomly assigned to be demonstrators and a lever-pressing response was shaped until they pressed the lever at least 75 times in a 7.5-min period. The remaining 24 rats were either kept in their cage, observed the empty arena, were shaped to press the lever, or observed the demonstrator for 7.5 min, followed by a testing period of the same length. Testing occurred once per day for a total of six days. The number of test sessions required for the rat to reach the criterion of 50 lever presses in the 7.5-min period was used as one dependent variable, and the number of total lever presses made served as the other. When analyzing the number of sessions it took to meet the 50-press criterion, the observational and shaping technique produced about equal performance, which was also superior to that seen in both control conditions. Additionally, when analyzing the results by total number of lever presses, the observational technique produced significantly more lever presses than all other conditions, and the shaping technique produced more lever presses than the control conditions.

Kohn and Dennis (1972) examined imitation learning in rats using a visual pattern discrimination task within a transparent arena. An expert demonstrator travelled through an arena containing two entrance paths leading to a goal box with a food reward. Vertical and horizontal stripes positioned prior to the path entrances were used to differentiate between the paths and indicate which one led to the goal box, and which one led to a blocked off goal box on any given trial. The observer rat had an opportunity to watch the demonstrator through the transparent

arena for three days at the rate of 10 trials per day. It was found that when the demonstrator and observer were given the same visual stimulus to denote S+ or S-, the observational experience facilitated the learning process. However, if the rules for the demonstrator and observer were opposite, the observational experience hindered the learning process.

Keshen (2011) examined the imitative learning abilities of rats for a cue learning task using a circular arena with 12 food towers equidistantly spaced in a circular formation. In the center of the arena there was a circular viewing cage. To determine if the relationship between the demonstrator and observer influenced the effectiveness of imitative learning, half of the demonstrator-observer pairs were cage mates and the remaining half were not. Six towers were marked with black and white stripes and were always baited, whereas the remaining six towers were plain white, and never baited. Demonstrator rats, after being held briefly in the viewing cage were released and allowed to forage until all baited towers had been found and the food rewards consumed. Once the demonstrators became proficient at the task, an observer rat was placed in the viewing chamber while the demonstrator foraged. Once the demonstrator had completed the task, the striped towers were rebaited, and the observer rats were allowed to forage themselves. It was found that during 20 trials, the observer rats took fewer visits to find all six baited towers than the demonstrator rats had taken on their first 20 trials. It was also found that the observer rats having has an opportunity to watch an unfamiliar demonstrator outperformed the observer rats that had an opportunity to observe a familiar demonstrator. It was argued that the rats learned better from an unfamiliar demonstrator because they were more interesting than the familiar rats. Thus, Keshen went on to argue, as a result of the higher interest, the observer rats were more attentive to the demonstrator and therefore, more attentive to the demonstration.

Buck (2012) replicated the experiment but introduced a 24-hour delay between observing the demonstrator rat and being given an opportunity to perform the task. It was found that the observer rats still outperformed the demonstrators, even after a 24-hour delay. The result was interpreted as evidence that the observers were not only using information from their working memories but rather a demonstration of reference memory learning from the demonstration. However, unlike the results of the experiment by Keshen (2011), there was no familiarity effect as the observer rats with opportunities to watch familiar and unfamiliar demonstrators performed equally well. As the familiarity effect found by Keshen (2011) was present after a 2-min delay and not after a 24-hour delay in Buck's experiment, it is possible that it was not due to an increase in attention. Perhaps the familiarity effect was present due to the observer seeing the demonstrator as a competitor. This competitive motivation would likely dwindle over time and be non-existent 24 hours later.

Keshen (2011) and Buck (2012) both demonstrated imitative learning for rats when the location of the baited towers had been indicated by a visual cue. Phillips (2013) conducted a follow-up experiment attempting to use a randomly-chosen baiting pattern as the indicator of food location. The methods replicated those of Keshen (2011), however, all towers were plain white, and all demonstrator-observer pairs were all non-cage-mates. The rats were expected to learn to select towers based on their position within the circle using only the extramaze cues in the test room to indicate baited locations. Which six towers were baited for each pair were randomly chosen and used throughout the entire experiment. Therefore, unlike the previous two studies, the solution could not be reduced to a simple rule: "striped towers have food". The difficulty of the task became evident during the demonstrator training as this training required a much greater number of trials to approach criterion than had been needed in the previous studies;

in spite of the additional training, the demonstrators still fell well short of the accuracy criterion of 90% demonstrator accuracy found by Keshen (2011) and Buck (2012). Additionally, it was found that the performance of the demonstrator and observer rats did not differ significantly over 40 trials, and therefore, the demonstration did not appear to have improved learning. However, it is unclear if this was due to the task difficulty overall, or to the poor performance of the demonstrators during the observational trials.

The present experiment was designed to determine if rats are more capable of learning a simpler and regular pattern task after watching a conspecific demonstration. This experiment is a replication of Phillips (2013), but rather than randomly selecting which towers will be baited, the towers will be baited in an every-other fashion so that no two adjacent towers will be baited. As there are no visual cues on the towers, once the starting point of the pattern is determined for a demonstrator, the same towers will be baited for the entirety of the experiment. The simple pattern should place a weaker cognitive demand on the rats than that placed on her rats by Phillips (2013).  The task can be reduced to a rule, similar to that in the Keshen (2011) and Buck (2012) experiments: from the starting point, pick every other tower. Based on the previous findings from Keshen and Phillips, it is predicted that the task performance of observer rats will surpass the performance of their demonstrators which will also be "expert" demonstrators.

Method

*Subjects*

Eight male, hooded-rats (*Rattus norvegicus*) of the Long-Evans strain were used in the present study. The rats were obtained from the Charles River Company in Montreal, Canada. Seven of the rats were delivered four months prior to the experiment and weighed approximately 300 g each upon their arrival. The remaining rat was delivered immediately before Phase 1 of the

study and weighed approximately 650 g. The rats were initially housed in pairs, however two pairs were separated shortly after their dual housing began due to one rat consuming too much of the daily food ration allotted to it . Clear plastic breeding cages were used to house the rats. The lid of each cage consisted of stainless steel bars with a depression used to hold food and one water bottle per rat. The bottom of the cage was covered in Beta Chips consisting of 100 percent Virgin Wood Fibre from the North Eastern Products Company in Warrensburg, NY. A piece of PVC pipe, with an average inner diameter of 8 cm and average length of 23 cm, was placed in the home cage for each rat to provide environmental enrichment.

The rats were fed Prolab® RMH 3000 manufactured by Lab Diet in St. Louis, MO, USA. The rats were given an unlimited supply of both water and food for several days following their arrival. After this brief period, the rats were weighed to the nearest 5 g to determine the food deprivation schedule leading up to and during the experiment. The goal weight of each rat was 90 % of their free-feeding weight and was used to encourage food foraging. Prior to the current experiment, the weight of the rats ranged from 450 g to 550 g.

All cages were kept in a common cage room that was kept at 22°C with 22 fresh air changes per hour and a 24-hour light cycle. For ease of monitoring, lights automatically turned on at four o'clock in the evening and off at four o'clock in the morning. Experimental trials were only conducted during the light-off portion of the cycle.

Seven of the eight rats had previous exposure to an operant chamber and a 12-arm radial maze. A series of conditioning procedures took place in the operant chamber while a foraging task took place in the radial maze. The remaining, and larger older, rat was experimentally naïve.

*Apparatus*

The apparatus was a circular arena bordered by a wall 40.6 cm high and 1.7 m in diameter. The wall was constructed of 0.5 cm thick Masonite® with white plastic on the inside of the wall. Twelve food towers 10 cm X 10 cm X 20 cm high were placed in a circle with adjacent towers 30.5 cm apart, center-to-center, and with the center 7.6 cm from the wall. Each tower was enclosed in a white Bristol Board® sleeve covered by clear plastic packing tape. A plastic food cup measuring 2.5 cm in diameter and 1.9 cm deep was made from a 3.5 cm film canister and attached to the center of the top of each tower with a small screw. Food cups were baited or sham baited with cubes of Black Diamond Medium Cheddar Cheese® measuring 1 cm$^3$. Disks constructed from 35 mm film canister lids, each containing 10 holes, 3 mm in diameter, were used to cover the food in the food cups of the six sham-baited food towers. These sham bait disks fitted tightly inside the food cups so that the bait was present but inaccessible. The purpose was to control for odor cues. A circular observation cage measuring 49 cm in diameter and 47 cm in height was constructed from Welded Hardware Mesh. The cage lid consisted of a Rubbermaid® garbage lid with a 2 kg brick on top. This configuration ensured that a rat would be incapable of moving or escaping from the cage.

The arena was placed in the center of a testing room measuring 1.8 m in width, 2.1 m in length, and 2.4 m in height. Each wall was painted creamy yellow; the side walls were made of cinder block while the rear and front walls were made of green board. The front wall contained a single grey-painted door that provided access to the test room and an electrical switch with a stainless steel cover. The room was well illuminated by four cool white 122 cm fluorescent tubes (GE F40CW-RS-WM 2400 lumens) in a fixture behind a translucent lens mounted in the center of the ceiling. The ceiling also contained a circular curtain rack bisected

by a wooden beam as well as a sprinkler, two vents, and a USB cord handing from the curtain rack.

A 23 cm by 23 cm speaker was located on the front wall 0.9 m from the center of the speaker to the ceiling and 0.9 m from the side walls. Just below the speaker there were two pieces of paper 21 cm by 11 cm. The right wall contained two silver 11 cm by 7 cm electrical panels and one piece of 2 cm by 3 cm black tape. The left wall only contained one piece of 2 cm by 3 cm black tape. The rear wall contained one silver 11 cm by 7 cm electrical panel with a white switch in the middle and a door. The door was light blue measuring 1.05 m wide and 2.1 m tall with the center of the door located 93 cm from right wall and 1.05 m from the floor. The dark blue doorframe extended 5 cm from either side of the door and 10 cm from the top of the door. The door had an 88 cm tall and 12.5 cm wide window located 63 cm from right wall 1.5 m from the floor to the center of the window as well as a circular silver door handle with a diameter of 5 cm extending 7 cm from the floor. The center of the door handle was 102 cm above the floor and 47 cm from the right wall.

*Procedure*

*Preliminary Training*. Half of the rats were housed together and half were eventually housed separately. As a result, demonstrator-observer pairs were assigned to control for housing variables. Each pair consisted of one rat housed with a companion and one rat housed alone. For half of the pairs, the rats with a cage-mate were assigned to be the demonstrator while the remaining half were assigned to be the observer. The only experimentally-naïve and older rat was an observer. For the two days prior to the experiment, all rats were given two cubed pieces of cheese in their home cage. Rats were then individually trained to eat from the towers by baiting three towers 10, 15, and 20 cm high, respectively, in the arena. Rats were given the

opportunity to forage until they had visited all three towers. All rats reliably consumed the cheese from all three towers after five such trials.

*Phase 1: Demonstrator Training*. Six towers were baited in an every-other fashion such that no two adjacent towers were baited and, therefore, there were two possible arrangements. Demonstrators were randomly assigned to one arrangement for the study. For the first five trials, demonstrators were placed in the observation cage for a 5-minute waiting period prior to foraging. In each successive block of five trials, the waiting period was calculated by averaging the foraging times of the previous trial block. This was done to replicate the waiting time of the observers that would occur later in Phase 2 trials while the demonstrator foraged. After the waiting time had elapsed, the rat was placed back in its home cage for a brief period then placed into the arena, free to forage until all six baits had been discovered and consumed. Each demonstrator was given two trials per day, seven days a week, with the first trial beginning at approximately 9:00 AM, and the second at approximately 3:00 PM. Following the final trial of each day, the rats were weighed and fed enough food to maintain 90% of their free-feeding weights. After 50 such trials, the rats were deemed to be adequate demonstrators for Phase 2.

*Phase 2: Demonstrator-Observer Training*. For each trial, the observer rat was placed in the observation cage while the demonstrator was free to forage, as in Phase 1. Once all the baits had been consumed, the rats were removed and placed into separate holding cages. The towers were then rebaited and rearranged such that the previously baited towers became the sham bated towers. This was done to ensure the observer rats were not following the scent or trail of the demonstrators or displaying location learning. Once the towers had been baited, the observers were then placed inside the arena to forage until all six baits had been consumed. Two trials were conducted per day, seven days a week, with the first beginning at approximately 9:00 AM and

the second beginning at approximately 3:00 PM. Following the final trial of each day, the rats were weighed and fed enough food to maintain 90% of their free-feeding weights. This schedule continued until 20 trials had been completed.

## Results

The percentage of correct choices within the first six choices was used as the dependent variable. The percentage of correct choices made by the observers and demonstrators over the first four 5-trial-blocks are shown in Figure 1. Although the performance of both the demonstrator and observer groups increased throughout the first four trial blocks, it appears that the observers outperformed the demonstrators on each trial block and this difference appeared to increase in the later trial blocks. The data were subjected to a 2 (demonstrator vs. observer) x 4 (blocks of trials) split plot ANOVA to determine if any effects were significant. The analysis revealed a significant main effect of trial blocks [$F(1, 6) = 269.25$, $p < .001$, η2p $= 0.98$] such that the overall performance increased throughout the trial blocks. A significant main effect of demonstrator type [$F(1, 6) = 126240.56$, $p < .001$, η2p $= 0.99$] was also found such that the observers outperformed the demonstrators. The analysis also revealed a significant demonstrator type X trial blocks interaction [$F(1, 6) = 16.55$, $p < .01$, η2p $= 0.92$]. Independent samples t tests were used to compare the performance difference between the observers and demonstrators in each of the four trial blocks. However, the t tests revealed that the observers performed significantly better than the demonstrators on all four trials: Trial Block 1 [$t(6) = 2.54$, $p < .05$], Trial Block 2 [$t(6) = 3.99$, $p < .01$], Trial Block 3 [$t(6) = 7.46$, $p < .001$], and Trial Block 4 [$t(6) = 12.68$, $p < .001$]. As the results from the t tests could not adequately explain the interaction, a One-Way Within Subjects ANOVA was conducted for the observer and demonstrator groups. The results indicate significant improvement over time for both the observers [$F(3, 9) = 563.05$,
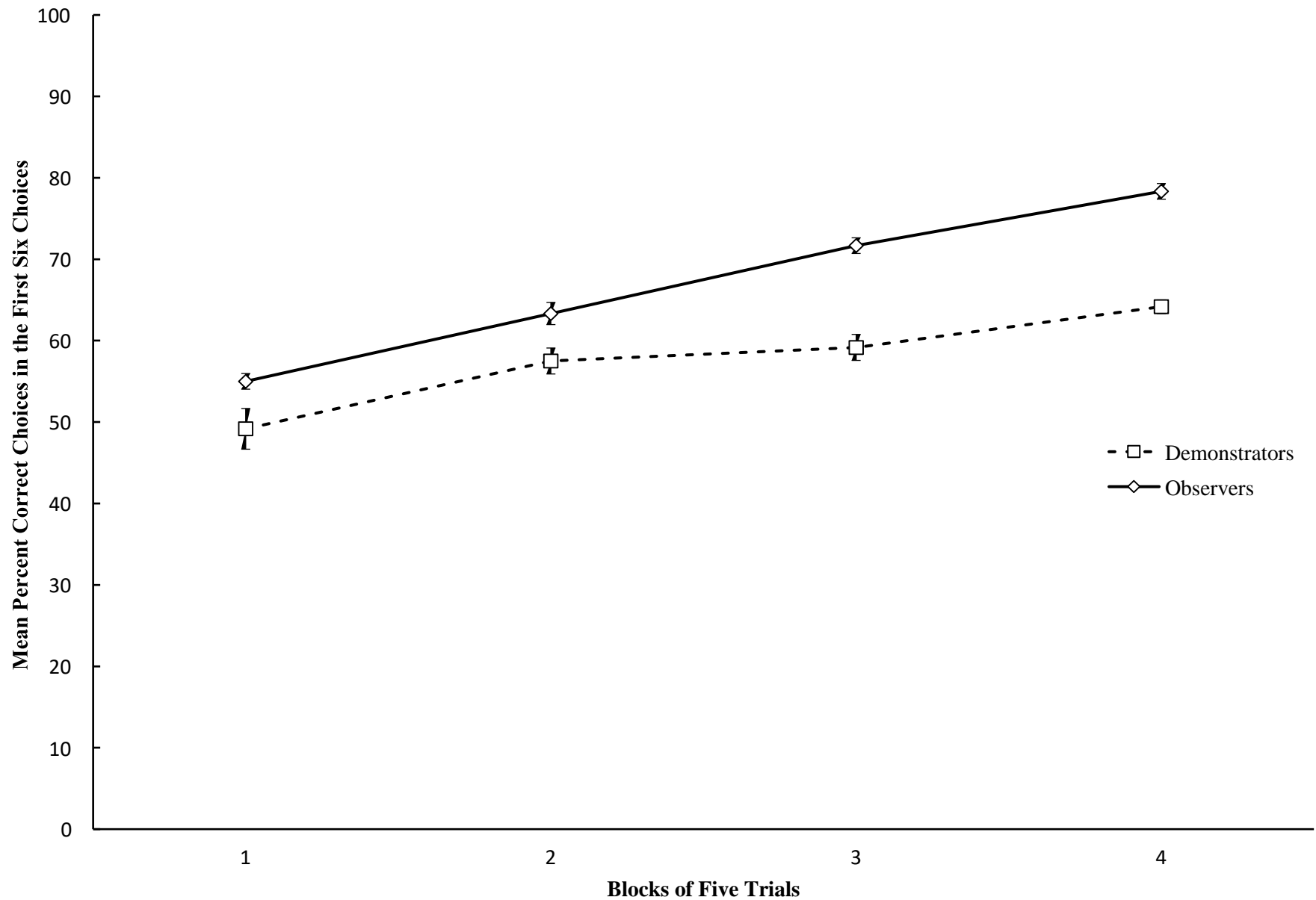
*Figure 1*. The mean correct choices within the first six choices over the first 20 trials are reported in 5-trial-blocks for both groups. The error bars represent the standard errors of the mean. The standard error of the mean for the demonstrators in Trial Block 4 is 0.85 and therefore, too small to be visible.

$p < .001$] and demonstrators [$F(3, 9) = 11.03$, $p < .01$]. Post hoc tests using the Bonferroni correction revealed that for the observers, performance increased from the first to second trial block ($p < .05$), the second to third trial block ($p < .05$), and third to fourth trial block ($p < .001$). On the other hand, the performance of the demonstrators did not differ significantly between any successive trial blocks however, performance significantly improved between the first and fourth trial block ($p < .05$). Therefore, the interaction was likely due to the observers continuously improving their performance between successive trial blocks while the demonstrators only improved between the first and fourth trial block.

## Discussion

The results indicate that both the observer and demonstrator rats were able to learn the pattern. Additionally, the observers outperformed the demonstrators at a statistically-significant level in each of the four trial blocks. These findings support previous research showing that subhuman animals can profit from observing skilled conspecifics (Kohn & Dennis, 1972; Keshen, 2011). Moreover, the present finding demonstrated that rats can learn by observing expert demonstrators when the task involves a pattern of food location not just which visually-distinctive locations are baited. Previous rat imitative learning studies had focused on visual cue learning (Keshen, 2011; Buck 2013; Biederman et al, 1986) however, little evidence has been produced for the imitative learning of patterns.

A previous study on imitative learning by Phillips (2013) used a patterned task but did not yield statistically-significant findings; however, this might have been due to the pattern being random, hence too difficult. The tower locations the researcher used could not be identified by a simple rule as the tower locations were selected randomly for each demonstrator-observer pair. As a result, the task may simply have been too difficult for imitative learning and even for trial-

and-error learning. On the other hand, the present study's pattern had a simple rule: "pick every-other tower" and the demonstrators gained a high proficiency in this task based only on trial-and-error learning. This simple rule was even more-easily learned by observers after observing the already-expert demonstrators. Additionally, the demonstrator rats from Phillips (2013) were not nearly as proficient as those in the current experiment by the end of Phase 1. It is possible that the demonstrators were not proficient enough for their performance to be sufficiently informative for the observers. If the observers do not perceive the demonstration as informative, they could not easily imitate the behaviour.

Although Phillips (2013) claimed to have used a complex patterned task, it has become clear that the rats were displaying location learning as the tower configurations were not able to be explained by a regular rule. As her configuration could not be explained by a simple rule and the current study used a pattern that could be described by a simple rule, no study has examined a pattern with a more-complex, but still relatively-simple rule. A more complex pattern configuration such as: five baited towers forming a pentagonal shape might determine whether task complexity moderates the effects of imitative learning. It could be the case that observers profit less from a demonstration when the pattern is more complex.

To ensure the rats were displaying patterned learning and not location learning in the current experiment, the observer and demonstrator in each pair were given the opposite bait configuration such that the baited towers for the demonstrators were the sham-baited towers for the observers. If the observers had been displaying location learning, it is expected that they would have performed significantly worse, not better, than the demonstrators. Although opposing configurations for demonstrator-observer pairs eliminates the possibility of location learning, it is possible that the observers used odor cues from the footsteps of the demonstrators

to determine which towers were baited. As the observers foraged immediately after their assigned demonstrator, they could have been following the trail of the demonstrators and avoiding the towers their demonstrators accessed. However, in order for this to occur, the observers would have to recognize that their configuration differed from that of their demonstrator and then use that information accordingly. Recognizing the different configurations would likely be a time-consuming process and therefore, it might be expected that significant performance differences between observers and demonstrators would not be found until the second or third trial blocks. The performance differences in the current study occurred in the first and all subsequent trial blocks. These results indicate that the imitative learning was likely not due to scent or trail cues. Additionally, demonstrators and observers had alternate bait configurations; therefore, there would be a trail leading to each tower following the first demonstrator-observer pair. As the pairs were not cage mates, it would make it extremely difficult, if not impossible, for the observers to identify and follow the trail of their own demonstrators.

It is unclear whether the demonstration was effective due to an increase in motivation or because the demonstration was informative. As there was no rat present before the demonstrators foraged in Phase 1, only the observers saw another rat in the arena prior to their own opportunity to forage. The observers could have viewed the demonstrators as competition for the food within the arena therefore, increasing the observers' attention to the food locations during their own foraging opportunity. Competition could also lead to a desire for foraging efficiency to ensure that the observer obtained all baits before the competitor returned to forage. However, this question might be answered by the results from Buck (2012), who used a 24-hour delay in a cue learning task to determine whether the results of Keshen (2011) were due to the presence of

competition or imitative learning. Their findings suggest the latter is the case for a cue-learning task. If the pattern learning process is similar to that of cue learning, the results of the current study should be attributed to imitative learning rather than the increased attention or desire for efficiency that could derive from competition.

Previous literature has demonstrated the presence of imitative learning within familiar and unfamiliar conspecific animals. Kinnaman (1902) found that rhesus monkeys (*Macacus mulattus*), could learn to manipulate latches by watching a familiar, conspecific demonstrator. The results from Keshen (2011) indicated that rats perform better on a cue learning tasks when the demonstrator is an unfamiliar rat instead of a familiar rat. However, a follow up study with a 24-hour observation-execution delay by Buck (2012) did not replicate this familiarity effect. Therefore, there are mixed familiarity results within the imitative literature. As Buck (2012) did not replicate the findings of Kehsen (2011) and the current study used a pattern-learning task rather than a cue-learning task, it is unclear whether a familiarity effect would have been found if unfamiliar demonstrator-observer pairs had been added to the study. It is possible that, similar to the familiarity effect found by Keshen (2011), observers might not perform as well on the pattern task when their demonstrator was familiar to them.

The results of the current study are consistent with previous imitative learning literature. It is evident that rat observers outperform demonstrators in various foraging tasks (Keshen, 2011; Phillips, 2013) however, it is not evident why this occurs. It is possible that learning by observation facilitates and accelerates the same learning processes found in trial-and-error learning or that imitative learning and trial and error learning are two qualitatively different processes. Perhaps different brain regions are activated during trial and error and imitative learning resulting in performance differences. As more support for imitative learning in animals

such as rats has become prevalent, future research should focus on determining why imitative learning is more effective than trial-and-error learning. This could be achieved by examining which brain regions are activated during both trial and error and imitative learning. The brain activation could be compared to determine if and how the brain activation differs.

Overall, imitative learning forging tasks have more ecological validity than those involving imitative learning in an operant chamber. Rearing and foraging are natural processes that are found in rat behaviour whereas pressing a leaver for food is not. However, pattern foraging likely has less ecological validity than the cue learning reported by Keshen (2011) and Buck (2012). Using visual cues to determine the location of food is more likely to occur in their natural environment than a pattern of food presence without visual cues. Similar to imitative learning in operant chambers, the results of the current study indicate that imitative learning can be present for tasks that would not typically occur in the natural environment of rats. Perhaps rats are capable of learning other complex tasks unnatural to them and therefore, would be capable of evolving their knowledge beyond what is innate to them. Therefore, their learning potential could be greater than previously anticipated.

Future research should further examine imitative learning for patterned tasks to help determine if demonstrator-observer familiarity or pattern difficulty would influence the demonstrator-observer performance relationship. Mixed results have been found within the imitative learning literature as to whether familiar or unfamiliar demonstrators are more effective or if they have an effect at all. As the current study has established that imitative learning can occur for patterned tasks, patterns with varying levels of difficulty should be compared within a single study. Each of these different patterns should be explained by a rule and towers should not be baited at random as in Phillips (2013). This would allow researchers to determine if rats are

capable of learning complex patterns and whether imitative learning accelerates this process. Future research should also be conducted to determine whether imitative learning is an accelerated, quantitatively superior process than that of trial-and-error learning or if the processes are qualitatively different. Temporal brain imaging techniques could be used to measure brain activation for both imitative and trial and error learning. Determining whether imitative learning is qualitatively or quantitatively superior to trial and error learning would allow researchers to gain a better understanding of the mechanisms behind imitative learning.

In conclusion, the current study adds to the research supporting Kinnaman's notion that non-human animals are capable of imitative learning while adding patterned tasks to the list of domains it can be found in. Although the findings of the current experiment suggest that imitative learning can be found when learning a patterned task, it remains unclear whether the differences seen in imitative and trial and error learning are of a qualitative or quantitative nature. Further research examining why and how imitative learning occurs should be done to truly understand the fundamentals of imitative learning.

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Appendix I

**Table 1**

*Raw Data for Demonstrator performance over 70 trials in 5-trial blocks.*

| Demonstrator | DR2 | DR3 | DR5 | DR8 |
|---|---|---|---|---|
| Block 1 | 53.3 | 43.3 | 53.3 | 46.7 |
| Block 2 | 53.3 | 56.7 | 60.0 | 60.0 |
| Block 3 | 56.7 | 63.3 | 56.7 | 60.0 |
| Block 4 | 63.3 | 63.3 | 66.7 | 63.3 |
| Block 5 | 66.7 | 56.7 | 63.3 | 66.7 |
| Block 6 | 86.7 | 60.0 | 83.3 | 66.7 |
| Block 7 | 76.7 | 70.0 | 90.0 | 60.0 |
| Block 8 | 76.7 | 63.3 | 80.0 | 83.3 |
| Block 9 | 90.0 | 80.0 | 96.7 | 93.3 |
| Block 10 | 93.3 | 90.0 | 96.7 | 93.3 |
| Block 11 | 93.3 | 90.0 | 93.3 | 93.3 |
| Block 12 | 93.3 | 90.0 | 96.7 | 93.3 |
| Block 13 | 96.7 | 93.3 | 93.3 | 93.3 |
| Block 14 | 93.3 | 93.3 | 96.7 | 96.7 |

**Table 2**

*Raw Data for Observer performance over 20 trials in 5-trial blocks.*

| Observer | OR1 | OR4 | OR6 | OR7 |
|----------|------|------|------|------|
| Block 1 | 53.3 | 56.7 | 56.7 | 53.3 |
| Block 2 | 60.0 | 63.3 | 66.7 | 63.3 |
| Block 3 | 70.0 | 73.3 | 73.3 | 70.0 |
| Block 4 | 76.7 | 80.0 | 80.0 | 76.7 |

Curriculum Vitae

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