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Observational Pattern Learning In Rats

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OBSERVATIONAL PATTERN LEARNING IN RATS

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Abstract

Previous research has shown that rats can profit from watching an expert demonstrator preform a simple foraging task. The purpose of the present experiment was to examine whether observing a skilled rat perform a difficult foraging task could influence performance by the observer. The present research also examined whether familiarity with the demonstrator would have an effect on imitation. In this experiment, the testing arena contained 12 towers arranged in a circle with six of them baited. The cues to finding the bait were three different and distinctive wall posters and the pattern of the baited towers. Twelve rats were randomly assigned to be either a demonstrator or an observer. In the first phase of the experiment, the six demonstrator rats were exposed to the task over 50 trials to become skilled demonstrators. In the second phase the observer rats were placed inside the arena with an opportunity to observe the demonstrators perform and then had the opportunity to perform the task themselves. Results revealed that both the demonstrators and observers performed equally over their first 20 trials. Thus, no imitation effects or familiarity effects were found.

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Introduction

The question of whether non-human animals exhibit imitative learning has attracted a considerable amount of research attention over the last century. Imitative learning laboratory experiments have been conducted in the hope of demonstrating vicarious learning in animals. Researchers have been interested in how transmission of knowledge or skills happens. True imitation has been defined as "the copying of a novel or otherwise improbable act or utterance, or some act for which there is clearly no instructive tendency" (Thorpe, 1963, p. 135). Whether animals show true imitation has been very controversial in the literature over the last century. Imitation learning implies the ability to take the perspective of another, which many researchers argue that animals are not capable of. Many experiments conducted since the earlier part of the 20th century have failed to produce convincing and replicated results of imitation learning, partly as a result of not being able to control for other types of learning as well as difficulty in creating adequate experimental designs (Galef, Manzig, & Field, 1986). As a result, imitation learning has become a phenomenon that many researchers have continued to study.

It is commonly assumed that there are survival and adaptive advantages for imitative learning in conspecifics, and it plays a role in such things such as learning to eat, communication, and predatory avoidance (Zentall & Galef, 1988). There is, however, also evidence that imitative learning is possible across two different species. Tayler and Saayman (1973) observed interactions between two Bottlenose Dolphin Cows (*Tursiops aduncus*) and one Cape Fur Seal (*Arctocephalus pusillus*) who were housed together over a two-year period. Over the first few months, the dolphins ignored the seal but then Haig, one of the dolphins, began to take interest in Tommy the seal. Over the next two years, researchers observed Haig start to replicate postures, movements, and sounds similar to Tommy during activities such as swimming, sleeping, and grooming. For example, Haig the dolphin replicated movements while grooming himself that Tommy the seal had exhibited, and Haig also started to adopt postures resembling those of a sleeping Cape Fur seal. Haig sometimes performed these movements while Tommy was engaging in them, yet at times, Haig also replicated these movements in the absence of Tommy. The ineffective outcome of these movements and the clumsiness of Haig in sufficiently exhibiting these movements emphasized how unnatural these movements were for a dolphin. These results reveal the remarkable abilities of bottlenose dolphins to imitate behaviour, and show that it is possible to demonstrate imitative behaviour across two different species. It was even more remarkable that Haig the dolphin continued to replicate Tommy's behaviour in the absence of Tommy performing the movements, especially given that no reinforcement was provided to encourage these behaviours. These results led researchers to conclude that an original stimulus does not need to be present to elicit imitative behaviour and that it is possible for a species to learn a new behaviour through observation that is not only unfamiliar to the organism, but also uncharacteristic of that species.

Previous research has investigated what part of conspecifics' behaviour animals attend to and whether they can extend that knowledge beyond specific contexts. It has been well documented that a wide range of species such as dolphins (Tayler & Saayman, 1973), pigeons (*Columbia livia*) (Zentall & Galef, 1988), and kittens (*Felis catus*) (Chesler, 1969) have been known to show imitative learning, but mixed results have been presented as to whether monkeys show true imitation. Voelkl and Huber (2000) conducted an experiment to answer this question. They permitted observer monkeys to watch a demonstrator display one of two techniques, and then observed what technique that observer used when allowed to behave themselves. Thirty-six adult marmosets (*Callithrix jacchus*) were used in this experiment, from which two groups were formed: Group 'mouth'; and Group 'hand'. Two marmosets served as demonstrators and 23 marmosets were used as control subjects. The apparatus consisted of a wooden board with five black film canisters, each one having a mealworm in it to serve as the reinforcement. In a pre-test phase, researchers observed only one marmoset (named BI) open the film canisters with her mouth, so she served as the Group 'mouth's' demonstrator. Six training sessions were conducted to ensure that Demonstrator BI opened the film canisters exclusively with her mouth. In the observation phase, six observers watched Demonstrator BI take off all the film canister lids with her mouth and access the food. Also in the pre-testing phase, when given the chance to explore with the apparatus and film canisters, marmoset GR spontaneously used his hands to open the canisters and access the food. As a result, marmoset (GR) was used for Group 'hand'. Seven training sessions were conducted to ensure that marmoset GR would only use his hands to open the canisters. The observation phase ran for five sessions during which observers watched from an adjoining mesh cage. Immediately after the fifth observation session, observers were tested individually for two test sessions. Results revealed that the marmoset observers who had watched BI (Demonstrator 'mouth') open the lids, themselves removed the canister lids almost exclusively with their mouths. Likewise the marmosets that watched demonstrator GR (Demonstrator 'hand') remove the lids with his hands, when given the opportunity to remove the lids themselves, never used their mouths and only used their hands. The researchers made the task harder by firmly securing the lid on the canister making it so the only way for the marmosets to access the mealworm would be to use the strength of their mouths. Even under these circumstances Group 'hand' never used their mouths and continued to exclusively use their hands to open the canisters. Two control groups of marmosets were also created: one group controlled for olfactory cues of the task; and the other group controlled for spontaneous learning.

Given that the ‘hand’ and ‘mouth’ demonstrators used different techniques, and that the observers replicated this behaviour even though there were multiple methods that might have been used to get to the reinforcement suggests that the marmosets are capable of imitative learning.

Whiten, Custance, Gomez, Teixidor and Bard (1996) wanted to expand previous literature on animal imitative learning from just encouraging an organism to imitate a behaviour, to investigating what exactly the observers were “taking in” and using at subsequent time points. Whiten et al. conducted an experiment comparing imitative learning in children (*Homo sapiens*) and chimpanzees (*Pan troglodytes*). Twenty-four children, with ages ranging from 2-4 years old, and eight chimpanzees with a mean age of 4.5 years old were used in this experiment. The apparatus used consisted of a clear plastic box firmly screwed to a board with a hinged lid on the top. The food reinforcement inside the box was always visible to children and chimpanzees and consisted of sweets for the children, and strawberries, plums and mangos for the chimpanzees. Before the lid could be opened in order to retrieve the food, two latching devices had to be dealt with. The bolt latch could be opened by using two techniques: the poke technique; or the twist technique. The barrel latch had two parts that had to be manipulated in order to open the lid and both parts permitted the use of alternative techniques. Part one of the barrel latch, ‘the pin’, could be opened with the turn technique or the spin technique. Part two, ‘the handle’, could be opened with the turn technique or the pull technique. Each subject underwent two test sessions, each consisting of four trials. In the first session, the barrel latch was demonstrated, and in the second session, the bolt latch was demonstrated, or vice versa. Human demonstrators opened the box using one of the techniques for the observers depending on the subject’s experimental condition. During each trial, the adult human demonstrator used a given technique to obtain the food. The box was reconstructed out of sight and then the subject was given 2 minutes to open the box. After the subject retrieved the food, the box was reconstructed and the demonstration began again. Results revealed that both children and chimpanzees are capable of imitative learning. Chimpanzees were more likely to first try the technique that the demonstrator modelled and then, secondarily, try methods of their own. Children were more likely to follow the exact steps that the demonstrator had made, even when the steps had no functional significance towards the outcome. For example, the demonstrators turned the pin and the bolt 16 times even though it was not necessary to get to the food reinforcement. The children imitated this response and turned the pin and the bolt at least 16 times, and up to 161 times, even after they discovered they could pull out the pin and the bolt with no turns and still gain access to the food. The chimpanzees learned faster than the children that the pin and bolt spinning was not a necessary action and omitted it. Even though imitative responses were less evident in the chimpanzees than the children, imitative learning still existed. The results of this experiment demonstrate that chimpanzees are capable of imitative learning.

As previously stated, many studies have shown that observation of a trained demonstrator can facilitate later response imitation. At the same time, what these studies have failed to show is that animals are learning about a response-reinforcer contingency through observation. Researchers have proposed that the imitative response can be explained by two alternative explanations. One alternative is a concept that Thorpe (1956) called ‘local enhancement’, which simply means that the imitative response is facilitated by the demonstrator’s mere presence near the manipulandum which may increase attention paid toward it. The second alternative explanation of imitative behaviour is ‘stimulus enhancement’, in which the observer focuses its attention on the lever or manipulandum because of the demonstrator’s activity. Stimulus enhancement is also known to play a role in imitation discrimination tasks (Edwards, Hogan, & Zentall, 1980). Heyes and Dawson (1990) designed an experiment to minimize any effects of local enhancement and stimulus enhancement on imitation learning. Sixteen male hooded Lister rats were used, eight randomly assigned to be demonstrators, and eight randomly assigned to be observers. The apparatus was a rectangle box divided into two compartments, one with a suspended joystick and illuminated food tray where the demonstrator performed, and the other compartment a featureless “room” from which observers watched. During demonstrator testing, half the demonstrators were trained to push the joystick to the left, and half were trained to push the joystick to the right. Demonstrator training was terminated after five sessions of the demonstrators successfully pushing the joystick in the correct direction 50 times. During observation training, observers were placed in the featureless compartment and demonstrators were placed in the compartment with the joystick. Demonstrators were removed when they had pushed the joystick either to the left (Group left) or to the right (Group right) and had received 30 food pellets. During the acquisition phase, the observer rats were placed immediately in the demonstrator chamber after watching the demonstrator perform. In the acquisition phase, observers were reinforced for pushing the joystick to both the right or the left. In the test phase, observer rats were only reinforced when they pushed the joystick in the same direction as their demonstrator rat had done. Observer testing was terminated when the observer moved the joystick in the same direction as their demonstrator rat 25 times. Results revealed that rats that had watched their demonstrator push the joystick to the right for reinforcement made more joystick movements to the right than the rats who had watched their demonstrator push the joystick to the left. From this, researchers concluded that observers had learned to perform a particular response as a result of watching a demonstrator perform that specific response. These results provide evidence that rats are capable of learning a response through conspecific exposure and observation.

Zentall, Sutton and Sherburne (1996) also conducted an experiment under conditions that eliminated the possibility of local enhancement and stimulus enhancement to provide stronger evidence that animals are capable of imitative learning. Zentall et al. designed an experiment in which pigeons were exposed to one of two different response topographies that produced the same outcome. Each observer watched a demonstrator that was trained to either peck a treadle for a food reinforcement, or step on a treadle for a food reinforcement. Twenty-eight 5-8 year old white Carneaux pigeons were used; four were designated to be demonstrators, and 24 were designated to be observers. The apparatus consisted of two modular test chambers, one for the demonstrator to perform in, and one for the observer to watch from. The response panel contained a lever and a treadle and a wall mounted feeder that provided 2 s access to grain when activated. The observer chamber was bare. Two of the demonstrators were trained to peck on the treadle for reinforcement, and two demonstrators were trained to step on the treadle for reinforcement. Demonstrator training was complete when the pigeon made only the response it was trained to make and made no alternative responses for a minimum of 50 responses in a row. Each observer was randomly assigned to a demonstrator and was exposed to it while it was performing for a total of 15 minutes. Immediately after observation training, the demonstrator was removed and observation testing began. The observer pigeon was placed in the demonstrator‘s chamber for 30 minutes. During observation testing, both responses (stepping or pecking) gave the pigeons access to the food. Observer pigeons showed a significant tendency to imitate the response that their trained demonstrator had exhibited. The results provided clear evidence that pigeons are capable of imitation learning.

Researchers in the field of research of imitative and observation learning have sought to investigate the mechanisms that underlie the ability to imitate. Chesler (1969) focused on the role of the demonstrator as a reason for imitation to see if demonstrator characteristics would play a role in how kittens (*Felis catus*) imitated. The aim of the experiment was to determine if speed and efficiency of observation learning would be improved by the use of a mother cat as demonstrator, as opposed to a stranger cat. Eighteen kittens between 9-10 weeks old observed either an unfamiliar cat, or their mother, press a lever for a food reinforcement. The cage consisted of a compartment for the demonstrator with a lever and a dipper that dispensed liquid food, and a compartment for the kitten to observe from. Kittens were divided into one of three experimental conditions: kittens who observed their mothers performance; kittens who observed a strange female cat perform; and kittens who were not exposed to a demonstrator and had to learn the task through trial and error. Five female demonstrators: three mothers and two strangers were used. Consistent with previous studies, Chesler found that watching a demonstrator perform the lever-pressing action significantly improved acquisition of learning. Chesler also found that kittens that watched their mother acquired the lever-pressing response more rapidly than kittens that observed a stranger cat. Additionally, the kittens that did not undergo observation training never learned to press the lever at all. In all the conditions, the kittens had no previous exposure to lever pressing prior to the experiment, and as such, researchers theorized that the enhanced acquisition of learning was due to a social or affective bond between mother cat and kitten. The results obtained could also suggest that the attention of the kittens to their own mother might also have played a role in the enhanced learning.

Galef and Whiskin (2008) conducted a series of experiments examining the relationship between demonstrators' and observers' performance, specifically whether the demonstrator was familiar-kin or unfamiliar non-kin to the observer. Galef and Whiskin hypothesized, based on previous literature, that Norway rats (*Rattus norvegicus*) would be more likely to learn to prefer a food from a familiar rat, rather than from an unfamiliar rat. Rats were housed in littermate trios that consisted of a demonstrator, a familiar-kin observer, and an unfamiliar-nonkin observer. Experiments took place in stainless-steel hanging cages with food presented to the rats in semi-circular food dishes. Demonstrators were fed in these hanging cages and observers were fed in their home cages. In Experiment 1, half of the demonstrators were fed rat chow mixed with ground anise, and half were fed rat chow mixed with ground marjoram. Researchers then placed one observer and two demonstrators into a hanging cage for 30 minutes. One of the demonstrators was familiar-kin and one was unfamiliar-nonkin to the observer. Additionally, one of the demonstrators had just eaten diet anise and one had just eaten diet marjoram. At the end of the 30 minutes, the demonstrators were removed and the observer was offered two food cups, one food cup contained diet anise and one contained diet marjoram. This procedure was repeated with 16 other observers. Contrary to what the researchers expected, results revealed that the familiarity of the demonstrator had no effect on the food choice of the observer.

The second experiment conducted by Galef and Whiskin (2008) was very similar to Experiment 1, with the exception that all the demonstrators with which observers interacted were nonkin. Thirty rats were used in this experiment. Ten served as demonstrators, and 20 served as observers. Rats were again housed in trios consisting of one demonstrator and two observers. One of the observers was familiar-nonkin and one of the observers was unfamiliar-nonkin. Familiar observers were classified as familiar due the fact that they were housed in the same cage as the demonstrator. The unfamiliar observers were housed in a cage separate from their demonstrators and the first interaction they had with each other was during the experiment. The procedure was the same as Experiment 1. Observers showed a marginally significant tendency to prefer the food of their unfamiliar-nonkin demonstrator. However when researchers combined the data from Experiments 1 and 2, the marginally significant tendency to prefer the food of the unfamiliar demonstrator became significant.

A third experiment was carried out by Galef and Whiskin (2008) to determine if this familiarity effect was due to observers spending more time interacting with unfamiliar-nonkin demonstrators than with familiar non-kin demonstrators. Fifteen female rats served as observers, and 30 rats used in previous studies served as demonstrators. The experiment was conducted in a rectangle box with a central compartment that contained two additional end compartments. Researchers placed one observer in the central compartment, one familiar-nonkin demonstrator in one end compartment and one unfamiliar-nonkin demonstrator in the other end of the compartment. Diets of the demonstrator rats varied among the different trios but in each trio, the two demonstrators were always fed different diets. The two different diets of the demonstrators were either cinnamon flavoured rat chow or cocoa flavoured rat chow. Observer and demonstrator activity in the apparatus was video recorded for later scoring. After 30 minutes in the apparatus, the observer was removed and placed alone in a hanging cage and offered two food cups, one containing diet cinnamon, and one containing diet cocoa. Results revealed that during the 30 minutes of testing, observers spent more time closest to the unfamiliar-nonkin demonstrators compartment than to the familiar-kin demonstrators compartment. Similar to the results of Experiment 2, observers preferred the foods that their unfamiliar demonstrators had eaten. The findings from Galef and Whiskin offer an explanation as to why the demonstrator familiarity effect exists, however given the inconsistent results of Galef and Whiskin and Chesler (1969), it also suggests that future studies need to be done to confirm findings.

Saggerson and Honey (2006) continued this area of study by analyzing the nature of the demonstrator. Specifically, Saggerson and Honey were interested in seeing if familiarity of the demonstrator as defined in terms of strain would influence the likelihood or extent of the observer matching their behaviour. Saggerson and Honey looked at rats of the same strain versus rats of a different strain in an instrumental discrimination task. Dark Agouti (DA) and Hooded Lister (HL) were used in this experiment. Each strain was subdivided into DA demonstrators and DA observers, and HL demonstrators and HL observers. Both DA and HL demonstrators were trained to discriminate between a click and a tone by being reinforced during a chain pull during one sound stimulus (e.g. click) but not by the other sound stimulus (e.g. tone). Once demonstrators had acquired the skill to discriminate, the observer phase began. One group of DA and HL observers watched a demonstrator from the same strain, and one group of DA and HL observers watched a demonstrator from a different strain. During observation training, one demonstrator rat was placed in the demonstration chamber and one observer rat was placed in the observation chamber. Demonstrators were given the same procedure that they were given during demonstration training, while the observers watched. Immediately after the demonstrator rat performed it was removed from the chamber. Following a 2-minute delay, the observer was placed in the chamber. Observers received four presentations of the tone and the click in a randomized order for each test session. No reinforcers were presented during the observer test sessions. Results revealed that observers who watched a demonstrator of a different strain were more likely to exhibit demonstrator consistent behaviour compared to the rats that watched a rat of the same strain. This finding led researchers to conclude that rats are capable of imitative learning, and specifically that rats learned more from a rat of a different strain than from rats of their own strain.

The majority of previous research on imitative learning has been conducted in laboratory settings requiring animals to perform abilities that they would never have otherwise learned. Imitation has been thought of as an innate process and therefore should happen in an organism's natural world, which is what motivated Keshen (2011) to create an experiment to test whether imitative learning is possible in a more-naturalistic setting. Inspired by the work of Saggerson and Honey (2006), Keshen conducted an experiment to see if rats could learn where food is located in a foraging task better from watching an unfamiliar rat or a familiar rat. For this experiment, familiar rats were cagemates, whereas unfamiliar rats were non-cagemates. Rats were trained to forage for food in a circular arena with 12 towers arranged in a circle within the arena. Six of the towers had black and white stripes and were baited with cheese in a food cup at the top. It was not possible to see into theses cups without rearing up on the tower and looking in. The other six towers were completely white and contained inaccessible food to control for olfactory cues. The random locations of the two types of towers were changed from trial to trial, so the only way for the rats to find the food was to learn that the striped towers contained the bait. Rats were paired up as demonstrator and observer, and half the rat pairs were familiar (cagemates) and half the rats were unfamiliar (non-cagemates). In Phase 1, all demonstrator rats were trained to forage for the food and when they reached a 90 percent correct success rate, the observers were introduced. Observer rats watched their paired demonstrator rat perform from a circular mesh cage located in the centre of the arena. Following this observation, both rats were removed and the locations of the baited and sham baited towers were changed. During Phase 2, the observer rat was then placed back in the arena within 2 minutes of observation and allowed the opportunity to forage. Results revealed that over 20 trials, observer rats visited a higher percentage of the baited tower during their first six choices than had the demonstrator rats during their first 20 trials. It was also found that observer rats watching a non-cagemate outperformed the observer rats that watched a cagemate. It might be that rats learn better from rats that are unfamiliar to them because they are novel, and thus they pay more attention to them. The result of the increased interest and attention to the unfamiliar rat is likely what accounted for the increased performance.

Buck (2012) replicated the Keshen (2011) experiment with a longer delay between watching an expert demonstrator rat and performing in the arena. Buck sought to determine if the effects seen in Keshen's experiment resulted from learning, or from social facilitation. The same apparatus and the same procedure were used, with the only difference being that the observers had a 24-hour time delay between observation training (Phase 1) and observation testing (Phase 2). Results were partially replicated in that the observer rats did perform better after watching an expert than had the demonstrator rats during their initial trials; however, no significant difference in performance was found between rats who watched an unfamiliar rat compared to rats who watched a familiar rat. These findings suggest that the modelling effect was due to learning because it survived the 24-hour delay. On the other hand, the familiarity effect was likely not due to learning, because there was no performance difference regarding familiarity after 24 hours. Instead the familiarity effect might have resulted from social facilitation, which requires the presence, or at least the recent presence of another.

Phillips (2013) performed a follow-up experiment to that conducted by Keshen (2011), and Buck (2012) to examine if modelling could be successful in a less-simple task. Phillips set up a foraging task with 12 identical towers arranged in a circle. Six of the 12 towers were baited with cheese and the remaining six towers were sham baited with inaccessible cheese. The only cue to where the cheese was located was the pattern in which the towers were baited. The pattern for each rat (e.g., bait located at 1 o'clock, 3 o'clock, 6 o'clock, 7 o'clock, 9 o'clock and 11 o'clock) was randomly selected for each rat and remained the same throughout the entire experiment. In Phase 1, demonstrator rats were trained to forage for food in the arena. After 60 trials, demonstrator training was terminated because demonstrators were only performing at a 70 percent success rate and it did not appear that additional training was likely to improve performance. It was believed, based on the demonstrator trials, that this task was going to be difficult for all rats, so Phillips decided that all demonstrators would be unfamiliar to the observers to maximize the probability of obtaining a modelling effect. In Phase 2 of the experiment, observer rats were introduced into an observation cage which was a circular mesh cage located in the centre of the arena. In Phase 2, demonstrators were placed in the arena and given the opportunity to forage for the food. Once the demonstrator had found all the cheese, both rats were removed. In order to ensure that observer rats were not merely following the footprints of their demonstrator, the observer rats' opportunity to perform did not immediately follow the trial of the demonstrator, but instead was delayed until after the performance of two other different demonstrators who found the bait according to different patterns. Contrary to the previous findings of Keshen (2011) and Buck (2012), observing another rat complete the task had no effect on how well the observer rats performed. Over the 40 observer testing trials, observers' performance was only equivalent to that of the demonstrators. Phillips attributed the findings to being too cognitively difficult for the rats to be able to profit from observation. Cognitive load has been defined as the amount of mental resources required to make sense of a stimulus (Whelan, 2006). According to the cognitive load theory, learners are constrained by the limited capacity of working memory and selective attention, and there is an optimal level of stimulation in which learning can take place (Whelan, 2006). Processing demands may exceed cognitive capacity at which point there is cognitive overload (Mayer, Moreno, 2003). Buck (2013) theorized that the experiment demanded too high of a demand on the rats cognitive system therefore resulting in no learning taking place.

Cole (in preparation) conducted an experiment to analyze if rats could learn to forage for food in an arena with a less-random baiting pattern compared to that used by Phillips (2013), and with the addition of extra-maze cues. The six towers on one side of a circle of 12 towers (East or West) were baited, and wall-mounted posters were hung on three of the four walls. Whether the East or West towers were baited was different for different rats, but once assigned remained constant for each rat. Three walls had a different 2.0 m long by 0.5 m patterned posters. The poster on the west wall had black and white vertical lines; and the poster on the East wall had black and white horizontal lines. The poster on the North wall had black polka dots on a white background. The first trial of any session began with the researchers baiting half the towers on one side of the arena (East or West) and sham baiting the other six towers on the other side of the arena. Demonstrators were placed inside the observer cage for a total of 2 minutes, and then the observer cage was removed and the rat was given the opportunity to forage for the food. Once the demonstrator rat found the sixth baited tower, it was removed.

Following this, the three towers that had been previously baited during the trial that just finished became sham baited towers for the next trial and three towers that had been sham baited on the previous trial became baited towers. The other three previously baited towers remained as baited towers on the next trial and the other three previously sham baited towers remained sham baited. At the end of this switching, the six baited towers were placed on whichever side of the arena was designated for that rat (East or West) and the six sham baited towers were placed on the other side. This was done to ensure the demonstrators were not following the spoor of the last demonstrator. The second demonstrator rat was then placed in the observer cage for 2 minutes before being allowed the opportunity to forage. This alternating sequence was repeated for Demonstrator Rats 3 and 4, and 5 and 6. All demonstrator rats were trained for a total of 40 trials at the rate of two trials per day, five days a week. In Phase 2, the observer rats were introduced. The observer rat was placed inside the observation cage and the demonstrator was placed in the arena and allowed to forage for the food. After the demonstrator found the sixth baited tower, both rats were removed. The towers were re-baited and sham baited in the new correct locations on the North and South wall for Demonstrator Observer Pair Number 2. Following that, the East towers were baited and the West towers were sham baited and the first observer rat was returned to the arena and allowed to forage until the rat found the sixth baited tower. This sequence was repeated until all 12 rats had been tested. This phase was conducted for a total of 20 trials at the rate of two trials per day, five days a week. Results revealed that observer rats performed better than had the demonstrator rats performed during their first 20 training trials. A late-developing familiarity effect was found. In Trial Blocks 1 and 2, familiar observers did not perform significantly differently from unfamiliar observers. However in Trial Blocks 3 and 4, unfamiliar observers outperformed familiar observers.

The current experiment was designed to use a similar set-up as the previously cited foraging experiments to determine if rats are able to learn to forage in an arena where all towers look identical, and the only cues to finding the baited towers are the wall posters and the pattern in which the towers are baited. The pattern of baiting towers was randomly determined but once chosen remained the same for each rat throughout the entire experiment, as had been the case in the Phillips (2013) experiment. As well, the current experiment used the same wall posters on the East, West and North walls to serve as extra maze cues, as in the Cole (in preparation) experiment. As in previous studies, this experiment also looked at whether watching an expert demonstrator rat perform would have an effect on the observer rats' performance and whether watching an unfamiliar or familiar rat would have an effect on performance. It was hypothesized, based on evidence from the research carried out by Keshen (2011), Buck (2012) and Cole (in preparation), that watching an expert demonstrator perform the task would result in the observer learning the task better, and in a quicker fashion. As well, based on previous evidence from Keshen (2011) and Cole (in preparation), it is hypothesized that observers who watched an unfamiliar demonstrator rat would outperform observers watching a familiar demonstrator rat.

Method

Subject

The subjects were 12 male rats (*Rattus norvegicus*) of the Long-Evans strain, obtained from Charles River in Montreal, Quebec. The rats, on average, weighed 350 g on arrival and were fed ad lib. food and water for several days in order to establish a baseline free feeding weight. Using that weight, a redline weight of 90% of the free feeding weight was calculated, and the rats were fed on a restricted diet to maintain them at, or close to, their redline weight. Prior to the start of the current experiment, the rats' weights ranged between 550 g and 820 g. The rats were fed PROLAB RMH 3000 diet, manufactured by PMI Nutrition International (Brentwood, MO).

The rats were housed in pairs in a laboratory room at Huron University College in clear plastic breeding cages. The cage lids were constructed of stainless steel bars, and had a depression built in which held food and two standard water bottles. There were two short PCV pipes with an interior diameter of 10 cm located in the cage to provide environmental enrichment. The cage was lined 3.0 cm in depth with Beta Chips (sterile wood chip bedding) manufactured by NEPCO (Warrensburg NY). The bedding was changed once a week and the rats were fed daily and given ad lib. water.

The lights in the cage room were on a 12-hour light-on-light-off cycle. Testing was carried out during the light-off period. The air in the cage room was exchanged 26 times an hour with fresh air from outside to ensure good air quality. There was a radio tuned to CBC2 in the room for environmental enrichment, and it came on when the lights went off. The temperature in the cage room was maintained at 22°C.

Nine of the 12 rats used in the current experiment had previous experience in a series of conditioning procedures in an operant chamber. These rats were also exposed to an experiment to identify whether rats showed a preference for either visual landmark cues or geometric cues when locating food. In the experiment, the rats navigated through a matrix of towers, on top of which food cups were located. On non-probe trials, four baited towers were always arranged in a square within the matrix, and were always marked visually with horizontal stripes. On probe trials, only three, correctly positioned towers were baited and the one striped tower that failed to complete the square within the matrix was unbaited. Results suggested a preference for visual landmark cues. The three remaining rats had not been exposed to any previous training or experiments.

Apparatus

The apparatus was placed inside an experimental room that measured 2.6 m in width, and 2.8 m in length. A circular arena wall was made of Masonite® with a height of 40.6 cm and a diameter of 170 cm. The inside of the arena contained 12 identical food towers, each having a base that measured 10 cm X 10 cm and a height of 15 cm. The towers were arranged in a circle that was 1.38 m in diameter, measuring from the centre of the base of each tower. The centre of each tower was, thus, positioned 7.6 cm away from the outside wall. The towers were 31.8 cm apart, centre-to-centre. The towers were made of cedar and each was covered by a sleeve of white Bristol board, coated with packing tape for durability. On top of each tower was a cup constructed from a 35 mm film canister cut down to a height of 1.5 cm and with an interior diameter of 3.0 cm. Six of the 12 food towers were sham-baited towers, and each of the sham-baited food cups had a circular plastic disk perforated with nine holes inserted into it so that friction held it firmly in place. President's Choice Medium Cheddar Cheese® cut into 0.5 cm X 0.5 cm cubes was used as bait. The centre of the arena contained a round mesh cage made out of hardware cloth, which measured 53 cm in diameter and had a height of 47 cm. A garbage can lid measuring 50 cm in diameter and a 2.25 kg weight was placed on top of the mesh cage for extra weight to prevent the cage from being moved by the rat inside.

Three of the four experimental room walls displayed a 101.6 cm long by 39.4 cm high poster. The East wall held a poster that had four horizontal black and four horizontal white stripes alternately arranged, with all stripes being 5.0 cm wide. The West wall held a poster that had 11 vertical black stripes and 11 white stripes, with all stripes being 5.0 cm wide. The North wall held a poster with 48 black polka dots on a white background arranged in 4 rows of 12 dots. The polka dots were each 5.0 cm in diameter with their centres 8.2 cm apart. The bottom of each poster was hung 27.9 cm from the floor and thus, each poster could easily be seen by a rat from any position within the arena. Figure 1 shows the layout of the experimental room and apparatus.

Keshen (2011) created six baiting patterns in each of which, six towers were baited and six were sham baited using a random number generator from which three were randomly selected by Phillips (2013). The current experiment used the same three randomly selected

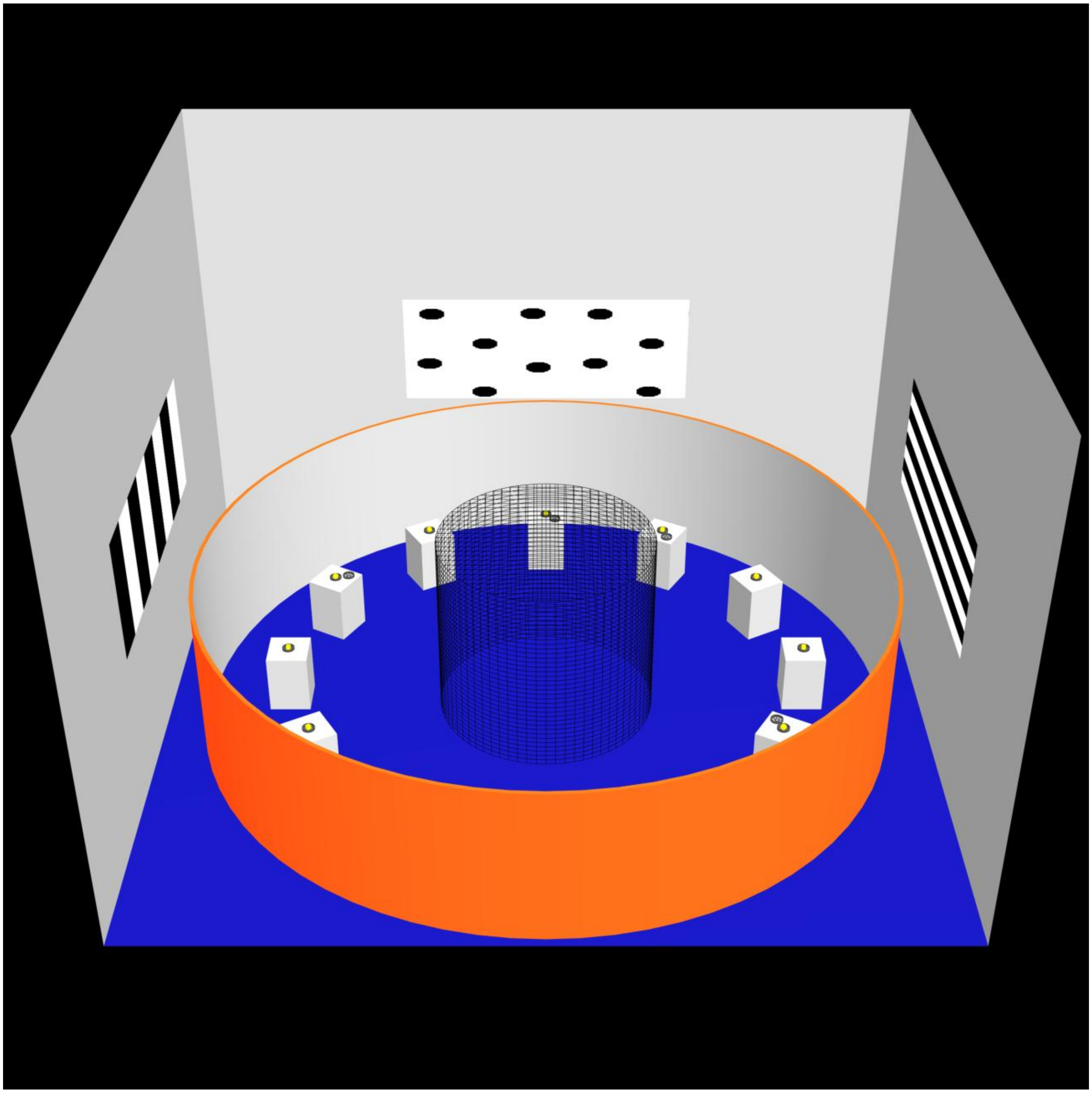

Figure 1. The layout of the experimental room and apparatus.

baiting patterns as Phillips. Figure 2 shows the three tower patterns selected for the current experiment.

Procedure

Pre-training. The rats were randomly assigned to be either a demonstrator or an observer. A demonstrator rats' role was to demonstrate how to find the cheese in the circle of identical towers while the observer rats role was to observe while the demonstrator completed the task. After these roles had been determined, the rats were assigned to a group: familiar or unfamiliar. In the familiar group, the rats were cagemates and were housed together in their home cages. In the unfamiliar group, the rats were strangers to each other as a result of being housed in separate home cages.

In the pre-training phase of the experiment, Rats 10, 11, and 12 were given little pieces of cheese in their home cages for several days before the start of the experiment to familiarize them with the cheese. Rats 10, 11, and 12 were then given exposure to the training towers to ensure that they knew how to rear up and access the food. The training towers they were exposed to ranged in size from 5.0 cm in height to the full size of 15 cm. Each tower had a food cup consisting of a 35 mm film canister cut down to the height of 1.5 mm, attached to the top, and contained a piece of cheese. The rats were placed in the arena with the four training towers for approximately 5 minutes. This procedure was repeated once per day for three consecutive days. At this time, each of the rats had successfully reared up and gained cheese from the full sized tower. Rats 1 through 9 had already become familiar with the cheese and the towers during a previous experiment, so they were omitted from this pre-training phase.

Phase 1. Prior to Phase 1, the six demonstrator rats were assigned to one of the three baiting patterns. The baiting pattern remained consistent for each rat throughout the entire. Each

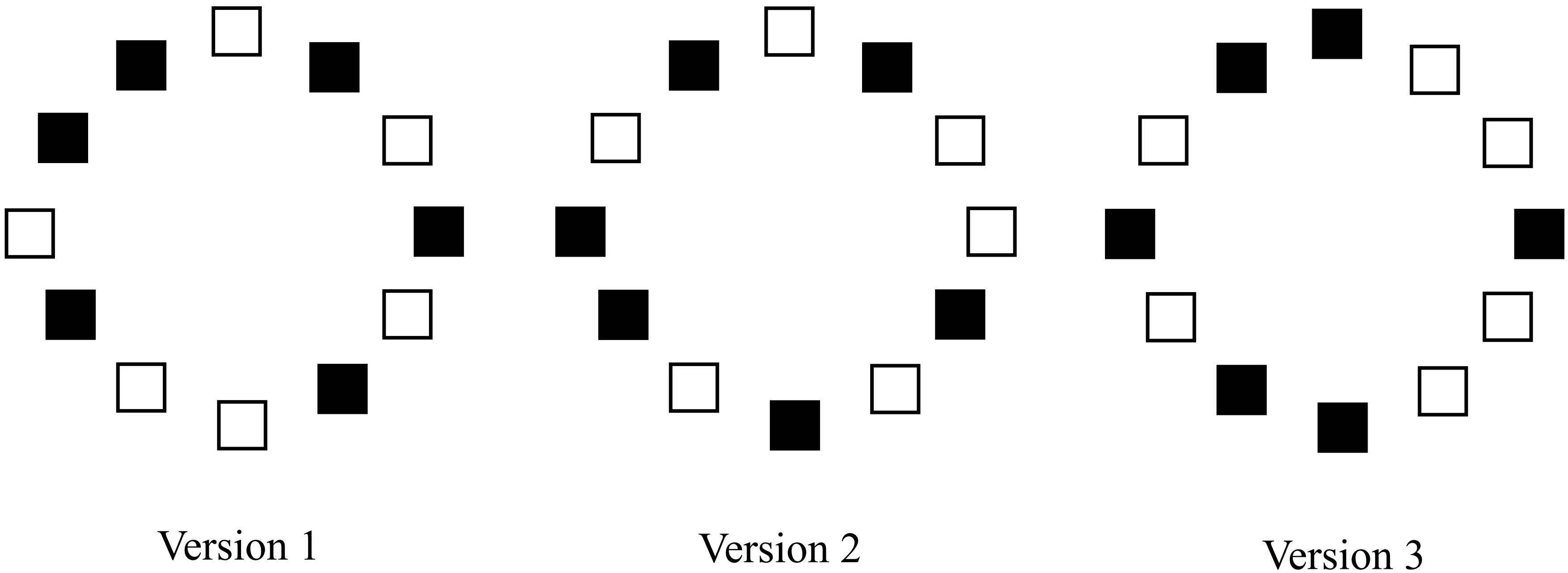

Figure 2. Three baiting patterns used. The black squares illustrate the baited towers; the white squares illustrate the sham-baited towers.

baiting pattern contained six baited towers and six sham-baited towers. At the start of a series of six trials, the researcher rubbed cheese inside all the film canisters to ensure that they all smelled of cheese. In the first phase of the experiment, a demonstrator rat was placed inside the small mesh cage located in the centre of the arena for approximately 2 minutes. After 2 minutes, the mesh cage was removed allowing the demonstrator the opportunity to forage for the cheese. The test room was closed and the researcher watched the rat from a small window. A tower was considered visited when the rat reared up on its back legs and put its nose into, or within 1 cm, of the food cup. The researcher recorded the visit as a correct choice only if it was its first visit to the baited tower. An immediate revisit to a baited tower was not counted as a revisit. But any revisit that was not immediate, counted as an incorrect choice. Once the rat had visited all six baited towers, the light was turned off indicating the end of the trial, and the rat was removed. The exception to this rule was that the rat was also removed from the arena if they had not visited all the baited towers within 5 minutes, or if it had made 36 visits and still had not visited all baited towers. In order to be able to complete the trials in one session, an upper limit was placed on the number of choices they could make or the amount of time they could spend in the apparatus. It was not necessary to impose this criterion beyond the first block of trials. Once the rat had completed the trial, the positions of the towers were rearranged into the next demonstrator's baiting pattern and special consideration was made so that three of the towers that had previously been baited became sham baited towers and three remained baited towers. This was done to ensure that the rats were not following the scent of previous rats and also to ensure that the towers themselves did not contain a baited scent. The procedure of placing the rat in the inner mesh cage and then giving them the opportunity to forage was repeated for each of the remaining five demonstrator rats. A total of 50 trials were completed for each demonstrator rat, by which time the mean percentage of correct choices in their first six choices was 68% and it did not seem likely that it was going to improve. The evidence for this will be presented in the results section. Each demonstrator underwent between zero and three trials per day. The minimum intertrial interval on days on which more than one trial was run was 30 minutes. All trials were run between the hours of 11:00 am and 6:00 pm.

Phase 2. In Phase 2, the observer rats were introduced to the foraging task. An observer rat was placed in the mesh cage in the middle of the arena, and its' paired demonstrator rat was placed in the main part of the arena giving the demonstrator the opportunity to forage for the food. After the demonstrator had reared up on all the baited towers, the light was shut off and the demonstrator rat and the observer rat were both removed. Both rats were placed in separate holding cages. This procedure was then repeated with another demonstrator-observer pair with a different baiting pattern. This was to ensure that the observer rats were not simply following the footsteps of their respective demonstrator rat. There was approximately a 4-minute gap between the observed watching its' paired demonstrator rat perform and the opportunity for in the observer rat to perform the task itself. Once the second observer had watched its respective demonstrator rat, the first observer rat was placed alone in the arena and given the opportunity to forage. The observer rat was removed when it had visited all baited towers or had made 36 choices or had spent 5 minutes in the apparatus. As in Phase 1, between each trial, three of the baited towers were switched to become sham-baited towers and three remained baited towers. This phase ran for a total of 20 trials. This procedure was done at the rate of one to two trials per day, seven days a week. The minimum intertrial interval on days on which more than one trial was run was one hour.

Results

The percentage of correct choices in the first six choices was recorded for each trial, for each demonstrator rat. These data were grouped into blocks of five trials for analysis as shown in Figure 3. The figure suggests that the performance increased over blocks of trials but that the two groups did not differ. For Phase 1, a 2 (demonstrator-familiar vs. demonstrator-unfamiliar) x 10 (blocks of trials) split plot ANOVA was conducted and results revealed a significant main effect of trial blocks $F(9, 36) = 5.18$, $p < .05$. As expected, the main effect of Group (demonstrator-familiar vs. demonstrator-unfamiliar) was not significant, nor was the Group x Blocks of Trials interaction. The raw data used for the split plot ANOVA can be viewed in Appendix 1, as Table 1.

Paired sample t-tests comparing mean performance between consecutive blocks of trials, collapsed over group were performed and revealed a significant performance difference between Block 1 (M = 43.9, SD = 4.9) and Block 2 (M = 55.57, SD = 10.25), with demonstrator rats performing significantly better in Block 2 than Block 1. A paired sample t-test also revealed a significant difference between Block 7 (M = 59.4, SD = 3.89) and Block 8 (M = 69.45, SD = 7. 98) with rats demonstrator performing significantly better in Block 8 than Block 7. No significance performance difference was found between Block 8 and Block 9 (M = 66.6, SD = 13.34) or Block 9 and Block 10 (M = 68, SD = 8.11) and therefore training was terminated. Raw data used for the paired samples t-test can be viewed in Appendix I, Table 1. None of the other paired-sample t-tests revealed a significant difference.

Ten single sample t-tests were performed to evaluate if the demonstrator rats were performing above chance level. Results revealed that the demonstrator rats were performing

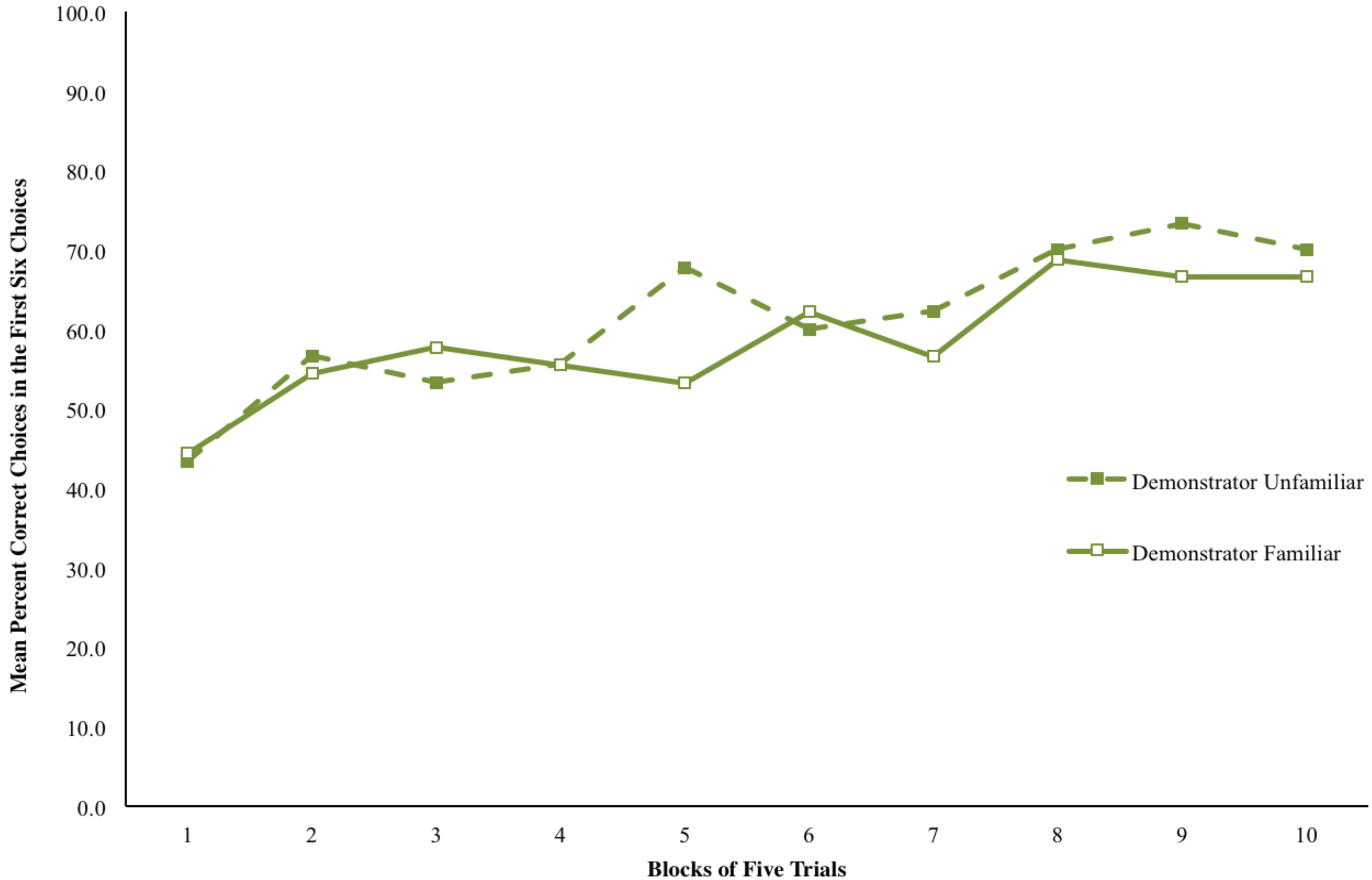

Figure 3. The mean correct choices in the first six choices over the first 50 trials for each group. The horizontal axis represents 10 blocks of five trials each.

significantly above chance level of 50% in the last 5 blocks. Refer to Appendix I, Table 1 to view raw data used for the one-sample t-tests.

During Phase 2, the percentage of correct choices in the first six choices was again recorded for each trial, for each observer rat. These data and the comparable data from the first 20 trials for the demonstrators were grouped into blocks of five for analysis as shown in Figure 4. The performance of both groups of rats: demonstrators and observers improved over the first 20 trials. However, the observers did not appear to outperform the demonstrators. A 2 (demonstrator vs. observer) x 2 (familiar vs. unfamiliar) x 4 (blocks of trials) ANOVA was conducted to determine if any of the apparent effects reached a level of significance. The results revealed that the overall performance improved over blocks of trials $F(3, 24) = 3.82$, $p < .05$. However, the main effect of observers vs. demonstrators was not significant, nor was the main effect of familiar vs. unfamiliar. No significant interaction effects were found. The raw data used for the split plot ANOVA can be viewed in Appendix 1, as Table 1 and Table 2.

Discussion

Previous research on imitative learning has shown that many species, such as dolphins (Zentall & Galef, 1988), marmosets (Voelkl and Huber, 2000), chimpanzees (Whiten et al., 1996), and pigeons (Zentall et al., 1996) are capable of imitative learning. It has also been found that rats are capable of imitative learning (Heyes & Dawson, 1990; Galef & Whiskin; Keshen, 2011; Buck 2012; Phillips; 2013; Cole (in preparation). The current study sought to determine if rats are able to learn to forage in an arena where all towers look identical, and the only cues to finding the baited towers were wall posters and the pattern in which the towers were baited. The results of the current experiment did not support previous research that rats are capable of imitative learning, and instead found that rats can only profit from observation when the

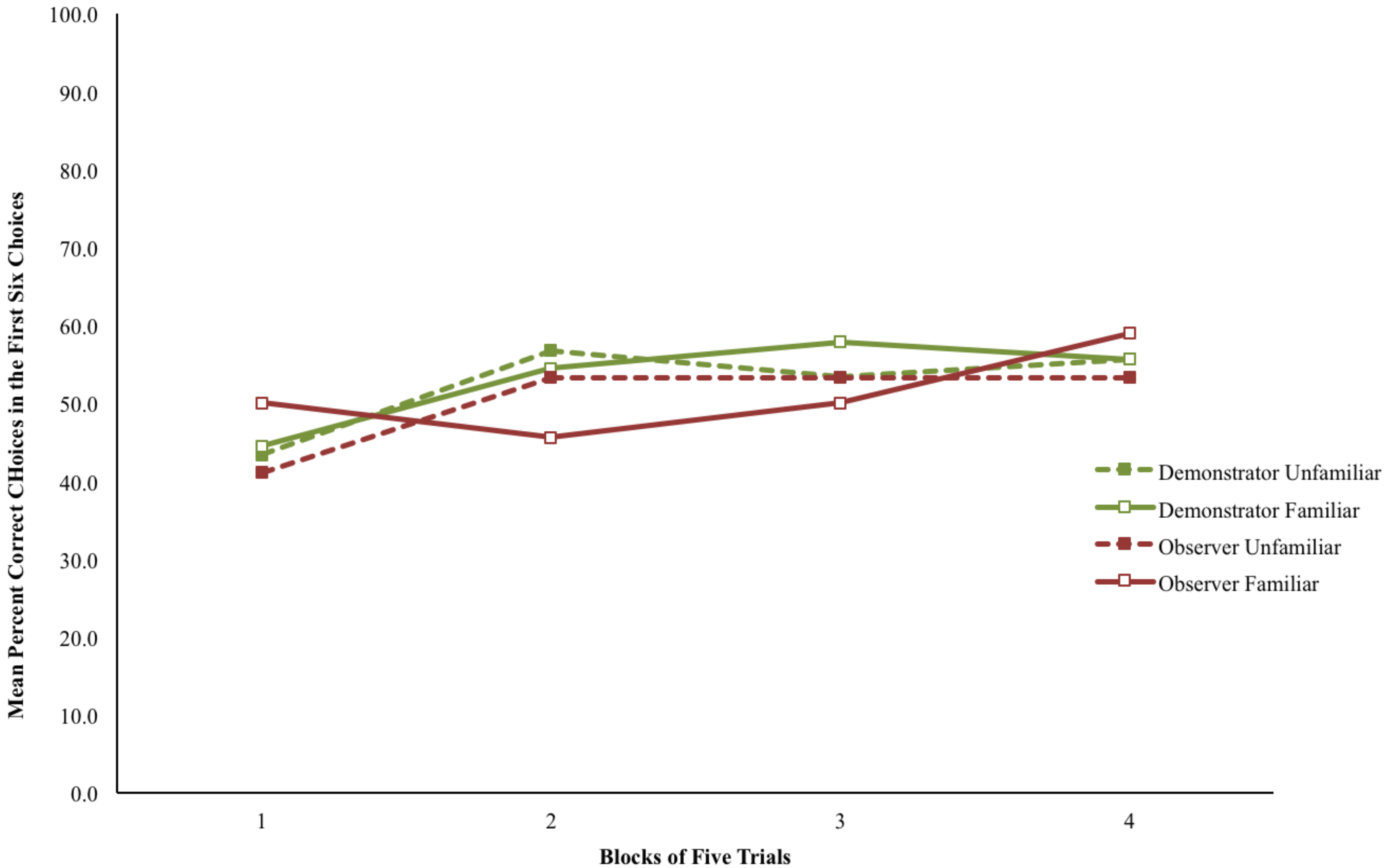

Figure 4. The mean correct percent choices in the first six choices. The horizontal axis represents four blocks of five trials each.

task demands a lower cognitive load.

Previous research on imitative learning has largely been conducted in quite artificial conditions. Keshen (2011) sought to determine if imitative learning with rats was also possible in a more naturalistic setting. Keshen found that not only were rats capable of imitative learning, but they also benefited from observing an unfamiliar rat more compared to observing a familiar rat. Buck (2012) replicated Keshen's experiment to determine if the results would be the same with a 24-hour time delay between watching the demonstrator perform, and attempting to perform the task themselves. Buck, like Keshen, found support for her hypothesis and found that observers learned the task faster than the demonstrators, however they did not find a difference in performance from observing a familiar demonstrator versus observing an unfamiliar demonstrator. Phillips (2013) conducted a follow up experiment to Keshen and Buck to examine if modelling could be successful in a less simple foraging task and found that observation did not facilitate learning. Cole (2013) conducted a study to analyze if rats could learn to forage for food in an arena with a regular baiting pattern, and with the addition of extra-maze cues and found that the observers out performed the demonstrators. Keshen, Buck and Cole designed a foraging task in which a simple rule allowed them to locate the bait. In all three experiments, the rats simply had to learn a simple rule such as "to pick the striped towers" or "bait is located on the right side." Phillips (2013) goal was to extend Keshen's and Buck's experiments and determine if rats could learn a less simple rule for locating the bait. The new rule to locating the bait was no longer a visual cue, but rather the pattern in which the towers were baited. Phillips found that visual observation did not facilitate learning when the task was made less simple. Given the previous research, the present study sought to determine if the reason why the observer rats did not outperform the demonstrator rats was because of insufficient extra-maze cues, or because the pattern was just too much of a cognitive load for the rats to handle with or without additional extra-maze cues. The current results suggest that the reason for the failure in the experiment reported by Phillips was that the task demanded too much in terms of cognitive load and not because of the absence of extra-maze cues in that experiment.

Previous research has focused on the role of the demonstrator to determine if demonstrator characteristics would play a role in imitation. Chesler (1969) found that kittens that observed their mother learned the task faster than the kittens that observed a stranger cat. Galef Whiskin (2008) and Saggerson and Honey (2006) also examined demonstrator characteristics and observational learning and found that rats can profit from observation, especially when the demonstrator is unfamiliar to the observer. Keshen (2011) and Cole (in preparation) found that rats that observed an unfamiliar rat out performed rats that observed a familiar rat. Not surprisingly, in the current experiment, because no observation effect was found, no familiarity effect was found either.

Phillips (2013) proposed that the 30-minute time delay between the observer rats watching the demonstrators and attempting the foraging task themselves might have had an impact on the observer rats’ performance. The current study eliminated this as a possible explanation for observer performance by lessening the time delay from 30 minutes to an average of 4 minutes. Although it would have been optimal to have the observer rat attempt the task themselves almost immediately after observation of the demonstrator, this would not have been possible due to the fact that if that had been the case the rat could have simply followed the demonstrator’s scent trials. In order to eliminate the possibility that the observer rat was simply following the spool of their demonstrator, the researcher rearranged the baiting pattern and had different demonstrator forage for the bait in between demonstrator and observer trials.

One limitation that should be considered as a possible explanation for why the observers did not outperform the demonstrators, is that the demonstrator rats did not reach the same level of expertise that they had in Keshen's (2011) or Buck's (2012) experiment. Although demonstrators in the present experiment completed 50 trials, they were performing, on average, only 68% correct during their first six choices by the end of Phase 1. In the previous experiments conducted by Keshen and Buck the demonstrator rats were performing at a minimum of 90% correct choice response within the first six, which was considered the point that the demonstrators become experts. In the present experiment, the rats were performing above chance level but not at an expert level. As such, the observers did not get to truly benefit from observation since the demonstrator rats were still making many errors.

For future replications, it would be interesting to increase the size of the bait. The demonstrator rats were not only quick to check a tower for bait, they were also quick to eat the bait. There were also many times when the observer rats were climbing up the wall of the inner observation cage, often on the opposite side of the arena to where the demonstrator was. Therefore there were many occasions that the observer rats had their backs to the demonstrator, or might not have been attending to the demonstrator rat. The fact that the demonstrator ate the bait so quickly and moved on, made it more likely the observer rat could have missed observing the demonstrator successfully locate the cheese. To eliminate this in the future, researchers could shorten the height of the inner mesh cage for the observer and increase the size of the bait. This would likely result in the observer rat having less distractions, and attend better to the demonstrator. Additionally, the increased bait size would likely cause the demonstrator rat to stay at the baited tower for a longer period of time.

Both the author of the current experiment and Phillips' (2013) came to the same conclusion: That the task was likely too cognitively difficult for the rats to benefit from observation. Future experimenters should consider simplifying the baiting pattern to have, for example, the baited towers be every other tower. This would allow the task to still be more cognitively difficult for the rats than what was used in Keshen (2011) and Buck (2012), but cognitively easier than what was used in Phillips' experiment and the current experiment. It would also be interesting to place the wall posters inside the arena, making the posters an even more salient location cue and see if this had an effect on observer performance.

In summary, the present study was a success in determining that the lack of imitative learning in the experiment by Phillips (2013) was not due to insufficient extra-maze cues, but rather was due to the task being too cognitively difficult. Future research needs to determine the point when the task becomes too difficult for observation to have a beneficial effect on learning.

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Appendix I

Table 1:

Raw Data for Demonstrator performance over 50 trials collapsed into 5 trials a block.

Demonstrator	DU4	DU5	DU11	DF1	DF8	DF8
Block 1	43.3	46.7	60.0	36.7	50.0	46.7
Block 2	46.7	63.3	53.3	40.0	56.7	66.7
Block 3	53.3	53.3	66.7	56.7	56.7	66.7
Block 4	53.3	46.7	66.7	50.0	56.7	66.7
Block 5	66.7	70.0	56.7	63.3	56.7	66.7
Block 6	63.3	60.0	60.0	56.7	56.7	66.7
Block 7	63.3	63.3	73.3	56.7	56.7	66.7
Block 8	56.7	80.0	76.7	66.7	56.7	66.7
Block 9	56.7	86.7	76.7	53.3	56.7	66.7
Block 10	66.7	70.0	73.3	76.7	56.7	66.7

Table 2

Raw Data for Observer performance over 20 trials collapsed into 5 trials a block.

Observer	OU12	OU3	OU6	OF2	OF7	OF10
Block 1	26.7	53.3	43.3	56.7	50.0	43.3
Block 2	50.0	53.3	56.7	43.3	46.7	46.7
Block 3	60.0	50.0	50.0	36.7	56.7	56.7
Block 4	60.0	40.0	60.0	43.3	70.0	63.3

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