THE NEAR-MISS EFFECT IN THE DOMESTIC HEN

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ABSTRACT

A near-miss in gambling is a loss situation which presents a similar stimulus to a win (e.g., two out of three reels that display an identical symbol on a pokie machine). The near-miss is thought by some to reinforce gambling behaviour, even though the outcome is still a loss. Some studies suggest that near-misses might function as conditioned reinforcers. To investigate a relationship between a near-miss event and conditioned reinforcement, six hens were exposed to concurrent VI schedules with two response keys. A response to one key provided a magazine light and food reinforcers in random order or food reinforcers only (the A1 key) while the other key provided food reinforcers only (the A2 key). From Conditions 2 to 4, the total reinforcer proportion was 2:1 for the A1 key: A2 key under VI 30-s VI 60-s schedule. From Conditions 5 to 10, the total reinforcer proportion (the proportion of food and conditioned reinforcers) was 4:1 under VI 25-s VI 100-s schedule. Response proportions and average responses were analysed in this study. The findings suggested that the subjects' response proportion and average responses on the A1 key were only significantly higher than on the A2 key when the A1 key provided more food reinforcers than the A2 key. There were two conditions which might indicate that the magazine light-stimulus might function as a conditioned reinforcer, however. In Condition 7, the hens' responses significantly increased from the previous identical condition (Condition 5). In Condition 10, Hens 71 and 72 increased the response proportion from the previous identical condition (Condition 8) while Hen 76 decreased the proportion. Further study is required to determine if the near-misses can reinforce a hen's behaviour.

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Chapter One: Introduction

Near-miss effect

The annual New Zealand Health Survey conducted by the Ministry of Health in 2012, indicated that the prevalence of respondents who were categorised as having some form of problem gambling behaviour was only 0.3%. On the other hand, 49% of the respondents were categorised as recreational gamblers. That such a large proportion of the population might be categorised as recreational gamblers has some potentially serious and negative implications. Skinner (1953) has previously noted that gambling activities can become highly addictive and these recreational gamblers could potentially become problem gamblers. According to Skinner, gambling activities involve a schedule of intermittent reinforcement and a near-miss event, and these two phenomena can reinforce gambling behaviour. Recently the phenomena of near misses has received increased attention from researchers trying to determine what role near misses play in the development of problem gambling (e.g., Clark et al., 2013; Kassinove & Schare, 2001).

A near-miss can be defined as when a person appears to have ‘almost won’ something while gambling. For example, two out of three reels that display an identical symbol on a pokie machine appear as close to win even though it is not different from any other loss situation. Reid (1986) stated that a near-miss is a type of failure which is close to being successful. According to him, the near-miss could be useful information to achieve a goal for a game of skill but it gives no information for a game of pure chance such as gambling. Nevertheless, a near-miss might encourage future gambling (Côté, Caron, Aubert, Desrochers, & Ladouceur, 2003; Dixon, MacLaren, Jarick, Fugelsang, & Harrigan, 2013; Dixon & Schreiber, 2004; Reid, 1986).

It is not known why the near-miss encourages gambling, but there are some studies which have investigated the effects of near-misses on gambling behaviour. In a study by Dixon, Nastally, Jackson, and Habib (2009), six of the 16 participants showed poor performance on deriving stimulus equivalence in a discrimination test using a simulated slot machine. Dixon et al. (2009) suggested that gamblers might have a problem associating a near-miss stimulus with a loss. Also, in a study by Dixon and Schreiber (2004), most participants reported that when two wining symbols were presented on either the left or right side in a pay line of a three-reel slot machine, an outcome of two consecutive winning symbols at either side was closer to a win than if those two symbols were split. Hence, the researchers suggested that the near-miss effect might be due to stimulus generalisation and may occur when the stimuli are presented close to each other.

Some researchers have discussed why the near-miss effect might be associated with a gambling problem and the following two reasons are presented in their papers. One reason for the problem behaviour is that the near-miss effect might enhance the gamblers' resistance to extinction. Côté et al. (2003) found that the experimental group, who was exposed to near-miss trials, played 33% more games on a video lottery terminal than the control group, who had no near-miss trials, when both of the groups did not have any winning trials and could quit playing at any time to exchange any credits they had for money. Another reason why the near-miss effect may contribute to problem gambling is that it may be aversive when the near-miss outcome is presented and consequently the players tend to spin the reels to avoid seeing the near-miss as suggested by Reid (1986) and Dixon et al. (2013). According to them, the aversion can make gamblers want to escape by spinning the reels again quickly, thus requiring them to place another bet.

Studies with animals have also shown that near-misses can influence animals' behaviour and that near-miss trials can affect the animals' behaviour the same as winning ones. Peters, Hunt, and Harper (2010) studied the near-miss effect with rats. They exposed the rats to chambers which had two retractable response levers. One was a "spin" lever which activated the next trial and the other was a "collect" lever which made a primary reinforcer available at a winning trial. There were five stimulus lights located above the levers. When a spin lever was retracted, according to an FR schedule, the lights were illuminated. In their first experiment, five illuminated lights at a time represented a big win (three dips of diluted sweetened condensed milk), four illuminated lights represented a small win (one dip of the milk) and a number less than that represented a loss (no reinforcement). Therefore, three illuminated lights were considered a near-miss trial. The researchers found that the proportion of the collect lever responses was significantly higher during the three illuminated light trials than during the other losing-trials. Winstanley, Cocker, and Rogers (2011) used a similar procedure with rats and confirmed that the proportion of the collect lever responses in near-miss trials, regardless of the absence of primary reinforcers on the near-miss trials as they were still losing-trials, was significantly larger than during the other losing-trials.

A key factor of the near-miss effect may be that stimuli associated with a win, come to act as conditioned reinforcers. Skinner (1953) commented that a near-miss on a pokie machine involves the effect of conditioned reinforcement. It is possible that gamblers may be reinforced without winning any money at all, because they are exposed to stimuli that are very similar to the symbol associated with a win. The data from the animal studies discussed previously, such as Peters et al. (2010), go some way to supporting this claim, as they have shown that the animals responded as if they had won when they were exposed to an identical winning stimuli (e.g., lights) even though they received no food reinforcers.

The conditioned reinforcer effect has been observed in an operant chamber with response keys. Zimmerman, Hanford, and Brown (1967) examined the value of conditioned reinforcers by changing the schedule of conditioned reinforcement. In their study, multiple types of stimuli were presented for 0.5 seconds simultaneously, in conjunction with a food reinforcer, and these stimuli were used as conditioned reinforcers. The pigeons experienced multiple two-component schedules. The first component was associated with either VI 1, 3, 6, 12-min or an extinction schedule of conditioned reinforcement (EXT). The second component was on VI 1-min schedule of conditioned reinforcement. The component alternated every 24 minutes. Concurrent with the component, food was available for the pigeons from a 3-min VI schedule. When the pigeons did not peck on the key for longer than 6-s, the food was presented to the pigeons. The results showed that their responses were maintained while the food reinforcers were provided when they did not respond to the key. Also the response rate for the first component was higher than the second component when the schedule in the first component was either VI 1, 3 or 6-min whereas when the VI 12-min or EXT was in effect during the first component the response rate was higher in the second component and especially in the EXT schedule, where the response rate was close to zero. The changes in response patterns were similar to the study of multiple VI VI schedules of primary reinforcement. Therefore, the results indicated that conditioned reinforcers could function as primary reinforcers.

According to Schwartz, Wasserman, and Robbins (2002), the behaviour of key-pecking can be explained by both Pavlovian (classical) conditioning and operant conditioning. Classical conditioning is a phenomena where a wide range of environmental stimuli, which previously had no effect on an organism's response, can elicit conditioned responses when those stimuli have been paired with unconditioned stimuli (Domjan, 2005). Thus, in an operant chamber, an illuminated response key can become a conditioned stimulus (CS) when it is presented with an unconditioned stimulus (US) such as food from a magazine, and by presenting those two stimuli, as one might on a conditioning trial, a pigeon can learn to peck the key to obtain food (eg., Schwartz, 1977). Operant conditioning, on the other hand, is an operation that requires a particular behaviour for an organism to gain a primary reinforcer. In the operation, a stimulus which is associated with the primary reinforcer can be established as a conditioned reinforcer and the conditioned reinforcer can also have the same effect of reinforcement as the primary reinforcer (Domjan, 2005). Therefore, when a pigeon in a chamber learns to peck an illuminated key for a food reinforcer, the illuminated key can become a conditioned reinforcer and this also functions to increase the probability of pecking the key again in the future.

Schwartz (1977) studied whether the key peck response was caused by classical or operant conditioning with pigeons. He assigned them to one of two groups after they were exposed to a continuous reinforcement procedure (CRF). One group was placed in a fixed-trial positive auto-maintenance condition and the other group was exposed to an omission condition. In the former condition, a response key was illuminated before the food hopper was raised and a response to the key did not affect the hopper's activation. In contrast, in the latter condition, when the pigeons responded to the key, the hopper was not activated. When the pigeons completed 14 sessions of either condition, they were exposed to the other condition for another 14 sessions and all of them were again placed in CRF for 14 sessions. The results indicated that the response durations were likely to be shorter at the omission and early in CRF condition, whereas the duration was longer for the auto-maintenance condition and late in the CRF one. The researchers suggested that their results were similar to the study conducted by Schwartz and Williams (1972). Both papers discussed that the short-duration pecks were insensitive to differential reinforcement and were similar to their normal feeding pattern, therefore those pecks could be under the control of classical conditioning, while longer duration pecks, which were sensitive to differential reinforcement, might be under the control of operant conditioning. Hence, the studies suggest that it might depend on how subjects are exposed to differential reinforcements as to whether pigeons' key-pecking behaviour may be under the control of operant conditioning or classical conditioning. It indicates that under a schedule of Variable Interval (VI) with a random presentation of primary reinforcers, an organism's behaviour might be under the control of operant conditioning.

A conditioned response requires a conditioned stimulus. Some studies have revealed that a visual stimulus can become a conditioned stimulus for avians, such as hens and pigeons (Moe et al., 2009; Newlin & LoLordo, 1976; Shahan, Podlesnik, & Jimenez-Gomez, 2006). For example, Moe et al. (2009) studied hens' anticipatory behaviour for food. The researchers defined this behaviour as the "duration of standing still or walking with slow steps, with legs, body and neck stretched upwards and eyes open, head sometimes moving up and down and kept at an angle, sometimes but not always directed at the light source and/or reward bowl" (p. 174). The results showed that a green light served as a CS and the CS functioned to increase the duration of the anticipatory behaviour.

The magazine light that is presented when a reinforcer is delivered may serve as a conditioned stimulus for pigeons. Stubbs and Galloway (1970) investigated how the magazine light might affect pigeons' responses in a discrimination task. The pigeons in the study were exposed to a discrimination task to peck the correct key (a right or left key) associated with the visual stimuli (a vertical or horizontal line) that they saw at the centre key. Under experimental conditions, a magazine light was lit when they pecked the correct key and 1 second of inter-trial interval (ITI) followed after an incorrect peck. Under control conditions, after both correct and incorrect responses, and a 1-s ITI followed. The pigeons were reinforced with food for correct responses under six different schedules of food reinforcement (VR 30, FI 90-s, FI 30-s, Differential Reinforcement of Long Latency (DRLL) 4-s, DRLL 8-s, FR 50). For example, in VR 30, a food reinforcer became available at every thirtieth correct response on average, while in DRLL 4-s they are only reinforced with food when they do not respond after four seconds. The response rates of the pigeons and their accuracy of correct choice responses under experimental conditions were higher. Therefore, the results of the study suggest that the magazine light can establish the correct response in a discrimination task.

It is possible that visual stimuli could become conditioned reinforcers for humans as well and, if so, those stimuli are likely to increase the probability of the behaviour of gamblers to bet more. For example, Dixon, Harrigan, Sandhu, Collins, and Fugelsang (2010) found that, when their participants had winning trials of less credits than the spin wager on multiple lines of slot machines, "losses disguised as wins" (p. 1819), despite losing credits, they showed similar skin conductance response-amplitudes to trials of winning more credits than the spin wager. The researchers discuss that both outcomes have the same reinforcing sound and sights accompanied with the winning spins, therefore the 'losses disguised as wins' are also arousal events which could contribute to problem gambling.

The characteristics of a conditioned stimulus have been discussed by McSweeney and Murphy (2014). They emphasise that conditioned reinforcers might not be formed by only reinforcing properties but might also include discriminative properties which signal a contingency of behaviour. The matter of whether a conditioned reinforcer has to include both discriminative and reinforcing properties has been investigated in past studies.

A study investigating the relationship of the discriminative and reinforcing functions of stimuli has shown that when two properties associate together, an organism's behaviour could be influenced sufficiently to function as a conditioned reinforcer (Webb & Nolan, 1953). The researchers trained rats to respond to black or white curtains, which were associated with a food reinforcer, in a discrimination device. After that, the rats' discrimination was tested using a T-maze. At the end of the T-arms were placed black and white goal boxes and food was only available at one of the two boxes. In this phase, those rats, which had been trained to respond to the black goal, were tested with the food reinforcer in the black box and the other half group was tested with the white food box. The other rats, which were previously trained to white curtains, were divided into two groups in the same way. The results indicated that the rats learned the correct response rapidly when the colour of discrimination training and the goals boxes were the same. Therefore, this experiment demonstrates that it is important for the organisms to learn behaviour that discriminative properties and reinforcing properties associate closely and this can make a conditioned reinforcer.

Conversely, the study by Kendall (1973) suggested that behaviour could be affected by a discriminative stimulus regardless of a reinforcer's strength. In his study, pigeons were exposed to positive and negative trials in a session that were presented in a random order within a session. In the positive trials, when the pigeons pecked a key six times (FR 6), the key would become illuminated in green. The 32-s trials were terminated with a presentation of food. Conversely, in the negative trials, the key was illuminated in red at the completion of FR6 and the trials were terminated with a timeout (a house light which was turned off without food presentation). Their responses did not affect the outcome of the trials (food or timeout), only the key illumination. Across conditions the probability of a positive trial was manipulated (25%, 50%, and 75%). The results showed that the pigeons' response rates were highest when the probability was 25% and lowest at 75%. Since the responses were not highest when the pigeons were exposed to the highest probability of a positive trial, it indicates that the reinforcing properties and discriminative stimulus properties might not be necessary to associate for making an organism's response.

Regardless of whether discriminative stimuli include reinforcing properties, they can serve as a cue to signal when certain behaviour may be reinforced or not. This is because an organism's behaviour is reinforced when particular stimuli are present but not necessarily when other stimuli are present. As a result, this creates a stimulus control in the organism when the stimuli signal the positive or negative consequences (McSweeney & Murphy, 2014).

The effect of stimulus control has been studied in animals for a long time. Eckerman (1969) investigated the effect in pigeons when exposed to positive and negative stimuli. The pigeons were exposed to two-component chain schedules. In the chamber there were three keys (S1, S2, and S3) and when they pecked the S1 key, either S2 or S3 became available to peck. The S2 and S3 keys were illuminated with different colours. The S2, positive stimulus, was associated with different probabilities of reinforcement depending on the group, while the S3, negative stimulus, was associated with no reinforcers. The results showed that the group of pigeons, which had the lower probability of reinforcement, tended to make more responses and respond in more trials on the negative stimulus. Hence, the study shows that the pigeon may be under stimulus control when the stimuli are associated with different probabilities of reinforcers.

Pigeons might also be under stimulus control when they are presented with two left and right side keys while one of them associates with reinforcers and the other does not. Watanabe (1999) investigated the effect of hippocampal lesions on discrimination performances in pigeons of two groups (hippocampal lesion group and sham lesion group). In the experiment, there were two left and right side keys to peck. One key was associated with food reinforcers and when the pigeons responded on the key, a food hopper presentation was followed after a termination of a key light. Conversely, when the other key was pecked, it terminated the key light but the food reinforcer did not follow. The results indicated that the subjects of the sham lesion group learned to peck the key with food reinforcers without pecking the other key in less than 20 sessions, while the subjects in the other group did not show discrimination of the stimuli. This study suggests that the pigeons without damage to the hippocampus might be able to discriminate the key location of left and right and respond accordingly to the reinforcer presentation. Hence, this study suggests that hens might also be able to discriminate a key from left or right location which allocates more reinforcers even when the key light of both keys is the same colour.

When an organism's behaviour is under stimulus control, they make choices based on the available options. Rachlin, Logue, Gibbon, and Frankel (1986) argued that every kind of human activity involves a choice, and this could be applied to gambling behaviour too. For example, people can choose gambling on a pokie machine or they can decide to not spend their money on the pokie machine, and those choices are supposed to be influenced by the reinforcement (or punishment) arranged for either gambling or not gambling. The choice, however, is often biased since, when the gamblers experience near-miss trials or 'losses disguised as wins' trials they tend to spend more money on pokie machines as previously discussed. Griffiths (1994) also found that regular gamblers tend to believe that winning on a slot machine depends on their skills, regardless of the fact that winning occurs by luck, and this might relate to their unreasonable choices.

Schwartz et al. (2002) argued that animals, like humans, have the ability to make decisions based on their available choices. Animals' choice behaviour is often studied with concurrent schedules because it is easier to see their behaviour when there is a different activity with a different outcome occurring simultaneously, instead of experimenting with only one available operant class. In fact, researchers study this topic and many papers have reported that a rate of primary reinforcers and secondary reinforcers can influence choice behaviour under concurrent and concurrent-chain schedules in pigeons (Fantino & Romanowich, 2007; Fantino, Squires, Delbruck, & Peterson, 1972; Mazur, 1995; Shahan et al., 2006). For example, Fantino et al. (1972) revealed that the pigeons' relative response rate of pecking a left key or right key matches with observed reinforcement rates of responding to those keys under concurrent schedules.

The idea of how the proportion of choice behaviour matches with rates of reinforcement is well described by the matching law (Herrnstein, 1961). Herrnstein observed pigeons' choice behaviour under concurrent schedules and found a couple of important aspects concerning the matching law. Firstly, when there was no change-over delay (COD), the pigeons swapped the keys frequently in order to gain reinforcers as often as possible. Therefore, it showed that the COD played an important role in maintaining the matching function. Secondly, when the COD was arranged under the schedules, there was a matching relationship between the relative rate of responses and the relative rate of reinforcers. It can be described in Equation 1:

$$B_1/(B_1+B_2) = R_1/(R_1+R_2) \qquad (1)$$

In Equation 1, 'B' represents 'Behaviour' (i.e. number of responses) and 'R' represents 'Number of reinforcements.' Hence, B_1 is the behaviour allocated to alternative 1 and R_1 is the reinforcer allocated to the alternative. Likewise, B_2 is the behaviour allocated to alternative 2 and R_2 is the reinforcer allocated to the alternative.

Although Herrnstein (1961) showed that the strict matching law fit well to the data obtained in his study, it has been argued that this does not fit perfectly to the data in some studies, and response proportions can deviate from reinforcer proportions due to undermatching, overmatching and bias. Undermatching is when a subject responds to the richer schedule less than expected from the differential proportion of reinforcers to the leaner schedule. Baum (1979) suggested that when the subject has longer pauses on the leaner schedule it can also contribute to undermatching in terms of time allocation. Conversely, overmatching is when the subject responds to the richer schedule more than expected. Bias is a constant preference for one alternative regardless of the difference of reinforcement proportions between available alternatives. The reason for the bias is unknown but it most likely occurs because of the subject's inherent preference to a particular stimulus (e.g. colours) or a particular setting in an apparatus (e.g., positions of the keys). When deviation occurs, the strict matching law does not provide a good description of the reinforcer and response relations because the data points do not show a slope of 1.0 (Baum, 1979; Poling, Edwards, Weeden, & Foster, 2011). Therefore, in those studies, which do not fit well in Herrnstein's matching law, the generalised matching law (GML) is often applied to study the relation between a reinforcer and response proportion:

$$\log(B_1/B_2) = \alpha \log(r_1/r_2) + \log k \qquad (2)$$

In Equation 2, α represents the slope of relative response allocation to two alternatives (B_1 and B_2) as a function of the relative number of reinforcers (r_1 and r_2). Log k represent the intercept (bias). As discussed previously, the GML can predict deviations from strict matching and more flexible to apply in various studies than Herrnstein's matching law. For example, Mattson, Hucks, Grace, and McLean (2010) used the GML to analyse sensitivity differences to the probability of reinforcers under different conditions in concurrent chain schedules. The subjects (pigeons) showed higher sensitivity to probability when they were in an un-signalled condition, which was with a continuous illumination of the house light during sessions regardless of the outcome of the terminal links (reinforcer or no reinforcer), than a signalled condition, which signalled the outcome of no reinforcer by a blackout or reinforcer by the flashing house light.

In some studies, concurrent schedules have been used to investigate the relationship between the relative rate of responses and conditioned reinforcers (e.g., Harris & Carpenter, 2011; Shahan et al., 2006). In Shahan et al. (2006)'s experiment, there were three response keys located in chambers. The keys that displayed a white light indicated a mixed schedule (VI 90-s and EXT). In the VI schedule, the three keys would change to green (S+) when only the right or left keys were pressed. The left and right keys were placed under a variety of concurrent VI schedules to establish different S+ delivery ratios (e.g., VI 100-s for the left key and VI 11.1-s for the right key to a ratio of 1:9). The subjects experienced each of the S+ ratios across the different conditions. There was another arithmetic-variable 90-s time schedule, ranging from 15-s to 165-s, for changing the food key schedule. If the change of the food key schedule occurred at the S+ schedule, the keys turned white and were placed into the EXT mixed schedule. Across these conditions the subjects obtained consistent overall rates of primary reinforcement (approx. 0.33 food reinforcers/min). Thus, it did not change the value of conditioned reinforcement. Nevertheless, the experiment revealed that the subject's response ratio was correlated with the S+ delivery ratio. In other words, the proportion of conditioned reinforcers was responsible for changes of response proportion. Similar results were found in Harris and Carpenter (2011). In their paper, rats were trained with the proportions of CS, followed by US (100%, 50%, 25%, 8%), and these were the independent variables and response rates which were dependent variables. The results indicated that the higher the proportion of CS, associated with US, the subjects tended to respond more. The researchers found that the response rates correlated with the different levels of conditioning strength, and these were described by a hyperbolic function.

In the present experiment the aim is to use concurrent schedules to investigate the effect of stimuli associated with food delivery on responding. If those stimuli function as conditioned reinforcers they should maintain higher rates of responding than would be maintained by food reinforcers on their own. When one key produces a conditioned reinforcer (a magazine light) during a session while the other key does not, the key with the conditioned reinforcer might be more preferred to the hens and thus would increase the rate of responses and change the proportion of responses to that key, like the near-miss effect. Therefore, it might be expected that the response proportions to the key where the magazine light is presented should increase in proportion with increased numbers of magazine light presentations.

Chapter Two: Method

Subjects

Six domestic hens (*Gallus gallus domesticus*), numbered 71 to 76, served as the subjects. They were approximately 1.5 years old when the experiments started. Hen 74 was replaced with another Hen 74 due to illness. The hens had not served in any previous experiments and were kept individually in home cages (430-mm high x 500-mm wide x 450-mm deep) except during the experimental sessions. Water was freely available in the home cages. Their body weight was targeted to maintain at 80% of their free-feeding body weight. Throughout the course of the experiment, while data was being collected, the hens' body weights were on average within 2.1% (SD 4.3%) of their target weights. Supplementary feed, consisting of commercial poultry pellets, was given if required to maintain the animals at the target body weight. Supplementary vitamins and grit were given weekly.

Apparatus

Sessions were conducted in a chamber (600-mm high x 600-mm wide x 400-mm deep). The chamber was made from particle board (15-mm thick) and the interior was painted matte white. A rubber mat (300-mm wide x 450-mm long) was placed on the floor of the chamber. On the front wall there were left and right circular response-keys (30-mm in diameter), made from Perspex which could be lit red. The keys were located 400-mm above the floor and 160-mm apart from each other. Each effective key peck required a force of approximately 0.1-N to operate a switch mounted behind the key and produced a brief audible beep. Underneath the response-keys, 110-mm above the floor, there was an opening (70-mm wide x 110-mm high) that allowed the hens access to reinforcement (wheat) for 3-s when the food hopper was raised. A white LED bulb was mounted inside the hopper opening illuminating the opening. A computer ran a Med PC IV program that controlled and recorded the experimental events.

Procedure

The hens were trained to peck a key and to eat from the food hopper prior to experiencing the following conditions.

Training (VI 15-s VI 15-s)

In this phase, the hens experienced concurrent VI 15-s VI-15-s with food reinforcers for several sessions. The training sessions continued for 10 sessions except Hen 74 which experienced VI 5-s VI 5-s and VI 15-s VI 15-s for 3 sessions each. Each session was terminated once the hens received 30 reinforcers or the session time exceeded 40 minutes, whichever came first. The concurrent schedule was programmed so that when a reinforcer became available on one of the keys, the VI timer on the other response key stopped counting down until the current access to the reinforcer was terminated. The hopper light was turned on 0.5-s before the hopper was raised and remained on for 3-s after which the hopper was lowered. The key light was turned off and the keys became inoperative whenever a hopper light was lit for the reinforcement period. In a session, 15 reinforcers were allocated to each response-key and the key, which provided a reinforcer, was randomly selected at each trial. A 2-s COD was also programmed for changing the keys, meaning that each time the subjects changed the key they were responding on, the VI timer for the key, which the reinforcer was due at, increased by 2-s. This made sure that the subjects responded at least twice to obtain a reinforcer, which was done to reduce key switching.

Condition 1 (VI 45-s VI 45-s)

The procedure in this condition was identical to the training sessions except that the schedule was VI 45-s VI 45-s during this condition. The number of sessions, food reinforcers and conditioned reinforcers are summarised in Tables 1 and 2.

Condition 2 (VI 30-s VI 60-s; A1 key with conditioned reinforcers and food reinforcers)

Half the hens experienced conditioned reinforcers on the left key and half on the right. The allocation of the key was randomly assigned. The key that had conditioned reinforcers associated with it was named the A1 key while the other one, which had no conditioned reinforcers was called the A2 key. For hens 73, 75 and 76, the left response-key was A1 key and the right key was A2 key. For hens 71, 72 and 74, the left response-key was the A2 key and the right response-key was the A1 key. In this condition, the A1 key (VI 30-s) provided approximately half the trials (10 of 20 trials) for food reinforcers and the other half (10 of 20 trials) for conditioned reinforcers without the food reinforcers, while A2 key (VI 60-s) provided approximately 10 food reinforcers in a session. Therefore, the food reinforcer proportion was 0.5 while total reinforcer (food and conditioned reinforcer) proportion was 0.66 allocated to A1 key, which was out of a total amount of reinforcers that the subjects could obtain from both keys. The presentation of either conditioned reinforcers or food reinforcers on the A1 key was randomly arranged and it was the same for the following conditions when the A1 key produced conditioned and food reinforcers. The number of sessions, food and conditioned reinforcers are summarised in Tables 1 and 2.

Table 1. *Number of sessions that each subject conducted and the number of reinforcers in each condition*

	Hen					
Condition	71	72	73	74	75	76
Condition 1 (VI 45-s VI 45-s)	17	20	21	20	19	21
Condition 2 (VI 30-s VI 60-s: A1 key with conditioned reinforcer and food reinforcers)	20	20	20	20	20	20
Condition 3 (VI 30-s VI 60-s: A1 key with only food reinforcers)	30	31	30	20	20	30
Condition 4 (Same as Condition 2)	27	27	27	25	25	26
Condition 5 (VI 25-s VI 100-s: A1 key with conditioned reinforcers and food reinforcers)	21	21	21	21	21	21
Condition 6 (VI 25-s VI 100-s: A1 key with only food reinforcers)	20	20	20	44	38	20
Condition 7 (Same as Condition 5)	35	34	35	20	20	35
Condition 8 (VI 25-s VI 100-s: A1 key with conditioned reinforcers)	20	20	20	20	20	20
Condition 9 (VI 25-s VI 100-s: A1 key with only food reinforcers)	20	20	20	21	20	20
Condition 10 (Same as Condition 8)	20	20	20			20

Table 2. *Programmed number of food and conditioned reinforcers allocated to each key and reinforcer proportions at each session. 'Right R' represents the number of food reinforcers allocated to the right key, 'Left R' represents the number of food reinforcers allocated to the left key and 'CR' represents the number of conditioned reinforcers and the key which provides conditioned reinforcers: 'L' for the left key and 'R' for the right* key.

		Hen						
Condition		71	72	73	74	75	76	Reinforcer Proportion on A1 key
Condition1 (VI 45-s VI 45-s)	Right R	15	15	15	15	15	15	
	Left R	15	15	15	15	15	15	0.5
Condition2 (VI 30-s VI 60-s; A1 key with conditioned reinforcers)	CR	R 10	R 10	L 10	R 10	L 10	L 10	
	Right R	10	10	10	10	10	10	0.66
	Left R	10	10	10	10	10	10	
Condition3 (VI 30-s VI 60-s; A1 key with more food reinforcers)	Right R	20	20	10	20	10	10	
	Left R	10	10	20	10	20	20	0.66
Condition4 (Same as Condition 2)	CR	R 10	R 10	L 10	R 10	L 10	L 10	
	Right R	10	10	10	10	10	10	0.66
	Left R	10	10	10	10	10	10	
Condition5 (VI 25-s VI 100-s; A1 key with conditioned reinforcers)	CR	L 30	L 30	R 30	L 30	R 30	R 30	
	Right R	10	10	10	10	10	10	0.8
	Left R	10	10	10	10	10	10	
Condition 6 (VI 25-s VI 100-s: A1 key with only food reinforcers)	CR							
	Right R	10	10	40	10	40	40	0.8
	Left R	40	40	10	40	10	10	
Condition 7 (Same as Condition 5)	CR	L 30	L 30	R 30	L 30	R 30	R 30	
	Right R	10	10	10	10	10	10	0.8
	Left R	10	10	10	10	10	10	
Condition 8 (VI 25-s VI 100-s: A1 key with conditioned reinforcers)	CR	R 30	R 30	L 30	R 30	L 30	L 30	
	Right R	10	10	10	10	10	10	0.8
	Left R	10	10	10	10	10	10	
Condition 9 (VI 25-s VI 100-s: A1 key with only food reinforcers)	CR							
	Right R	40	40	10	40	10	10	0.8
	Left R	10	10	40	10	40	40	
Condition 10 (Same as Condition 8)	CR	R 30	R 30	L 30	R 30	L 30	L 30	
	Right R	10	10	10	10	10	10	0.8
	Left R	10	10	10	10	10	10	

Condition 3 (VI 30-s VI 60-s; A1 key with only food reinforcers)

This condition was identical to the previous condition except that all the reinforcers for VI 30-s were food reinforcers only. The number of sessions, food and conditioned reinforcers are summarised in Tables 1 and 2.

Condition 4 (VI 30-s VI 60-s; A1 key with food and conditioned reinforcers)

The experimental arrangements were the same as for Condition 2. The number of sessions, food and conditioned reinforcers are summarised in Tables 1 and 2.

Condition 5 (VI 25-s VI 100-s; A1 key with food and conditioned reinforcers, A1 and A2 keys were swapped over)

In this condition, the keys associated with the VI schedules were reversed; the A1 key was swapped with A2 key. The hens, which had been previously exposed with the left key associated with conditioned reinforcers at previous conditions, were now exposed with the right key associated with conditioned reinforcers and vice versa. The schedule of reinforcement was VI 25-s for responses to the A1 key and VI 100-s for responses to the A2 key. For 71, 72 and 74, the left-key responses (VI 25-s) provided approximately 30 food reinforcers and 10 conditioned reinforcers, while the right-key responses (VI 100-s) provided approximately 10 food reinforcers in a session. For 73, 75 and 76, the left-key responses (VI 100-s) allocated approximately 10 food reinforcers and the right-key responses (VI 25-s) yielded approximately 30 food reinforcers and 10 conditioned reinforcers in a session. The number of sessions, food and conditioned reinforcers is summarised in Tables 1 and 2.

Condition 6 (VI 25-s VI 100-s; A1 key with only food reinforcers)

This condition was identical to the previous condition except that all the reinforcers for VI 25-s were food reinforcers but not conditioned reinforcers. The number of sessions, food and conditioned reinforcers are summarised in Tables 1 and 2.

Condition 7 (VI 25-s VI 100-s; A1 key with food and conditioned reinforcers)

This condition replicated the experimental arrangements of Condition 5. The number of sessions, food and conditioned reinforcers is summarised in Tables 1 and 2.

Condition 8 (VI 25-s VI 100-s; A1 key with food and conditioned reinforcers)

In this condition, as with Condition 5, the A1 key was swapped with the A2 key. The schedule of reinforcement is VI 25-s for responses to the A1 key and VI 100-s for responses to the A2 key. For 71, 72 and 74, the right response-key (VI 25-s) provided approximately 30 food reinforcers and 10 conditioned reinforcers, while left-key responses (VI 100-s) provided approximately 10 food reinforcers in a session. For 73, 75 and 76, the right-key responses (VI 100-s) provided approximately 10 food reinforcers and the left-key responses (VI 25-s) provided approximately 30 food reinforcers and 10 conditioned reinforcers in a session. The number of sessions, food and conditioned reinforcers are summarised in Tables 1 and 2.

Condition 9 (VI 25-s VI 100-s; A1 key with only food reinforcers)

This condition was identical to Condition 8 except that response to the A1 key only provided food reinforcers. The number of sessions, food and conditioned reinforcers are summarised in Tables 1 and 2.

Condition 10 (VI 25-s VI 100-s; A1 key with food and conditioned reinforcers)

This condition replicated the experimental arrangements of Condition 8. The number of sessions, food and conditioned reinforcers is summarised in Tables 1 and 2.

Hens 74 and 75 were not exposed in this condition because they were a few sessions behind from other hens and run out of the time.

Chapter Three: Results

In this experiment, four hens were exposed to 10 conditions and two hens were exposed to nine conditions. The VI schedule, delivery of reinforcers (food and conditioned reinforcers) and the location of the A1 key manipulated across conditions in order to measure changes in the hens' responses on the A1 key (See Table 1 for an outline of the experimental conditions).

Condition 1

The response proportions to the A1 key in Condition 1, which provided conditioned reinforcers or more food reinforcers in the following conditions, are shown in Figure 1. As can be seen on Figure 1 each of the six hens responded to the key around the response proportion of 0.5 throughout the condition and the proportion did not largely increase or decrease at any individual session. This is obvious for Hens 73 and 74 in particular. Other hens, however, showed a small range of variations, for example, the response proportion for Hen 75 ranged from .3 to .6 during Condition 1. Figure 2 shows the averaged response proportions of the last five sessions for each hen, for each condition. On Figure 2 the solid reference line represents the relative ratio for food reinforcers only and the short dashed reference line represents the relative ratio for food reinforcers. The top left panel shows the first condition. It shows similar to Figure 1. A paired t-test revealed that throughout Condition 1, among the subjects ($N = 6$) there was no statistically significant difference between the response proportions to the A1 key ($M = 0.470$, $SD = 0.091$) and the proportions to the A2 key ($M = 0.529$, $SD = 0.091$), $t(5) = -0.778$, $p = .472$. Response proportions against reinforcer proportions were also investigated. Table 2 shows the number of reinforcers programmed for each condition and reinforcer proportions allocated to the A1 key. In Figure 3, the averaged response proportions of the last five sessions in each condition were plotted

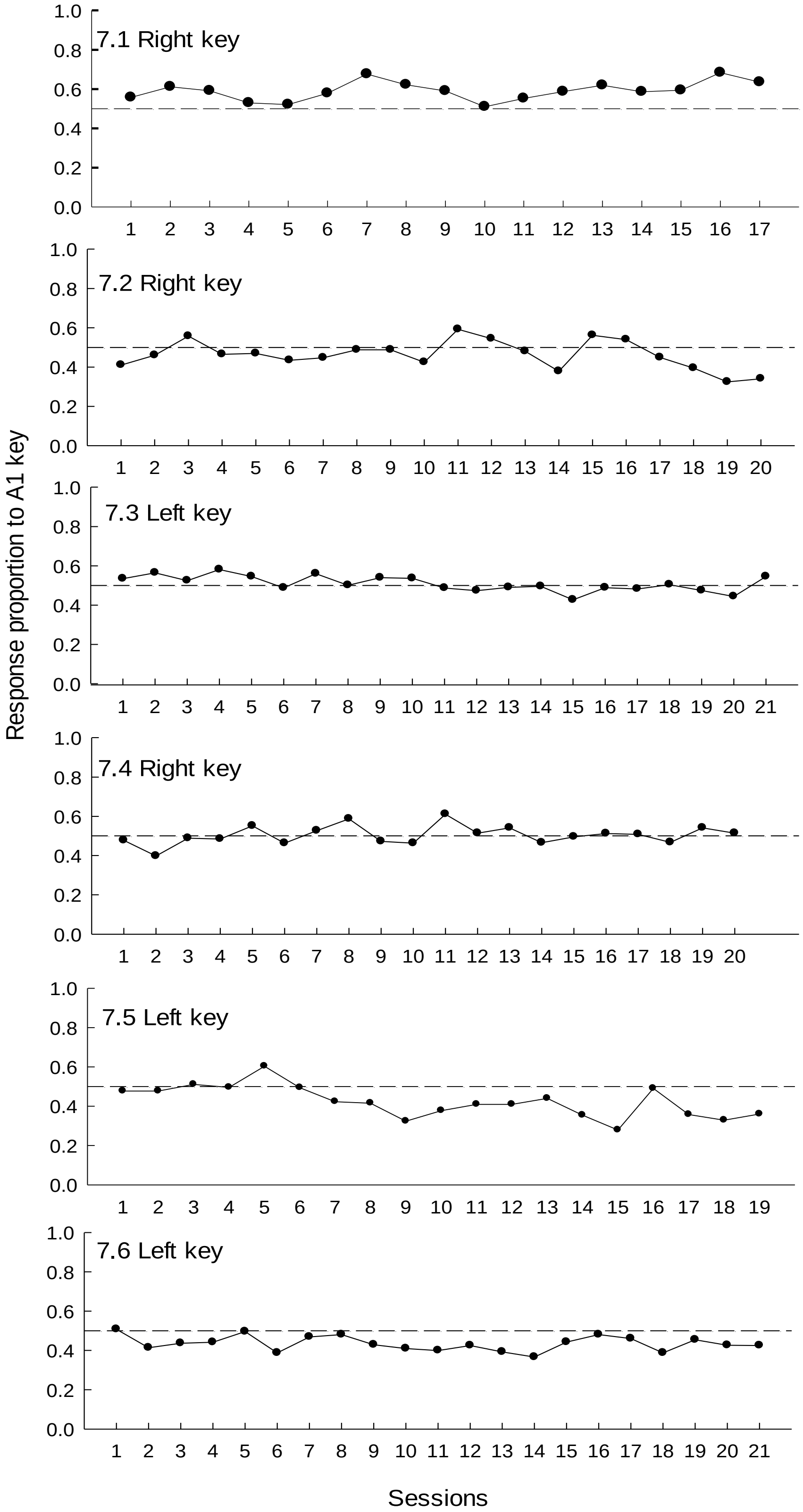

Figure 1. Response proportions of Condition 1 for the A1 key which provides more food reinforcers or conditioned reinforcers

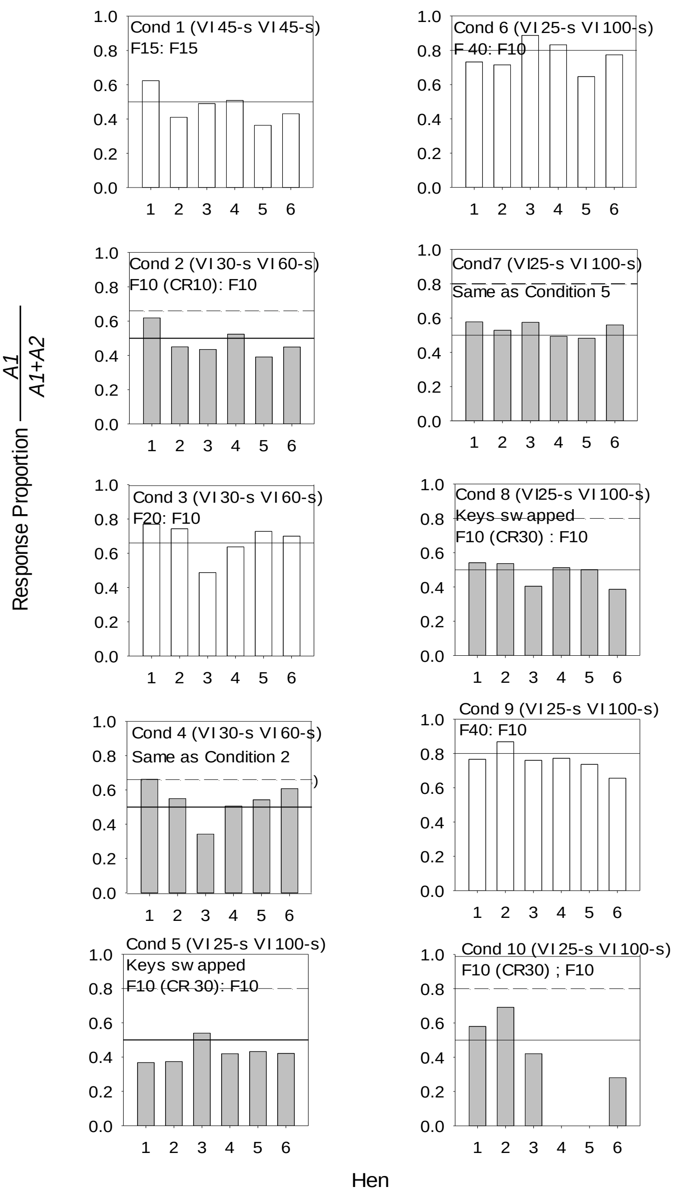

Figure 2. Response proportions in the last five sessions in each hen. ‘F’ and ‘CR’ represent programmed food reinforcers and conditioned reinforcers allocated to the richer-leaner key at each session. Hen 1 to 6 represent Hen 71 to 76.

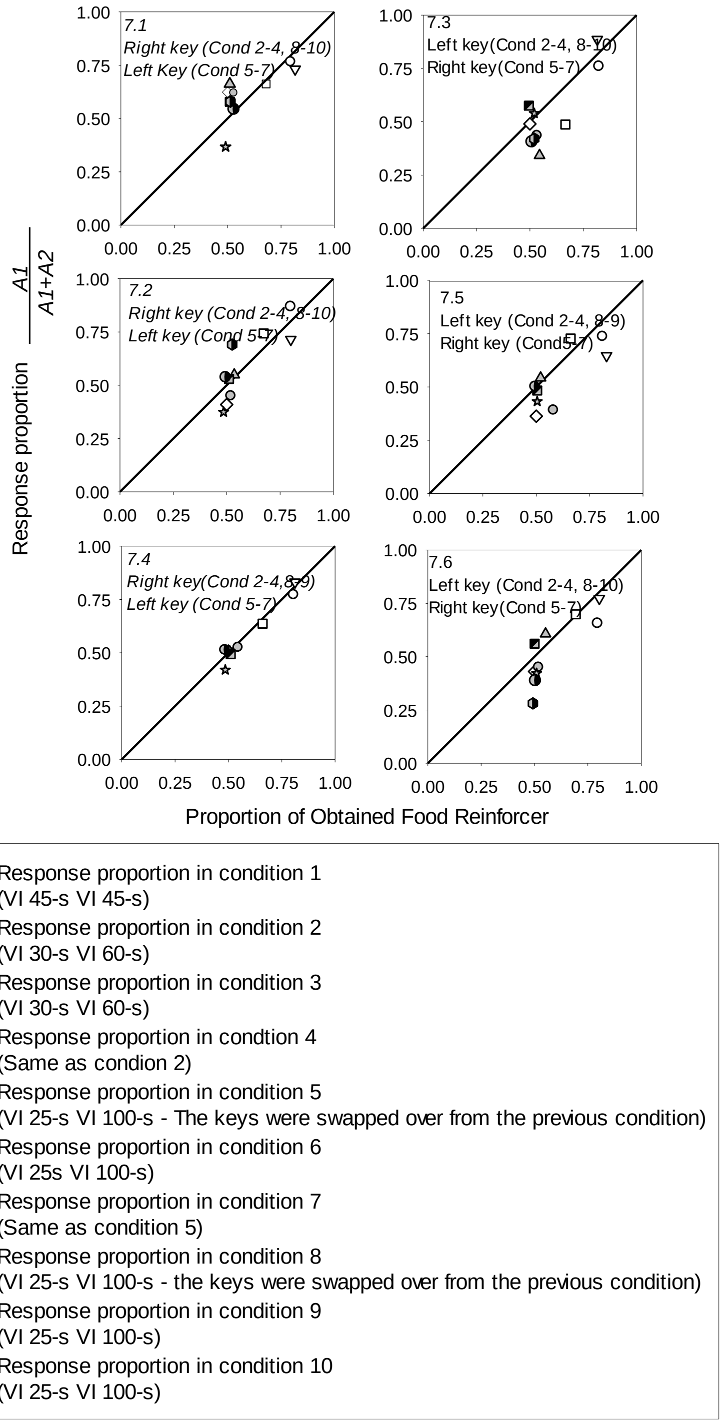

Figure 3. Averages of the last 5 sessions of response proportion in each condition, which were plotted against the proportion of obtained food reinforcer. Grey or grey and black symbols indicate that the A1 key produced conditioned.

per hen. It shows that the response proportions fall onto the strict matching line. The hens' response proportions and food reinforcer proportions were analysed statistically. The results of a paired t-test were; for the response proportion (*M* = 0.470, *SD* = 0.0918), and the food proportion (*M* = 0.500, *SD* = 0.000), *t*(5) = .-0.778, *p* = .472. Therefore, the t-tests suggest that the response proportions for the A1 key were not significantly different from food proportions. Figure 4 shows the average responses of each hen per reinforcer. It shows that the average responses per reinforcer were higher for both keys in Condition 1 than in other conditions. The average of the responses varied among the hens but at least approximately 15 responses per reinforcer were recorded in this condition which was higher than the other conditions.

Condition 2

Figure 2 shows that the response proportions to the key were reasonably close to .5 among the subjects except Hen 71 in Condition 2. A paired t-test showed the response proportions for the A1 (*M* = 0.478, *SD* = 0.081) and A2 keys (*M* = 0.522, *SD* = 0.081), *t*(5) = -0.663, *p* = .537, were not statistically different. Figure 3 also showed that the response proportions of the hens were lower or just on the matching line except Hen 71. A paired t-test shows that in Condition 2, the response proportion (*M* = 0.478, *SD* = 0.081), food proportion (*M* = 0.500, *SD* = 0.000), *t*(5) = .-0.663, *p* = .532, Therefore, the t-tests suggest that the response proportions for the A1 key at each condition were not significantly different from food proportions. Figure 4 shows that the average responses per reinforcer for both keys reduced largely from Condition 1 and particularly the averages for the A1 key for all hens were lower than for the A2 key.

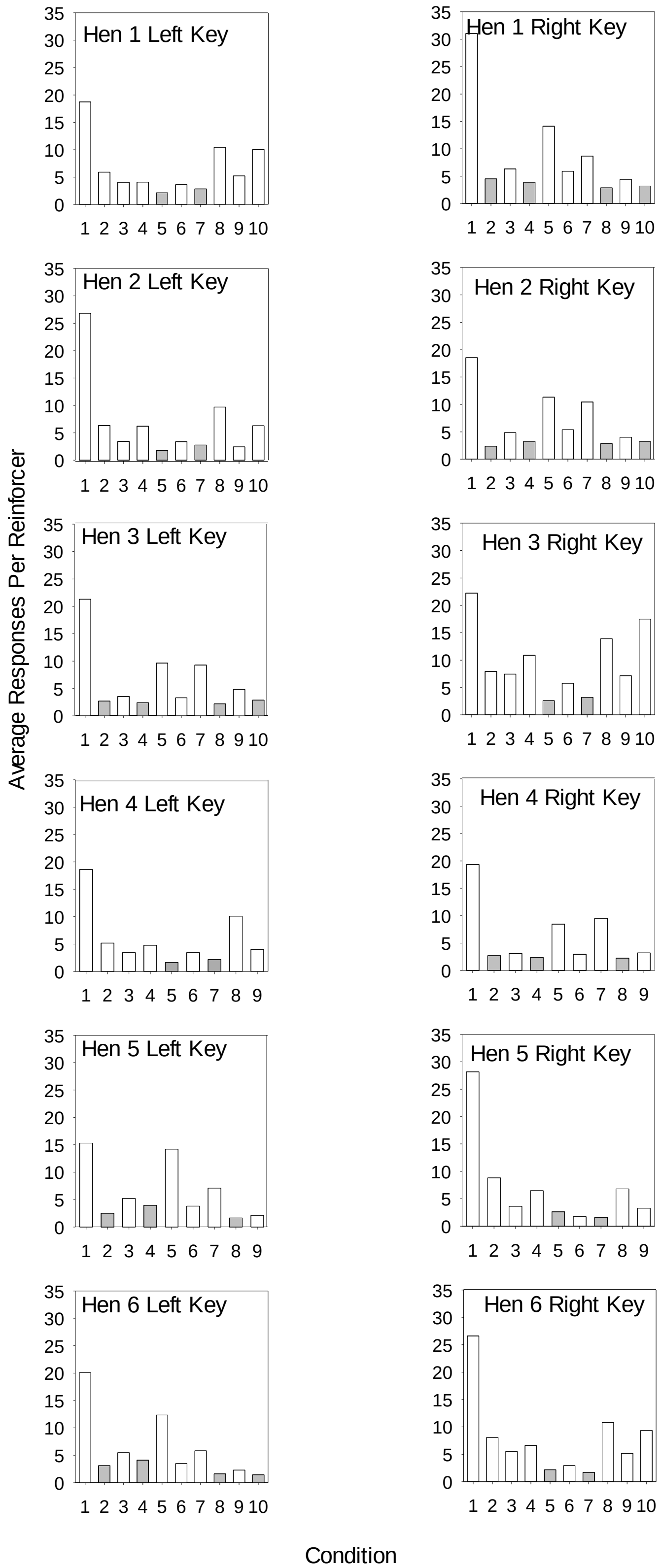

Figure 4. The average responses per reinforcer in each condition. The grey bars represent that the key produced conditioned reinforcers.

Proportions for the A1 key, which provided conditioned reinforcers, show more negative deviation values than for the A2 key.

Condition 3

In Condition 3, where food reinforcers replaced conditioned reinforcers on the A1 key, the response proportions for the A1 key were much higher than the previous conditions apart from Hen 73 (Figure 2). A paired t-test revealed that there was a statistically significant difference of response proportions between the A1 (M = 0.677, SD = 0.104) and A2 keys (M = 0.321, SD = 0.104), t(5) = 4.182, p = .009 . Thus, the t-test suggests that the response proportion to the A1 key was statistically different from the proportion to the A2 key in Condition 3. Figure 3 shows that except Hen 73 the response proportions of the hens were higher or very close to .66 of the food reinforcer proportion. A paired t-test shows that the response proportion (M = 0.678, SD = 0.104), food proportion (M = 0.660, SD = 0.000), t(5) = 0.437, p = .680. Therefore, the t-tests suggest that except Condition 5, the response proportions for the A1 key at each condition were not significantly different from food proportions.

Condition 4

Figure 2 shows that In Condition 4, Hens 1 and 6 still responded close to .66 though the all hens' response proportions to the A1 key decreased from Condition 3. A paired t-test revealed that there was a statistically significant difference of response proportions between the A1 (M = 0.530, SD = 0.109) and A2 keys (M = 0.469, SD = 0.109), t(5) = 0.689, p = .522. Therefore, the t-tests suggest that the response proportion to the A1 key and A2 key were statistically similar. Figure 3 also shows that except Hens 71 and 76, the response proportions were on the matching line or lower than the line. A paired t-test showed that the response proportion (M = 0.530, SD = 0.109), food proportion (M = 0.500, SD = 0.000), t(5) = 0.689, p = .522. Therefore, the t-test suggests that the response proportions for the A1 key at each condition were not significantly different from food proportions. Figure 4 and 5 show that the average responses were lower than the previous condition in all hens. A paired t-test shows that Condition 3(M = 4,748, SD = 1.218) and Condition 4 (M = 3.341, SD = 0.779), $t(5) = -5.943$, $p = .002$. Therefore, the t-test suggests that the averages were significantly different between Conditions 3 and 4.

Condition 5

Table 2 shows that in Condition 5, the A1 and A2 keys were swapped and also the schedule of reinforcement and the amount of food and conditioned reinforcers were changed from the previous condition and the total reinforcer proportion was increased to .8 from .66 while the food reinforcer proportion was still .5 on the A1 key. All the subjects except Hen 73 responded much less than .5 to the A1 key (Figure 2). A paired t-test revealed that there was a statistically significant difference of response proportions between the A1 (M = 0.425, SD = 0.061) and A2 keys (M = 0.574, SD = 0.061), $t(5) = -2.953$, $p = .032$. Figure 3 also shows that the response proportions for all hens except Hen 73 were lower than the strict matching line which means the responses proportions were lower than food proportion. A paired t-test shows that the response proportions (M = 0.425, SD = 0.061), and food proportion (M = 0.500, SD = 0.000), $t(5) = -2.953$, $p = .032$, were significantly different from the food reinforcer proportion of .5. Figures 7 shows that the average responses for the A2 key (i.e., the A1 key in the previous condition) increased largely except Hen 73.

Condition 6

Figure 2 shows that in Condition 6, when only food reinforcers were allocated to the A1 key, the response proportions were increased largely from the previous condition. The proportions, exempting Hens 73 and 74, were still under the ratio of .8

which was the food reinforcer proportion allocated to the key, however. A paired t-test showed that there was a statistically significant difference between the A1 key (*M* = 0.764, *SD* = 0.085) and A2 key (*M* = 0.235, *SD* = 0.085), *t*(5) = 7.535, *p* = .001. Figure 3 also shows that except Hens 73 and 74, the response proportions were plotted below the matching line though they were still close to the reinforcer proportion of .8. A paired t-test shows that the responses proportions (*M* = 0.764, *SD* = 0.085), food proportions (*M* = 0.800, *SD* = 0.000), *t*(5) = -1.011, *p* = .358, Therefore, it suggests that the response proportions for the A1 key were not significantly different from the food proportion.

Condition 7

Figure 2 shows that in Condition 7 the hens responded at nearly the same proportion of food reinforcers. A paired t-test also shows that there was no statistically significant difference of response proportions between the A1 (*M* = 0.536, *SD* = 0.041) and A2 keys (*M* = 0.463, *SD* = 0.041), *t* (5) = 2.150, *p* = .084. Therefore, the t-test suggests that the proportions of the A1 and A2 keys were relatively equal. This condition replicated Condition 5 and Figure 5 shows the response proportions of each hen through conditions 5 and 7. In Condition 7, all of the subjects' response proportions to the A1 key were higher than 0.5 of food reinforcer proportion during the first session. Hens 71, 73 and 76 also reasonably maintained the proportion higher than .5 and occasionally reached almost 0.8 which was the total reinforcer (conditioned and food reinforcers) proportion. A paired t-test revealed that the proportions of Condition 5 were significantly different from Condition 7, *t*(5) = -3.979, *p* = .011. Figure 3 shows that the response proportions of each hen were over or close to the food proportion of .5 but none of them responded much less than the proportion. A paired t-test shows that the response proportion (*M* = 0.536, *SD* = 0.041), and food proportion (*M* = 0.500, *SD* =

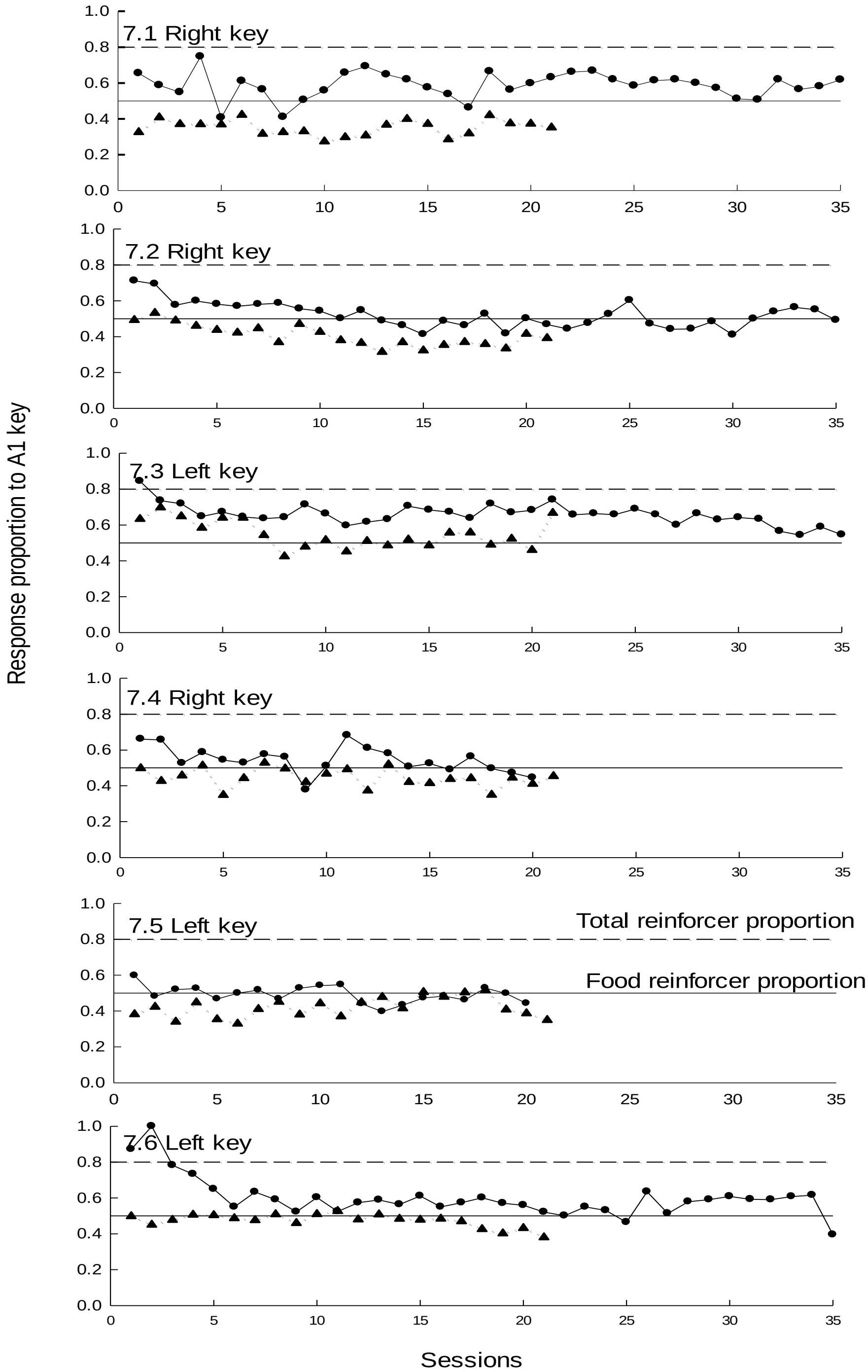

Figure 5. Response proportions to the A1 key in Condition 5 and 7. Triangle symbols with a dotted line describe response proportions in Condition 5. Circle symbols with a solid line describes response proportions in Condition 7.

0.000), *t*(5) = 2.150, *p* = .084, were not significantly different from the food reinforcer proportion. Figures 4 and 5 show that the average responses per reinforcers were less than the preivious condition but similar to Condition 5. A paired t-test showed that the average responses in Condition 7(*M* = 2.395, *SD* = 0.660) and Condition 6 (*M* = 3.493, *SD* = 1.317), *t*(5) = -3.207, *p* = .024, were significantly different from Condition 6. The average responses in Condition 7 and Condition 5 (*M* = 2.159, *SD* = 0.413) were, however, not significantly different, *t*(5) = -0.727, *p* = .500. Therefore, the t-test suggests that the average responses in Condition 7 were not significantly different from those of Condition 5.

Condition 8

Apart from the A1 and A2 keys being swapped in Condition 8, this condition was the same as Condition 7 (i.e., the same schedule of reinforcements and reinforcer proportions). Figures 2 shows that in Condition 8, the hens responded to the A1 key just above proportion of .5 except Hens 73 and 76. A paired t-test showed that the response proportion for the A1 key (*M* = 0.487, *SD* = 0.071) and the A2 key (*M* = 0.519, *SD* = 0.068) were not statistically different; *t*(5) = -0.570, *p* = .594, therefore, it suggests that the response proportions for the A1 key were similar to the A2 key. Figure 3 shows that the 4 hens' proportion just fell on the matching line. A paired t-test showed that the response proportion (*M* = 0.487, *SD* = 0.071), and food proportion (*M* = 0.500, *SD* = 0.000), *t*(5) = -.443, *p* = .676, were not statistically different.

Condition 9

Figure 2 shows that In Condition 9, the proportions increased to near at .8. A paired t-test showed that the response proportion for the A1 key (*M* = 0.759, *SD* = 0.068) and those for the A2 key (*M* = 0.240, *SD* = 0.068); *t*(5) = 9.310, *p* = .000, were significantly different. Figure 3 shows that the all hens' response proportions were very close to the strict matching line and they are also close to the response proportions in Condition 6. A paired t-test shows that the response proportion (*M* = 0.760, *SD* = 0.068), food proportion (*M* = 0.800, *SD* = 0.000), *t*(5) = -1.455, *p* = .205. Therefore, it shows that hens' response proportions were not significantly different from the scheduled food proportions of .8 shown with a solid horizontal line on the right fourth panel of Figure 2.

Condition 10

Figure 2 shows that in Condition 10, Hens 71 and 72 responded more than the food reinforcer proportion of .5 and particularly 72 responded at more than .7 of proportions. The two other hens responded just less than .5. A paired t-test shows that the proportion for the A1 key (*M* = 0.493, *SD* = 0.179) and the A2 key (*M* = 0.507, *SD* = 0.179), *t*(3) = -0.078, *p* = 0.943, therefore, it suggests that the response proportions for the A1 key were not significantly different from those for the A2 key. Figure 3 shows that the response proportion in Hen 2 was almost high as those in Conditions 3, 6 and 9. In Hen 6, however, the proportion was lowest among all conditions. A paired t-test shows response proportion (*M* = 0.493, *SD* = 0.179), food proportion (*M* = 0.500, *SD* = 0.000), *t*(5) = -0.078, *p* = .943. Therefore, the t-tests suggests that the response proportion for the A1 key was not significantly different from food proportions. Figure 6 shows the response proportions for the A1 key in Condition 8 and 10. It shows that the triangle symbols (Condition 10) are plotted higher than the circle symbols (Condition 8) at most of sessions for Hen 71, 72 and 73 throughout the conditions except 76. A paired t-test shows that the proportion for Condition 8 (*M* = 0.487, *SD* = 0.071) and Condition 10 (*M* = 0.493, *SD* = 0.179), *t*(3) = -0.484, *p* = .662, therefore, it suggests that the response proportions for Condition 8 were not significantly different from Condition 10. Figure 4 shows that the average responses in Condition 10 were lower than Condition 9 but similar to Condition 8. A paired t-test shows the average responses in Condition 9 (*M* = 3.411, *SD* = 1.062) and Condition 10 (*M* = 2.675, *SD* = 0.851), $t(3) = 3.887$, $p = .030$. Therefore, the t-test suggests that the averages in Condition 10 were significantly different from Conditions 9.

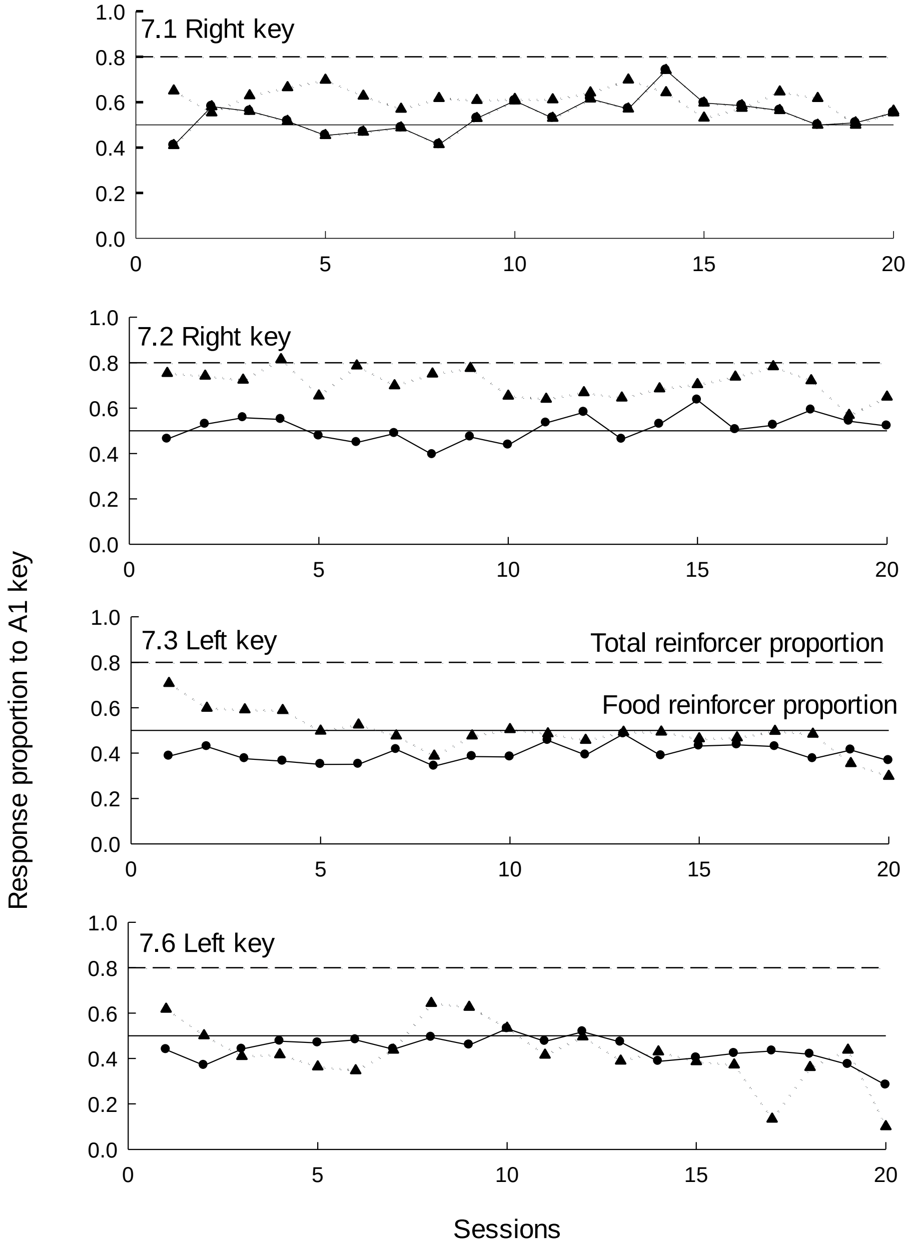

Figure 6. Response proportions to the A1 key in Condition 8 and 10. Circle symbols with a solid line describes response proportions in Condition 8. Triangle symbols with a dotted line describe response proportions in Condition 10.

Chapter Four: Discussion

The aim of this study was to determine whether hens would prefer the key that provided a magazine light-stimulus in addition to food reinforcers as consequences for key pecking, more than another key which presented the same number of food reinforcers only. If the hens preferred the key that provided the magazine light-stimulus, then one might claim that the magazine light functioned as a conditioned reinforcer and as a result, that would be the reason for them to prefer the key. The results, however, suggested that the hens' behaviour was not affected by the magazine light-stimulus (so the stimulus is called a 'magazine light-stimulus' instead of a conditioned reinforcer) and that their responding was only influenced by the food reinforcers for the majority of conditions. There were two conditions which might indicate that the magazine light-stimulus might function as a conditioned reinforcer, however. In Condition 7, the hens' responses significantly increased from the previous identical condition (Condition 5). In Condition 10, Hens 71 and 72 increased the response proportion from the previous identical condition (Condition 8) while Hen 76 decreased the proportion. Additionally, the magazine light-stimulus did not increase the response proportions as much as the food reinforcers did in those conditions. Average responses per reinforcer showed similar finding to the proportions.

A1 key with food-only reinforcer

Figure 1 suggests that the proportions to the A1 and A2 keys were stable and not biased towards either of the keys in Condition 1, i.e. the hens did not show a particular preference to either of the keys throughout the condition. Statistical analysis confirmed that the hens' response proportions for the A1 and A2 keys were similar. Another t-test showed that their response proportions for the A1 key were similar to the food proportions for that key. These findings were expected as both keys provided the same proportion of food reinforcers under the same schedule of reinforcement. Therefore, the finding suggests that the hens did not have any bias to the left or right keys.

The hens' behaviour was found to be similar in other conditions with food-only reinforcers. Figure 2 shows that in Conditions 3, 6 and 9, most of the hens responded to the A1 key at or close to the food proportions of the A1 key. For instance, in Condition 3, the food proportion for the A1 key was 0.66 and the hens' response proportions were close to 0.66 except Hen 73. The paired t-tests suggested that the response proportions for the A1 key were significantly higher than the A2 key and the response proportions of all the hens were similar to the reinforcer proportions in these conditions. Hence, in these conditions, the findings suggest that the hens' choice behaviour matched with the rates of food reinforcement as one expect given what we know about Herrnstein's (1961) Matching Law.

A1 key with food reinforcers and magazine light-stimulus

Food reinforcers effectively increased the hens' response proportions in this study. However, the magazine light-stimulus did not affect the hens' responses much, and on the basis of what was observed in this experiment did not function effectively as a conditioned reinforce. If magazine light presentations had functioned as a conditioned reinforcer then response proportions should have been biased towards they key that provided a large number of those presentations as well as food reinforcers relative to the key that only provided food reinforcers. In Condition 2, the response proportions for the A1 key did not differ from the A2 key or were even much lower than the response proportions for the A2 key except for Hen 71, as Figure 2 shows. The statistical analysis also suggested that response proportions for the A1 key were similar to the A2 key across all the subjects and that the response proportions were also similar to the food reinforcer proportions. It also suggested that the response proportions and total stimulus proportion (the proportion of 0.8) were significantly different. Therefore, the hens responded according to the food proportions to the keys and the magazine light did not serve as a conditioned reinforcer in this condition. The findings were the same in Condition 4 which was a replication of Condition 2. Figure 2 shows only two hens (71 and 76) clearly having a conditioned reinforcer effect but the other hens only responded close to the food reinforcer proportion (the proportion of 0.5). Since the magazine light did not function as a conditioned reinforcer, it makes sense that the hens' response proportions matched with food reinforcer proportions instead of total stimulus proportions.

Stubbs and Galloway (1970) found that the magazine light did function to increase the response rates while this study did not find that it influenced the hens' response proportions. The former study, however, used different procedures to study the effect of conditioned reinforcers. For example, they used different schedules of reinforcements from this study and also the consequence of whether the hens could access to the reinforcers were in a result of a discrimination task. Therefore, the difference in the procedure might be a cause for the different findings between the two studies.

The ineffectiveness of the magazine light-stimulus to act a conditioned reinforcer was observed even when the total number of outcomes in a session at Condition 5 was increased to 50 from 30 and this increased the stimulus proportion for the A1 key from .66 to .80. Regardless of this, Figures 2 and 3 show that all of the hens except 73 responded to the key at a value of less than .5. The t-test confirmed that their response proportions for the A2 key were higher (see Figures 2 and 3). This was not predicted and it is unknown why this happened. One possibility is that the magazine light-stimulus might serve as an aversive stimulus because the hens occasionally received the stimulus without food reinforcers for a few trials in a row and the possibility of this occurrence was higher than for the previous conditions as the presentations of the magazine light-stimulus increased from 10 to 30.

Stagner and Zentall (2010) have found that pigeons prefer more predictable alternative which signals when they can gain food reinforcers over less predictable alternative which can possibly provide more reinforcers overall. Therefore, the finding in the current study might indicate that the hens preferred more predictable alternative for food reinforcers (the A2 key) than the less predictable alternative (the A1 key).

On the other hand, In Condition 7, the magazine light might function as a conditioned reinforcer. Figure 2 and 4 show that the hens' response proportions were higher in Condition 7, which was replication of Condition 5, than Condition 5. Figure 5 shows that the response proportions for the A1 key decreased from the beginning to the end of Condition 7. A statistical analysis also showed that the hens' response proportions to the A1 key were higher than the Condition 5. Hence, this indicates the magazine light could actually function as a conditioned reinforcer in Condition 7. This might be due to the previous condition which provided more food reinforcers than the A2 key and perhaps this might have some effect in establishing the magazine light as a conditioned reinforcer. Regardless of the increase, a statistical analysis shows that the response proportions on the A1 key were similar to the proportion of the food reinforcers but different from the total stimulus proportions, however. Figures 2 and 3 also show that the response proportions of the hens were under .80 and therefore, the magazine light was probably not effective in reinforcing their behaviour as much as a food reinforcer could. The reinforcer proportions in Condition 7 decreased from the beginning to the end (Figure 5) and in Condition 8, the reinforcer proportions of hens were again close to 0.5 which means the magazine light-stimulus was not reinforcing the hens' pecking behaviour. Therefore, this finding does not support what Zimmerman et al. (1967) found in their study that the pigeons responded more to the richer schedule and less to the leaner schedule of conditioned reinforcement.

In Conditions 6 and 9, the same 0.8 of food-only reinforcer proportion was allocated to the A1 key. Therefore, the rich food reinforcer proportion in these conditions should have similarly affected the hens' preference to the key in the following conditions (Conditions 7 and 10). Regardless, the findings in Condition 10 were different from Condition 7. Unlike Condition 7, there were only 2 out of 4 hens (Hens 71 and 72) that showed an increase in their response proportions from Condition 8 (Figure 2). Figure 6 also shows that, in the majority of sessions, the hens responded more for the A1 key in Condition 10 than in Condition 8. The other two hens did not show an increase at Condition 10 apart from during the first couple of sessions, and this is also confirmed by the statistical analysis. Hence, although the magazine light-stimulus might function as a conditioned reinforcer to couple of hens, the conditioned reinforcer effect was not clearly observed in this condition.

Average responses per stimulus

Figure 4 shows that the hens' average responses per stimulus were highest in Condition 1 for both keys among all conditions. This might be because the hens were given the least number of stimuli (20 food reinforcers in total) and, because of this, they were given a longer duration where the response keys were able to be pecked than in the other conditions. Figure 4 and 5 shows that food-only reinforcers allocated to the A1 key were higher than the former and latter conditions of each of those conditions with food-only reinforcers. For example, the average responses in Condition 3 were higher than those of Conditions 2 and 4. This supports the previous discussion that the magazine light-stimulus was not effective in reinforcing the hens' pecking behaviour as the food reinforcers did.

Summary

Changes in response proportions were similar among all hens across conditions except that Hen 73 showed lower response proportions than other hens in early and late conditions. Therefore, the results were reasonably consistent and the findings do not clearly support the other studies which suggest there are near-miss effects found in animals (Peters et al., 2010; Winstanley et al., 2011).

One limitation of this study was that the method was different from the former studies which showed a near-miss effect in animals. In those studies, the researchers facilitated light illumination where a certain number of illuminated lights represented a win, loss, and a near-miss trial. In contrast, only one illuminated key light was used for representing both a near-miss and win trial in this study. Therefore, while in the method of the former studies, the subjects' behaviour could be influenced by a stimulus discrimination and generalisation which was formed by a different number of lights, in this study responses to the key light to provide a food reinforcer or magazine light occurred randomly which means the hens had no way to predict the outcome prior to pecking a key. Therefore, the results might have been similar to those studies if the methodology was the same.

Another limitation was that Hens 74 and 75 were not exposed to Condition 10 due to them being several sessions behind the other hens. The results may have been different if other hens were used or there was enough time for Hens 74 and 75 to be exposed to Condition 10 which might support a magazine light-stimulus function as a conditioned reinforcer.

Future studies could implement the method of Peters et al. (2010) and Winstanley et al. (2011) and determine whether the magazine light-stimulus functioned as a conditioned reinforcer to study hens' behaviour. If the hens are presented with different numbers of light illuminations, which is similar to a real pokie machine, it might help to study the near-miss effect in hens more accurately.

This study is based on the notion that a near-miss effect might be produced by a conditioned reinforcer (Skinner, 1953). Although there might have been a limited conditioned reinforcer-effect observed in a couple of conditions, it is not enough to provide evidence that there was a conditioned reinforcer-effect in this study. Since the magazine light-stimulus did not increase the response proportions according to the proportion of the stimulus consistently, this study does not support the findings of Harris and Carpenter (2011) and Shahan et al. (2006) which found that a response proportion matched with a conditioned reinforcer proportion. Further investigations would be required to determine the relationship between a conditioned reinforcer and the near-miss effect, although this study might contribute to understanding how the near-miss effect could reinforce gambling behaviour such as betting more credits per line in a pokie machine and influence the development of problem-gambling.

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Appendix A

Excel files with a summary of raw data are attached on the accompanying CD.

Appendix B

Ethics approval (protocol number: 917) is attached on the accompanying CD.