CHOOSING TO CHOOSE:

PREFERENCE FOR FREE-CHOICE OVER FORCED-CHOICE

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Abstract

Brown Shaver hens responded on a concurrent chain procedure, containing two independent initial link keys, that ran on VI 30-s schedules. Following the conclusion of the initial link schedules either 1 or 2 terminal link keys were made available to the subject, all of which ran on a FI 20-s schedule and resulted in 3-s access to reinforcement. The results replicated Catania's (1975) findings demonstrating preference for the terminal link which contained two available keys. The second experiment aimed to equalise terminal link entry ratios by changing the initial links to concurrently running dependent VI 30-s schedules. The last experiment attempted to increase the observed preference for the terminal link that contained two keys, by reducing the initial link schedules to dependent VI 10-s. These later experiments were not able to successfully replicate the strength of the preference for the 2 key terminal link shown in the initial experiment and by Catania (1975).

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Establishing operations

The provision of appropriate reinforcers is effective in encouraging responding when teaching individuals with an intellectual disability (Vollmer & Iwata, 1991). However, numerous studies have noted that the effectiveness of a stimulus as a reinforcer can vary both within and across situations. Vollmer and Iwata (1991) note that satiation and deprivation alter the effectiveness of a stimulus as a reinforcer, these motivational variables have been termed 'establishing operations' (Michael, 1982).

Vollmer and Iwata (1991) investigated responding on one of two motor tasks, switch closure or block placement, following periods of satiation and deprivation with adults diagnosed with an intellectual disability. The results of their study showed that each of the consequences used (food items, social praise and music) functioned as a reinforcer with different degrees of effectiveness following periods of satiation and deprivation. Following periods of deprivation the items were more effective as a reinforcer than following periods of satiation.

Similarly, Gottshalk, Libby and Graff (2000) investigated the effects of establishing operations, satiation and deprivation, during a paired choice preference assessment procedure. Approach responses for all the participants, following satiation to a stimulus were lower when compared to baseline levels. Following deprivation of a stimulus approach responses were higher than baseline levels. McAdam, Klatt, Koffarnus, Dicesare, Solberg, Welch and Murphy (2005) also investigated the effect of satiation and deprivation on a paired choice preference assessment procedure, with similar results. The findings presented by Gottshalk et al. (2000) and McAdam et al. (2005) suggest that satiation and deprivation can affect responding during preference assessment procedures and

thus support Vollmer and Iwata's conclusions that establishing operations have an effect on responding.

Habituation

It is commonly accepted that within-session changes in responding are reflective of changes in the reinforcing effectiveness of stimuli being used, and that reinforcers will become less effective after repeated presentations (McSweeney, 1992; McSweeney, Hinson & Cannon, 1996; Murphy, McSweeney, Smith & McComas, 2003). Within session changes in responding have been shown to be large, orderly and reliable and to occur across a range of species, settings, reinforcers, responses and procedures (McSweeney et al., 1996) Traditionally this has been labelled 'satiation'; however recent research has shown that the term 'habituation' may be more relevant (e.g. Murphy et al., 2003; McSweeney et al., 1996). Murphy et al. (2003) note that satiation manifests differently dependant on the stimuli, and that no characteristics have been identified for the non-ingestive stimuli used by applied behaviour analysts. Such as praise, attention and access to tangible reinforcers, for example toys. In comparison the characteristics of a behaviour undergoing habituation are well known and relatively general across stimuli and species (Murphy et al., 2003). Several potential characteristics of habituation have been identified (McSweeny & Murphy, 2000; Murphy et al., 2003) including but not limited to: dishabituation and the variety effect.

Dishabituation is a commonly demonstrated characteristic of habituation. Dishabituation is defined as an increase in responding following the introduction of a novel stimulus, this area has been extensively researched using novel food stimuli (Epstein, Caggiula, Rodefer, Wisniewski & Mitchell, 1993; Epstein, Saad, Handley, Roemmich, Hawk & McSweeney, 2003; Ernst & Epstein, 2002; Temple,

Giacomelli, Roemmich & Epstein, 2008; Temple, Kent, Giacomelli, Paluch, Roemmich & Epstein, 2006). Dishabituation research has demonstrated both recovery of salivation upon the presentation of the novel stimulus (Epstein et al., 1993; 2003: Temple et al., 2006) and the recovery of motivated responding after presentation of the novel stimulus (Epstein et al., 2003; Temple et al., 2006; 2008)

Another characteristic of habituation is the 'variety effect'. The variety effect states that habituation will occur at a slower rate when the stimuli are presented in a varied format compared to a fixed format. Melville, Rue, Rybiski and Weatherly (1997) investigated the effect of reinforcer variety on the rate of habituation, shown by operant responding on a lever by rats. Four qualitatively different reinforcers were used; 3 different types of pellets and a grape flavoured liquid. Reinforcer variety was manipulated by varying the percentage, from 0% to 75%, of the grape flavoured liquid with the three types of food pellets. Melville et al. (1997) found that conditions with less reinforcer variety resulted in responding decreasing at a steeper rate.

This effect has also been demonstrated with humans. Ernst and Epstein (2002) investigated operant responding for food with non-obese male adults. The subjects were split into two groups: a variety group and a constant group. The subjects self-selected food reinforcement, presented according to the group they were assigned to. On the ninth trial a novel stimulus, to demonstrate dishabituation, was introduced for both groups. Ernst and Epstein's (2002) results showed that higher rates of responding were observed for the subjects assigned to the variety group than for subjects assigned to the constant group over the course of the early trials. As shown with previous dishabituation research, the introduction of a novel stimulus resulted in an increase in motivated responding for both groups.

Stimulus Variability to Increase Motivated Responding

When working with children with intellectual disabilities the child's characteristic lack of motivation often creates difficulties in encouraging learning (Egel, 1981; 1981). Due to their ease of delivery primary reinforcers, such as food items, are often used. However, due to habituation, responding is often inconsistent and can sometimes stop entirely. It has been identified that a procedure which can reduce habituation effects, increase fixation time, increase responding and consequently increase learning, would be beneficial when working with children with an intellectual disability (Egel, 1980).

Dunlap and Koegel (1980) believe that repetitively presenting children with the same task demand until 'mastery criteria' is met, may lead to the child failing to respond which is falsely labelled as the child not learning the task. They suggest that varying antecedent stimuli, such as task demands, may increase motivation and reduce habituation effects, described as 'boredom' by Dunlap and Koegal (1980), when working with children with autism.

Dunlap and Koegel's (1980) results demonstrated not only a declining trend in correct responses as the session progressed when the antecedent stimulus was held constant, but also a declining trend in perceived levels of enthusiasm, happiness, interest and general behaviour by the participant. Following the introduction of antecedent stimuli variation, responding in general and the number of correct responses increased. Furthermore the child's perceived enthusiasm, happiness, interest and general behaviour were relatively high and appeared to remain stable over the course of the varied condition.

This effect was noted by Egel (1980), based on this research he hypothesised that varying the reinforcer stimuli would also lead to increases in responding and less, what Egel described as, satiation effects in developmentally

delayed children. Initially Egel tested his hypothesis in a laboratory setting (Egel, 1980) using a lever press as the required response. However, he later extended the initial study and moved to a more 'applied' classroom setting (Egel, 1981) using discrimination tasks as the required response. The results of this research demonstrated that the children responded at a significantly higher rate when the reinforcer stimulus was varied; compared to when the stimulus was held constant. Furthermore, it was also shown that the participants responded more rapidly in the varied condition, shown by a shorter inter trial interval. Most importantly it was shown that the children satiated much quicker and more frequently during the constant condition sessions compared to the varied condition sessions.

This area was also researched by Milo, Mace and Nevin (2010) with children diagnosed with Autism Spectrum Disorder. The participants were exposed to reinforcement delivered in a varied format and in a constant format. The results of their study also showed that the participants tend to allocated more responding, and respond at a higher rate on the task demand associated with the varied reinforcement. It can therefore be concluded that the participants preferred the varied reinforcer delivery method.

Egel's (1980; 1981) research was later extended by Bowman, Piazza, Fisher, Hagopian and Kogan (1997) who investigated the preference of a constant highly preferred reinforcer compared to varied 'slightly lesser preferred' reinforcers. The results of their study showed similar findings to Egel's research (1980; 1981) for some but not all of the participants. Bowman et al. (1997) suggest that this may be due to the highest preferred reinforcer being available in the constant condition. Therefore it can be said that the effectiveness of reinforcer variation, as a method to increase responding, decrease satiation and increase

fixation time, can be affected by the level of preference the individual has for the reinforcer stimuli being used in the trials.

Choice Making Opportunities

In the above studies, it was shown that organisms prefer reinforcer variety over the repeated presentation of the same reinforcer. It was also shown that reinforcer variety slows the rate of habituation. However, in all of the above examples the participant is only able to choose the varied condition, but is not able to choose which reinforcer they receive; the allocation of reinforcer stimuli was random. Choice making research investigates the effect that access to choice of antecedent or reinforcer stimuli has on motivated responding.

Parsons, Reid, Reynolds and Bumgarner (1990) investigated the effect that providing choice making opportunities had on attention to work tasks, with adults diagnosed with a moderate to severe intellectual disability. Three conditions were conducted in this study, firstly the instructor assigned the participant to work on a high preference task, secondly the instructor assigned the participant to work on a low preference task, and finally the instructor allowed the participant to select either a high preference or low preference task. Each condition was conducted separately for a 30 min period; on task behaviour was assessed during each session.

This study was also replicated and extended by Bambara, Ager and Koger (1994). Changes by Bambara et al. (1994) included the choice condition consisting of access to two tasks from the same preference category (highly preferred or moderately preferred) and the no choice condition consisting of one of those tasks being assigned by the experimenter.

The findings from these two studies show that when assigned to work on the high preference task, or able to choose their own task the participants' on-task

behaviour was higher than when they were assigned a low preference task. This effect has also been demonstrated with rates of responding on a free operant task with individuals with intellectual disabilities by Smith, Iwata and Shore (1995) and Lerman, Iwata, Rainville, Adelinis, Crosland and Kogan (1997).

The results of these studies show that providing an individual with an intellectual disability a choice will result in better work performance when compared to assigning them to work on a low preference task. However they also show that assigning a high preference task is as effective in maintaining work performance as providing a choice, therefore it cannot be determined if the choice itself is reinforcing for the participant.

Lerman et al. (1997) note that although the results show that choice procedures did not increase rates of responding, above response rates observed when access to higher preferred reinforcers was provided, they may still be useful in an applied setting. Choice making procedures may increase the likelihood that higher preferred tasks, reinforcers and activities are made available, without requiring a preference assessment procedure to be completed at the start of each session. Therefore, choice making procedures can account for changes in preference over time.

Reinforcing Effects of Choice

Fisher, Thompson, Piazza, Crosland and Gotjen (1997) investigate another method for varying reinforcement, in which individuals are able to choose from a set of available reinforcers each time a reward is earned. This method takes into account momentary changes in motivation and reinforcing stimulus effectiveness. Fisher et al. (1997) utilised a concurrent operant procedure, as they felt it would provide a sensitive measure enabling them to investigate the effects of choice versus no choice when a) both options lead to the same outcome and b) the no

choice condition provides more access to higher preferred stimuli than the choice condition.

Experiment 1 consisted of three different phases, which investigated preference for choice over no choice, when both choice alternatives lead to the same outcome. During the higher preference (HP) phase the two highest ranked stimuli were made available to the participant, during the lower preference (LP) phase the two lowest ranked stimuli were made available, during the HP-LP phase one of the higher and one of the lower ranked stimuli were made available to the participant. The results from Experiment 1 show that all participants consistently preferred the choice condition; regardless of whether it provided access to highly preferred stimuli, lower preferred stimuli or one of each.

During Experiment 2 Fisher et al. (1997) investigated the degree to which the participants preferred the choice condition over the no choice condition. This was done by altering the procedure slightly so that responding on the choice key produced access to a choice between relatively lesser preferred stimuli, and the no choice key produced access to more highly preferred stimuli. Therefore preference for choice was in direct competition with their preference for the higher rated reinforcer stimuli. Overall the results of Experiment 2 show that when the phases changed, so that the choice option only provided access to lower preferred stimuli whilst the no choice option provided access to a higher preferred stimulus, preference shifted to the no choice option. It can therefore be concluded that their preference for choice was outweighed by preference for higher preferred reinforcement

Fisher et al. (1997) concluded that the results from their study supported the findings from previous studies (Bambara et al., 1994; Lerman et al., 1997; Parsons et al., 1990; Smith et al., 1995) which show that the reinforcing effects of

high-preference stimuli will outweigh the reinforcing effects of access to choice. However, Fisher et al. (1997) have also shown that when access to reinforcement is held constant between the two conditions, then access to choice can increase reinforcer effectiveness.

Choosing to Choose

Fisher et al. (1997) present two possible, although not mutually exclusive, explanations for why individuals prefer a choice condition compared to a no choice condition. Firstly that when given a choice of reinforcers or tasks an individual will choose the option that is most preferred at that point in time. Therefore will prefer the choice condition as the choice condition is more likely to provide access to momentarily preferred stimuli. This is supported by Parsons et al. (1990), Smith et al. (1995) and Lerman et al. (1997), as the results of all three studies suggest that effects of choice may be due to increased access to higher preferred stimuli. Secondly that an individual with a disability will prefer choice conditions over no choice conditions, even when both options lead to the same outcome (Fisher et al., 1997). The second option presented by Fisher et al. (1997) is consistent with choosing to choose research, and perhaps the clearest indication of the reinforcing effectiveness of choice.

Choosing to choose research utilises a concurrent chain procedure. In this procedure the subject is presented with two response keys in the initial link of the chain, each of these keys is often associated with a Variable Interval (VI) schedule. Once the schedule requirements has been met on either one of the available keys, a terminal link schedule, often a Fixed Interval (FI) schedule is made available. Access to reinforcement is provided at the conclusion of the terminal link. The studies in this area have used a free-choice option, where two or more alternatives are available to choose from in the terminal link, and a forced-choice option,

where only one alternative is available in the terminal link. Each of the two terminal link options is assigned to one of the initial link keys. Preference for the options available in the terminal links is determined by examining the proportion of responding during the initial link schedules (Suzuki, 2000). This has been investigated with humans (Suzuki, 1997; 2000) and animals, namely pigeons (Catania, 1975; Catania & Sagvolden, 1981; Hayes, Kapust, Leonard & Rosenfarb, 1981). A number of factors in the terminal links have been manipulated, including the number of stimuli available in the terminal links (Suzuki, 2000), magnitude of reinforcement (Hayes et al., 1981; Suzuki, 1997) and delay to reinforcement (Hayes et al., 1981).

Hayes et al. (1981) investigated how magnitude of reinforcement and delay to reinforcement affected preference for free-choice alternatives in pigeons. In their study the free-choice terminal link consisted of two concurrently available alternatives in the free-choice terminal link. One alternative, red key, provided immediate access to reinforcement for T seconds (2 s, 1 s, .5 s, .25 s), and the other alternative, green key, provided delayed access to reinforcement for 4 seconds. The forced-choice terminal link provided only delayed access to reinforcement, the green key. Each session consisted of 50 trials; 20 forced trials followed by 30 free trials. During free trials both initial link keys were illuminated and the subjects were free to choose; during the forced trials each initial link key was presented randomly 10 times. A single peck on an initial link key or a terminal link key ended the current schedule; inter trial blackouts were calculated in each trial so that they were equal regardless of which terminal link option was selected.

The results of Hayes et al. (1981) experiment show that at higher values of T (longer access to reinforcement), preference for the free-choice was generally

very strong and the selection of red, when given the choice between the red and green alternatives, was universal. However as the value of T was reduced, subjects began to prefer the forced-choice option and began to select the green key during the free-choice terminal links.

A number of potential problems were identified in this experiment, namely the possibility that positional preferences may have accounted for the results, as the positions of red and green in the terminal links were fixed. This issue was addressed in Experiment 2 by randomizing the position of the red and green keys in the terminal links from trial to trial. The subjects continued to prefer the forced-choice option. Furthermore when the forced-choice initial link key was shifted from left to right, the subject tracked the forced-choice initial link key. A final experiment also demonstrated that the presence of a second key was not aversive; therefore did not affect preference.

Hayes et al. (1981) findings are similar to that shown by choice making research (Bambara et al., 1994; Fisher et al, 1997; Lerman et al., 1997; Parsons et al., 1990; Smith et al., 1995). The results from Hayes et al (1981) support the premise that access to more rewarding stimuli, in this study longer access to reinforcement, outweighs the reinforcing effects of access to choice.

Suzuki (1997) also investigated this area with human participants. The participants were required to complete computer-based tasks, where points were earned that were later exchangeable for money. During the initial link schedule the participants were required to select of one of two green rectangles available on the screen. Both free-choice (two triangles) and forced-choice (one triangle) alternatives were available to the participant following the completion of the initial link. During the terminal links the participants were required to select a triangle from the available options. Consistent with findings from previous studies

(Bambara et al., 1994; Hayes et al., 1981; Fisher et al., 1997; Lerman et al., 1997; Parsons et al., 1990; Smith et al., 1995) Suzuki (1997) found that if the amount of reinforcement, number of points, available in the free-choice option was equal to or of greater value, than the forced-choice condition, then the free-choice option was preferred over the forced-choice option. However, when the free-choice alternatives resulted in smaller reinforcement, less points, than the forced-choice alternative, then there was no difference in preference between the free-choice and forced-choice options.

Suzuki (1997) also investigated the preference for the free-choice option, when the number of alternatives available was manipulated. The results showed that the participant's preference for free-choice option increased as the number of alternatives increased, provided that the alternatives were of equal or greater value to the forced-choice option. In this initial study the number of alternatives available to the participants in the free-choice terminal link was either two or three. Suzuki (2000) later extended this study by increasing the number of alternatives available in the free-choice condition to either two or five. Suzuki's (2000) experiment was conducted using the same computer-based task as their earlier study. Suzuki (2000) also showed that the degree of preference for the free-choice task was dependant on the number of alternatives available.

The above choosing to choose research manipulated various aspects in the procedure, including delay to reinforcement, magnitude of reinforcement and number of available stimuli. Catania and Sagvolden (1980) investigated whether pigeons preferred the free-choice option when all aspects of reinforcement were held constant. In each of the available terminal link alternatives all factors, including stimulus number, stimulus variety and information, were held constant. In the free-choice terminal link, three of the four keys were illuminated green, and

one was illuminated red. In the forced-choice terminal link, three of the keys were illuminated red and one of the keys was illuminated green. The green keys all led to 3-s access to food reinforcement, pecks on the red keys had no scheduled consequences. The free-choice option was alternated from the left to right initial link key.

Preference for the free-choice option, shown by higher proportions of responding on the initial link key associated with the free-choice terminal link, was observed throughout their study. In the first experiment, terminal link increased (FI 10-s, FI 20-s and FI 30-s) over successive pairs of conditions and the position of the odd coloured key in the terminal link was random. The results showed that the magnitude of preference shift increased over successive conditions for two out of the four participants. In the second experiment the position of the odd coloured terminal link key was fixed. As with the first experiment corresponding shifts in responding from the left to right initial link key, following the free-choice option, were observed.

Overall the findings presented by Catania and Sagvolden (1980) show similar results to Fisher et al.'s (1997) research on the reinforcing effectiveness of choice, this was that, when reinforcement between the available options remains constant, a preference for free-choice is evident. This study was an extension of Catania's (1975) study which also investigated preference for choice, when the value of reinforcement is held constant.

Catania (1975) conducted three experiments; of relevance to the present study is the initial experiment. Experiment 1 investigated preference for free-choice versus forced-choice using a concurrent chain procedure with pigeons. In the free-choice option, two differently coloured keys were available to choose from. In the forced-choice option one key, which alternated in colour or position,

was available to the subject. The initial link keys operated on a VI 30-s schedule and the terminal link keys all operated on a FI 20-s schedule. Reinforcement was the same regardless of what alternative it was earned on. The results of Catania's (1975) Experiment 1 were that the subjects preferred the free-choice option over the forced-choice option, demonstrated by higher proportions of responding on the initial link key associated with the free-choice terminal link. Thus, although there is some research that shows that choice is preferred, there are not a large number of studies or participants and so the findings do deserver replication.

Experiment 1

The aims of the present experiment were to replicate Catania's (1975) Experiment 1, extend the findings to another species and to demonstrate that when all aspects of reinforcement are held constant, an organism will prefer free-choice over forced-choice. It was hypothesised that the subjects would demonstrate a corresponding shift in preference as the free-choice option was moved from the left terminal link to the right terminal link across conditions.

Method

Subjects

Six Brown Shaver hens, numbered 11.1 to 11.6, were used in the present experiment. Each hen was individually housed in a wire cage measuring 450-mm high, 510-mm wide and 450-mm long. Water was freely available to every hen, ad libitum, in the home cage. Vitamins and grit were provided weekly. The aim was to maintain the hens at 80% (+/- 5%) of their free feeding body weight. The hens were approximately forty two months old at the start of the experiment, and had been previously used in an experiment using a five key chamber similar to the six key chamber used in the present experiment.

Apparatus

Sessions were conducted in a chamber that was 650-mm long, 550-mm high, 410-mm wide and painted white internally. The floor of the chamber was lined with a metal tray (48cm long and 40cm wide) with a rubber mat placed inside the tray (45cm long and 30cm wide). Within the chamber there were six circular response keys made of semi-translucent Perspex and backlit using LED bulbs in a range of colours. Each Perspex key was 30 mm in diameter and was surrounded by an aluminium plate. The six keys were attached together in a row as illustrated in Figure 1; there was 200-mm of metal plate between each of the keys. The distance from the top of the keys to the top of the plate was 70mm and from the bottom of the keys to the bottom of the plate was 35-mm. The plate of keys was situated on the front wall of the chamber; the distance from the top of the plate to the top of the chamber was 40-mm.

In order for a response on any of the key to be effective, a force of 0.1 N (10 g) was required. Each effective response was followed by a brief audible

feedback beep provided by an electronic beeper, situated centrally behind the keys. Responses made to unlit keys had no scheduled consequences.

Situated on the front wall, 140-mm beneath the response keys was an open square 100-mm high and 70-mm wide, which provided 3-s access to reinforcement when the food hopper was raised. The hopper was part of an external magazine, which contained wheat. Each magazine was manually filled with the wheat when required. During the 3-s reinforcer access period, all key lights were extinguished and the response keys became inoperable. A 1-W white bulb, situated 30 mm above the hopper, illuminated the reinforcer during periods of reinforcement access. The light from the response keys and the food hopper were the only sources of illumination in the experimental chamber.

Procedure

Sessions were conducted daily. The hen was removed from her home cage and placed in the experimental chamber. The programme was then started manually by the experimenter. Key 2 and Key 5 (initial link keys), were then illuminated white, as shown by Figure 2. Both initial link keys were running on concurrently operating independent VI 30-s schedules. As the initial link schedules were run independently, the availability of the terminal link on one initial link schedule had no impact on the availability of the terminal link associated with the other initial link schedule (Sumpter, Foster & Temple, 2002). Once a terminal link entry was available the first response on the initial link key, associated with the available terminal link schedule, resulted in the initial key lights being extinguished and the appropriate terminal link key lights being immediately illuminated. The terminal link keys were the first, third, fourth and

Figure 1: Photo of Experimental Chamber and Keys

sixth keys in the chamber. The terminal link key colour and key position for each of the ten conditions are shown in Table 1.

All of the terminal link keys operated on a FI 20-s schedule of reinforcement. Following the conclusion of the 20-s interval, the first peck on an illuminated key resulted in the terminal key lights being extinguished and reinforcement, 3-s access to wheat, beginning. However, if a changeover occurred, responding shifting from one available key to the other within the terminal link, then the first response had no scheduled consequences but the second response led to reinforcement. Pecking on keys that were not illuminated had no scheduled consequences. After the terminal link schedule had concluded and reinforcement was given, the initial link key lights were once again illuminated.

During reinforcement all key lights were extinguished and the light above the food hopper was illuminated. Daily sessions were concluded after the initial link schedules had been available for 15 min. Initial link timing was stopped while the terminal link schedules and reinforcement were in effect. At the conclusion of the daily session the hen was removed from the experimental chamber and returned to the home cage, post-session feed was then calculated and provided if necessary.

During the baselines conditions the left initial link lead to Key 1 or Key 2 being illuminated yellow in Condition 1, and blue in Condition 2. The key that was illuminated was randomly alternated at the start of each terminal link. The right initial links lead to Key 4 or Key 6 being illuminated red in Condition 1, and green in Condition 2.

During Conditions 3 and 5 the left initial link led to the free-choice option. In both conditions during the free-choice option Key 1 was illuminated yellow, and Key 3 was illuminated blue, or vice versa. At the start of each terminal link

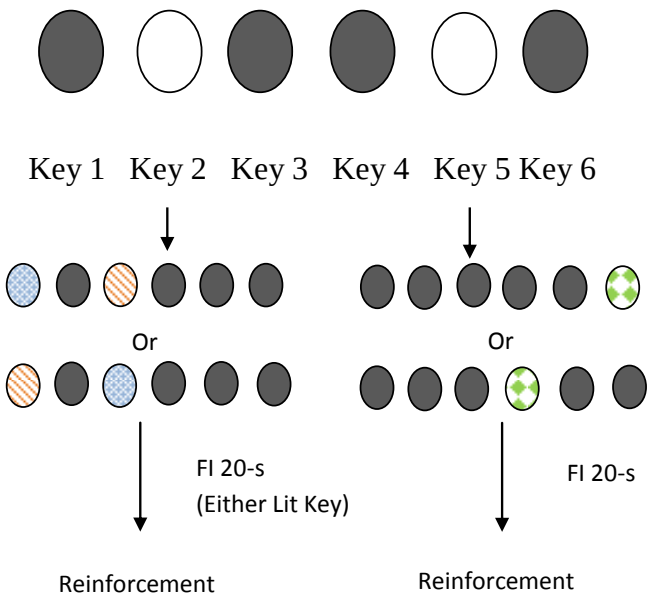


Figure 2: Example of Concurrent Chain

Table 1: Key light colour and positions for each condition

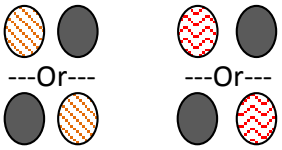
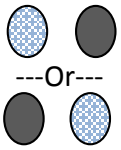
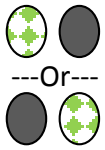
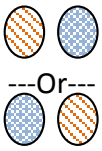
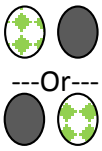
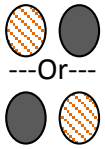
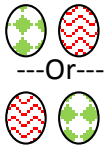
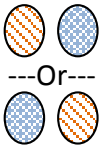
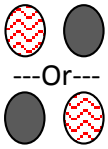
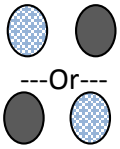
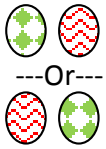
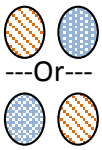
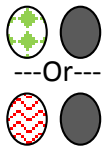
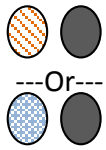
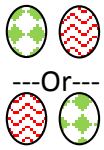
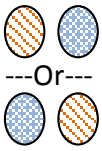
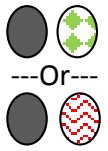
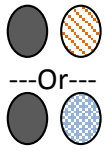
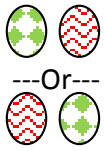
	Terminal Link		*Condition*	*Terminal Link*		*Condition*
	Left	*Right*	*Number*	*Left*	*Right*	*Number*
Baseline- No Choice			1			2
Forced Choice- Colour			3			4
			5			6
Forced Choice- Position			7			8
			9			10

*Table 2***:** Number of sessions per condition during Experiment 1

Condition Number	1	2	3	4	5	6	7	8	9	10
Number of Sessions	7	7	14	14	14	14	6	7	7	7

the key lights were randomly alternated between the two possible colour combinations. The right terminal link lead to the forced-choice option. If the right hand initial link was activated then Key 4 or Key 6 would illuminate green in Condition 3, and red in Condition 5. At the start of each terminal link the key that was illuminated was randomly alternated.

During the Condition 4 and 6 the left hand initial link led to the forced-choice option. If the left initial link was activated then Key 1 or Key 3 was illuminated yellow in Condition 4, and blue in Condition 6. At the start of each terminal link the key that was illuminated was randomly alternated. During both conditions the right initial link led to the free-choice option. During the free-choice option the Key 3 was illuminated red and Key 6 was illuminated green or vice versa. At the start of each terminal link the key lights were randomly alternated between the two possible colour combinations.

During Condition 7 and 9 the left hand initial link led to the free-choice option. In both conditions during the free-choice option Key 1 was illuminated yellow and the Key 3 was illuminated blue, or vice versa. At the start of each terminal link the key lights were randomly alternated between the two possible colour combinations. The right hand initial link lead to the forced-choice option. If the right hand initial link was activated then Key 4 in Condition 7, and Key 6 in Condition 9, was illuminated red or green. At the start of each terminal link the key lights were randomly alternated between the two possible colours.

During Condition 8 and 10 the left hand initial link led to the forced-choice option. If the left hand initial link was activated then Key 1 in Condition 8, and Key 2 in Condition10, was illuminated blue or yellow. At the start of each terminal link the key lights were randomly alternated between the two possible colours. During both conditions the right initial link lead to the free-choice option.

During the free-choice option Key 4 was illuminated red and Key 6 was illuminated green or vice versa. The key lights were randomly alternated between the two possible colour combinations.

Results

Proportion of responses

Proportion of left responding is shown on Figure 3, plotted against condition number, for each subject. Each point represents the average proportion of pecks on the left key (Pecks L/(Pecks L + Pecks R) during the initial link schedules for each condition. Increases and decreases, shown on the graph, correspond to shifts in preference towards the left or right terminal link respectively. Conditions 1 and 2 were the baseline conditions. Conditions 3, 5, 7 and 9 were those with the free-choice terminal link on the left side. Conditions 4, 6, 8 and 10 were those with the free-choice terminal link on the right side.

Data from the two baseline conditions showed a relatively stable proportion of left responding for Hen 11.1, Hen 11.5 and Hen 11.6. A decrease in the proportion of left responses between Condition 1 and Condition 2 is shown for Hen 11.3 and 11.2 and an increase is shown for Hen 11.4. Hen 11.1, 11.2, 11.4 and 11.5 showed baseline levels of responding of approximately .6. Hen 11.3 and 11.6 showed baseline proportions of responding of approximately .4. For 4 of the 6 subjects an increase in the proportion of left responses above baseline levels were observed following the introduction of the free-choice option on the left terminal link in Condition 3.

There were systematic increases and decreases in the proportion of left responding observed across successive experimental conditions (3-10) for the majority of the subjects. These increases and decreases in proportion of left responding demonstrated a shift in responding toward the free-choice terminal link. One way to assess the measure of preference for the free-choice option is to count the number of occasions that preference moved in the anticipated

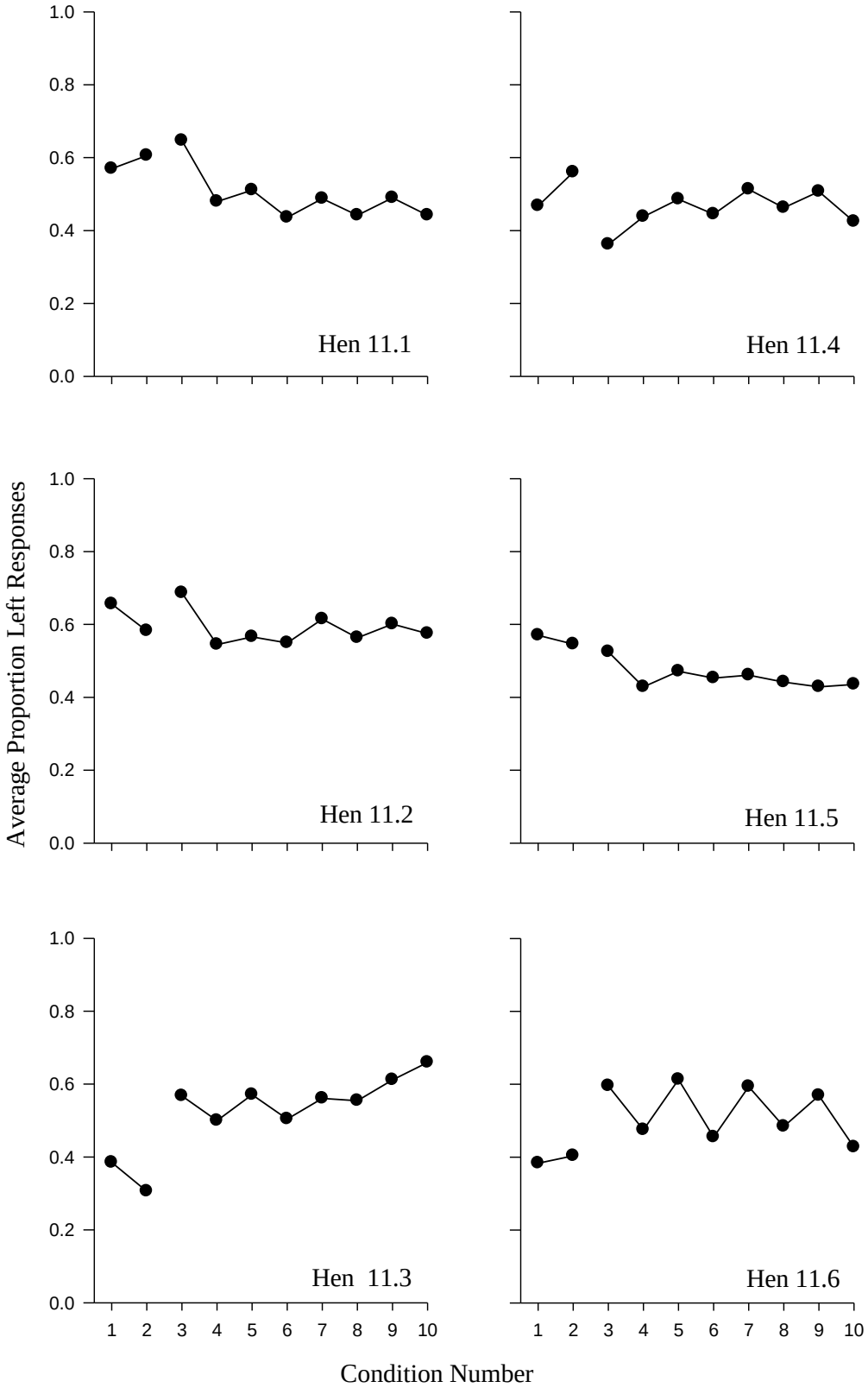


Figure 3: Average Proportion of Responding on Left Initial Link Key across Successive Conditions

direction, increase in proportion of left responses during free-choice left conditions and decrease in proportion of left responses during free-choice right conditions, compared to the total number of opportunities. Thus if the preference alternates over conditions on every occasion it is clear that the animals are pursuing the free-choice option. This measure was that used by Catania (1975). Of 42 possible alternations in preference between Condition 3 and Condition 10, 38 alternations in hypothesised direction occurred.

Where data trend across conditions, this can produce a misleading description of the variance between successive conditions. More desirable is to analyse local variance, which is calculated by taking the magnitude of difference between successive conditions and averaging these. This local variance produces the best measure of the animal's preference for the free-choice option. The average local variance was largest for Hen 11.6 (.127) and smallest for Hen 11.5 (.024).

Proportion of time

Figure 4 shows the average proportion of time spent on the left initial link key, plotted against condition number, for each subject. For all 6 subjects the function of average proportion of time was similar to the function of average proportion of responding across all ten conditions. Of 42 possible alternations in preference, between Condition 3 and Condition 10, 32 alternations in the hypothesised direction occurred.

Latency to first peck in terminal link

Figure 5 shows the average latency to the first peck in the free-choice and forced-choice terminal links, plotted against condition number. There was a clear overall trend which demonstrated that the time to the first peck was higher in

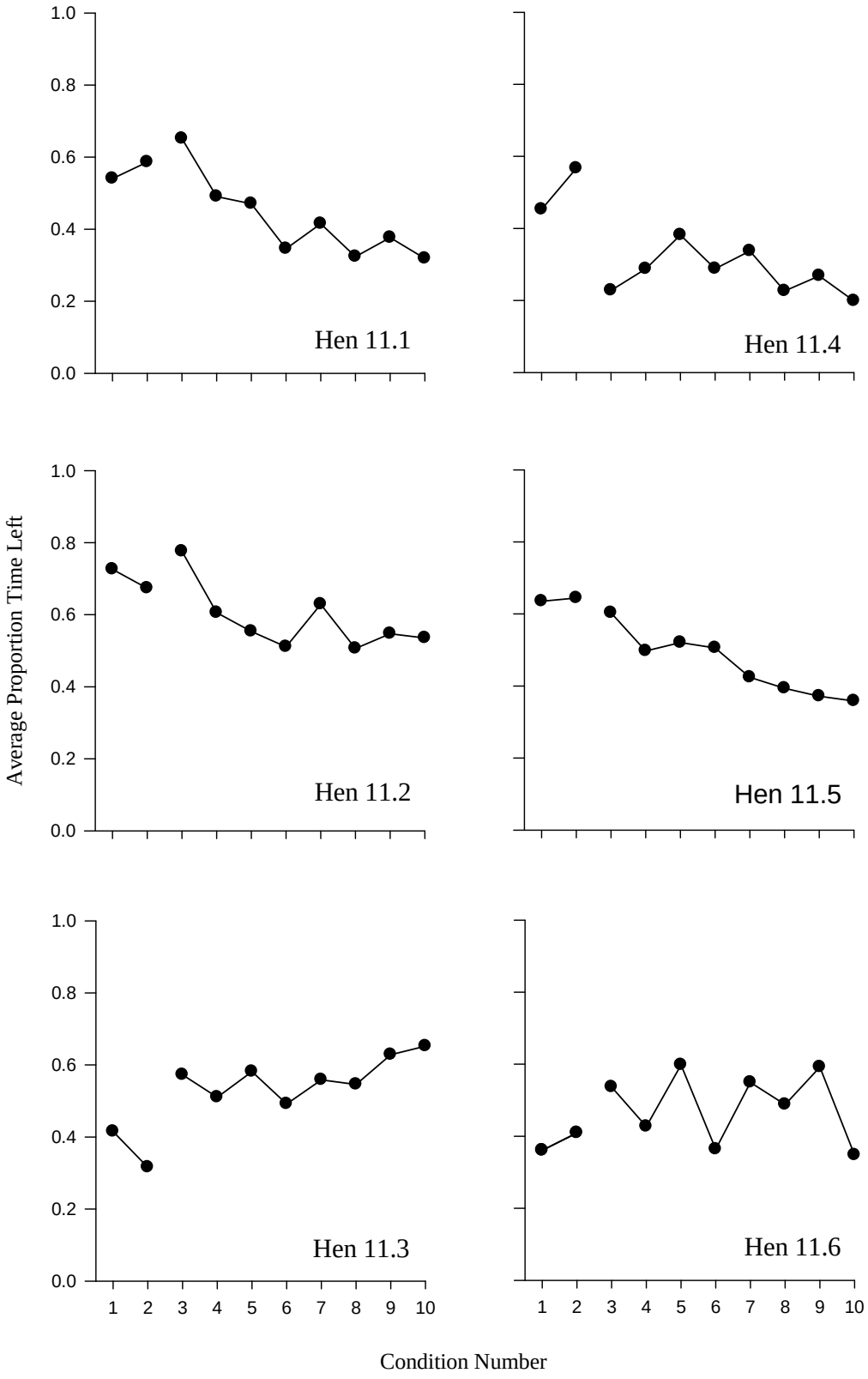


Figure 4: Average Proportion Time Spent of Left Initial Link Key across Successive Conditions

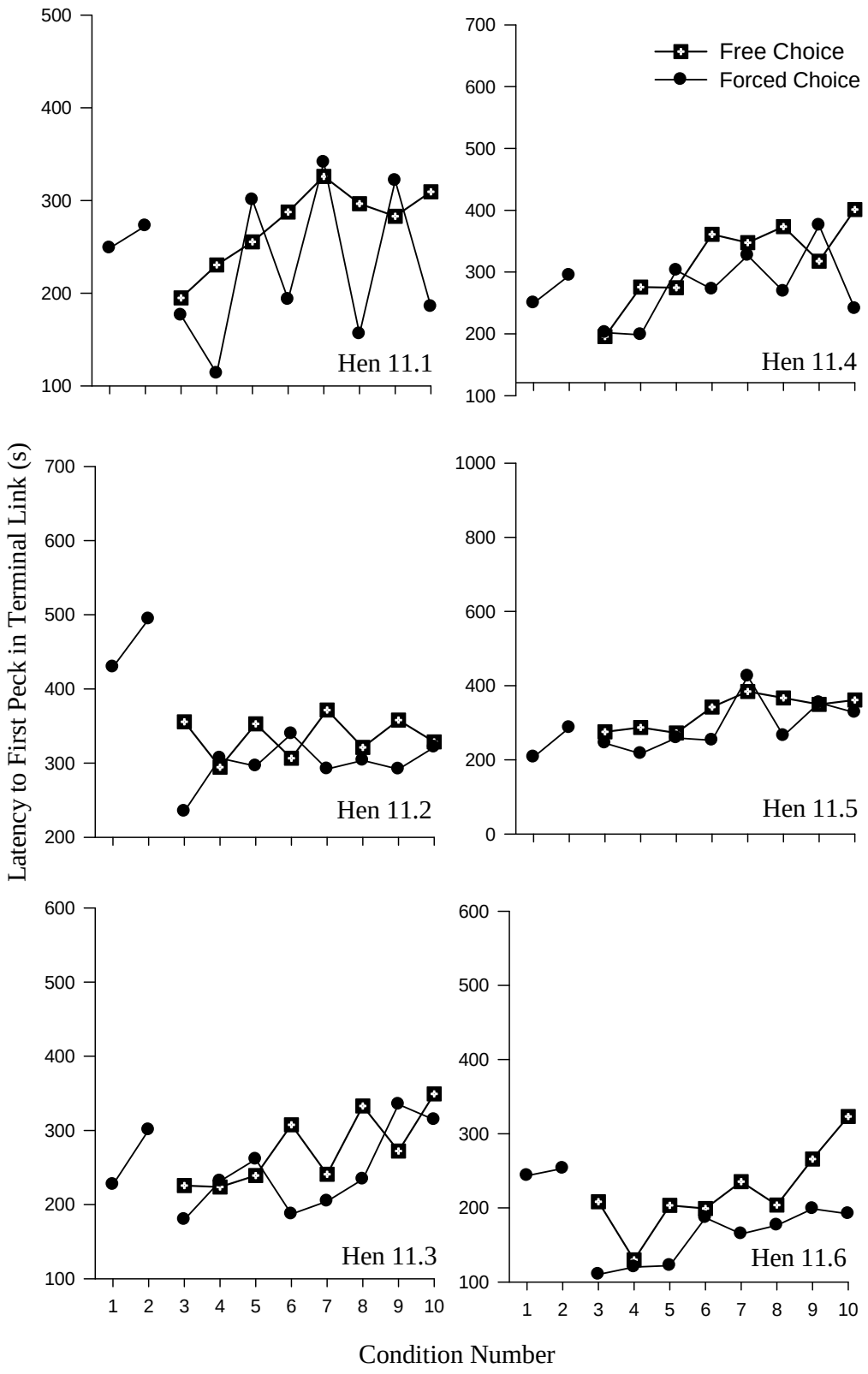


Figure 5: Average Latency to First Peck in Free-Choice and Forced-Choice Terminal Links across Successive Condition

the free-choice terminal links compared to the forced-choice terminal links. This effect was shown for all subjects across most conditions. Out of 48 conditions, for all subjects in the present experiment, latency to first peck was higher in the free-choice terminal link in 33 of the conditions. This effect was most evident for Hen 11.6, as the latency to first peck in the free-choice terminal links was higher than the forced-choice terminal links across all conditions.

Initial link changeovers

Figure 6 shows the average number of changeovers that occurred between the two initial link keys, plotted against condition number for each subject. Overall a general upward trend can be observed for the majority of subjects; this trend was most evident in the data of Hen 11.5. Equally high levels of changeovers were also observed in the data of Hen 11.4 where there was a steady upward trend across the first seven conditions, before the number of changeovers reduced during the final three conditions. Hen 11.5 also demonstrated the largest range of initial link changeovers between conditions with a range of approximately 80-200. Hen 11.1 demonstrated the smallest range, 40-70, between conditions. Hen 11.6 was the only subject whose data did not trend even slightly upward. For Hen 11.6 the number of initial link changeovers decreased in early sessions, before increasing back to baseline levels over the final four conditions.

Terminal link changeovers

Figures 7 shows the average number of changeovers that occurred in the terminal links, plotted against condition number, for each subject. For the majority of subjects changeovers occurred at a relatively low rate across all of the conditions. Hen 11.1 demonstrated the highest numbers of changeovers during the terminal links across all conditions. Hen 11.1 also demonstrated the largest range,

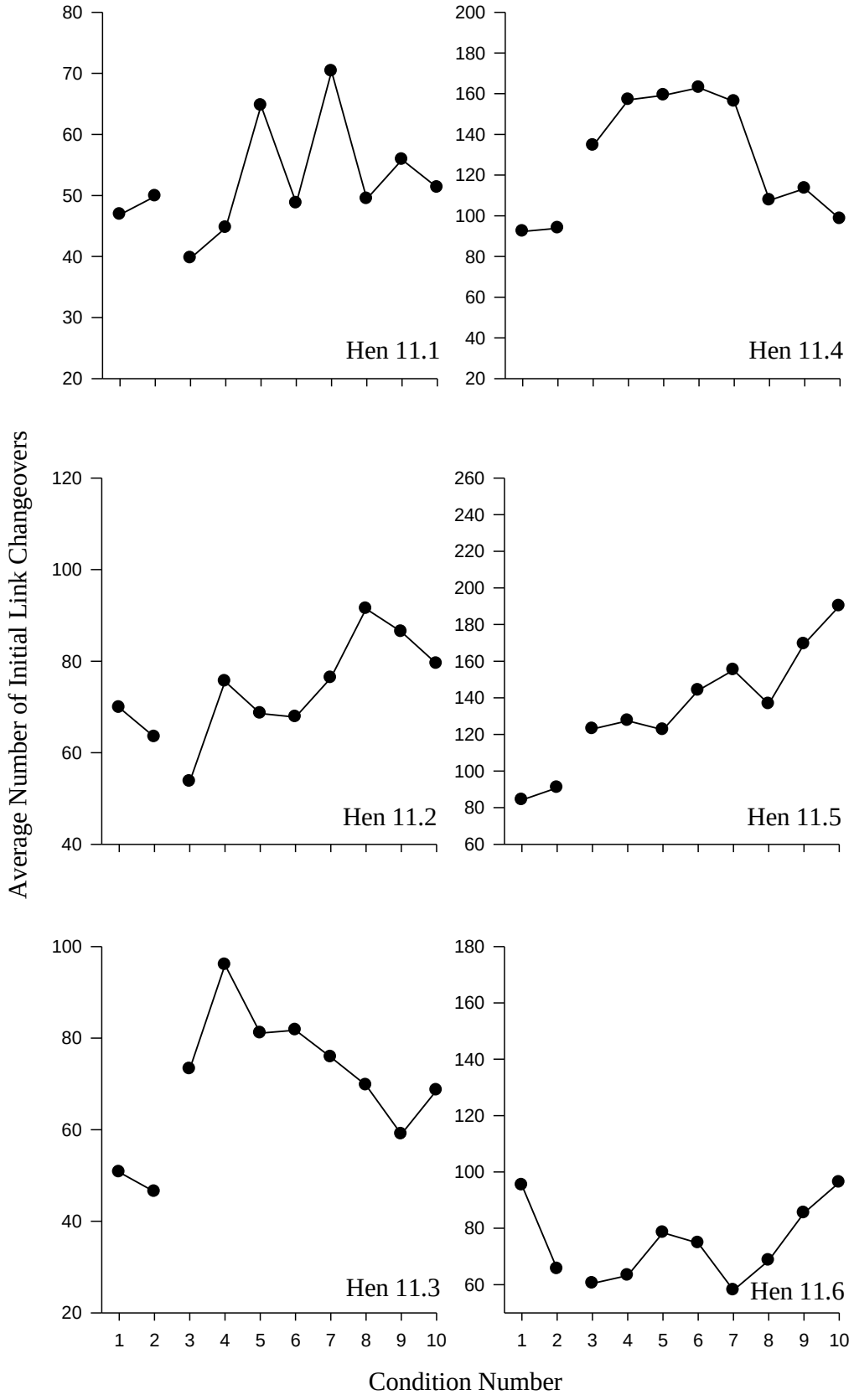


Figure 6: Average Number Initial Link Changeovers across Successive Conditions

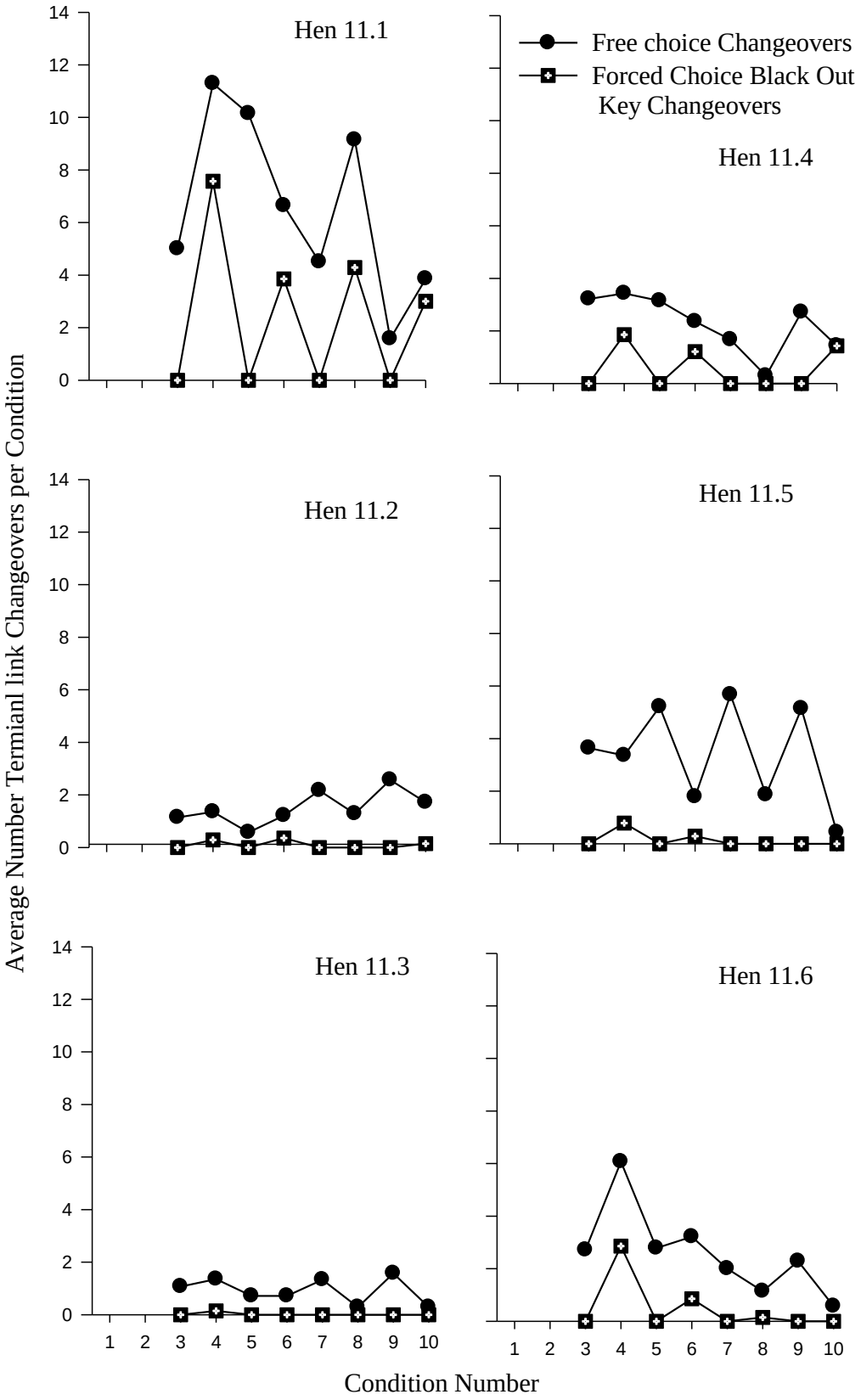


Figure 7: Average Number Terminal Link Changeovers across Successive Conditions

2 to 12, between conditions. The general trend of the data shows that the average number of changeovers per condition decreased as the experiment progressed.

During the forced-choice terminal link the subjects also changed over between the available lit key and black out keys, which had no scheduled responses (black out key changeovers). Black out key changeovers occurred only in conditions where the forced-choice option was associated with the left terminal link. Of 24 forced-choice conditions, for Hen 11.1-11.6, black out key changeovers occurred in 15 conditions. Hen 11.1 demonstrated relatively high (range of approximately 4-8) numbers of black out key changeovers. The remaining subjects demonstrated much lower levels of black out key changeovers. As with changeovers in the free-choice terminal links, the general trend of the data shows that the average number of changeovers in the forced-choice terminal link decreased as the experiment progressed.

Relationship between initial link and terminal link changeovers

Inspection of Figure 6and Figure 7 shows no relationship between responding patterns of changeover responding. Subjects, who had higher levels of initial link changeovers, did not have higher levels of changeovers in the terminal links.

Terminal link behaviour

The proportion of responses on the left key and on each key colour, in the terminal links, for each session and each subject were plotted and are presented in Appendix B. Hen 11.1 and 11.2 demonstrated a right key bias, during the free-choice terminal link, regardless of the colour of the key. Hen 11.3 demonstrated a key colour bias, regardless of key position, for the yellow key when it was available in the free-choice terminal link (Conditions 3, 5, 7 and 9) and the green key when it was available in the free-choice terminal link (Conditions 4, 6, 8 and

10). During the initial five conditions Hen 11.4 demonstrated no clear across conditions trends; however, within session trends with both key colour bias, and key position bias were observed. During the final five conditions a trend did emerge, showing a bias toward the left key during free-choice right terminal links, and the right key during free-choice left terminal links. Hen 11.5 also demonstrated this pattern of behaviour. Hen 11.6 showed a bias towards the left key on free-choice right terminal links. However, on free-choice left terminal links both a key position and a key colour bias were observed across sessions.

Number of sessions per condition

During Conditions 3-6 sessions ran for 14 days per condition. However when the data averages were compared for the first 7 days compared to all 14 days the differences were not significant, shown by Figure 8. It was therefore decided that we could reduce the number of sessions to 7, without affecting the results of the study. Over the final conditions of the experiment, for the majority of the subjects, no changes in responding were observed. However, for Hen 11.3, once the number of sessions had been reduced to 7 days per condition from Condition 7 onwards, preference for the free-choice option, which was previously evident, disappeared.

Free-choice terminal links compared to free-choice changeovers

Figure 9 shows the average number of terminal link changeovers compared to the average number of free-choice reinforcers earned per condition. Overall the number of terminal link changeovers was much lower than the number of free-choice reinforcers earned. This effect was shown by all subjects, across all conditions.

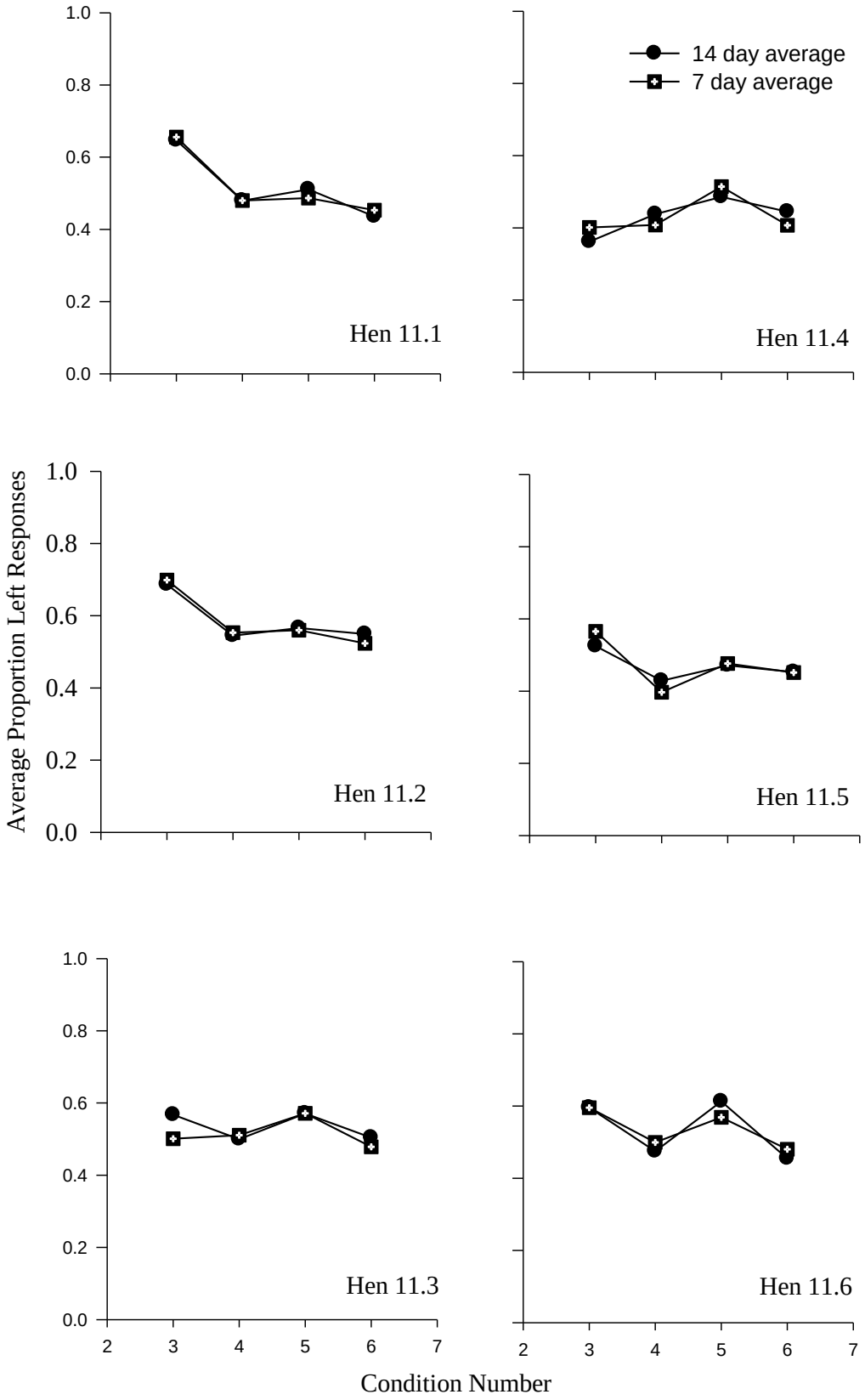


Figure 8: 14 day versus 7 day Average Proportion of Left Responding across Successive Conditions

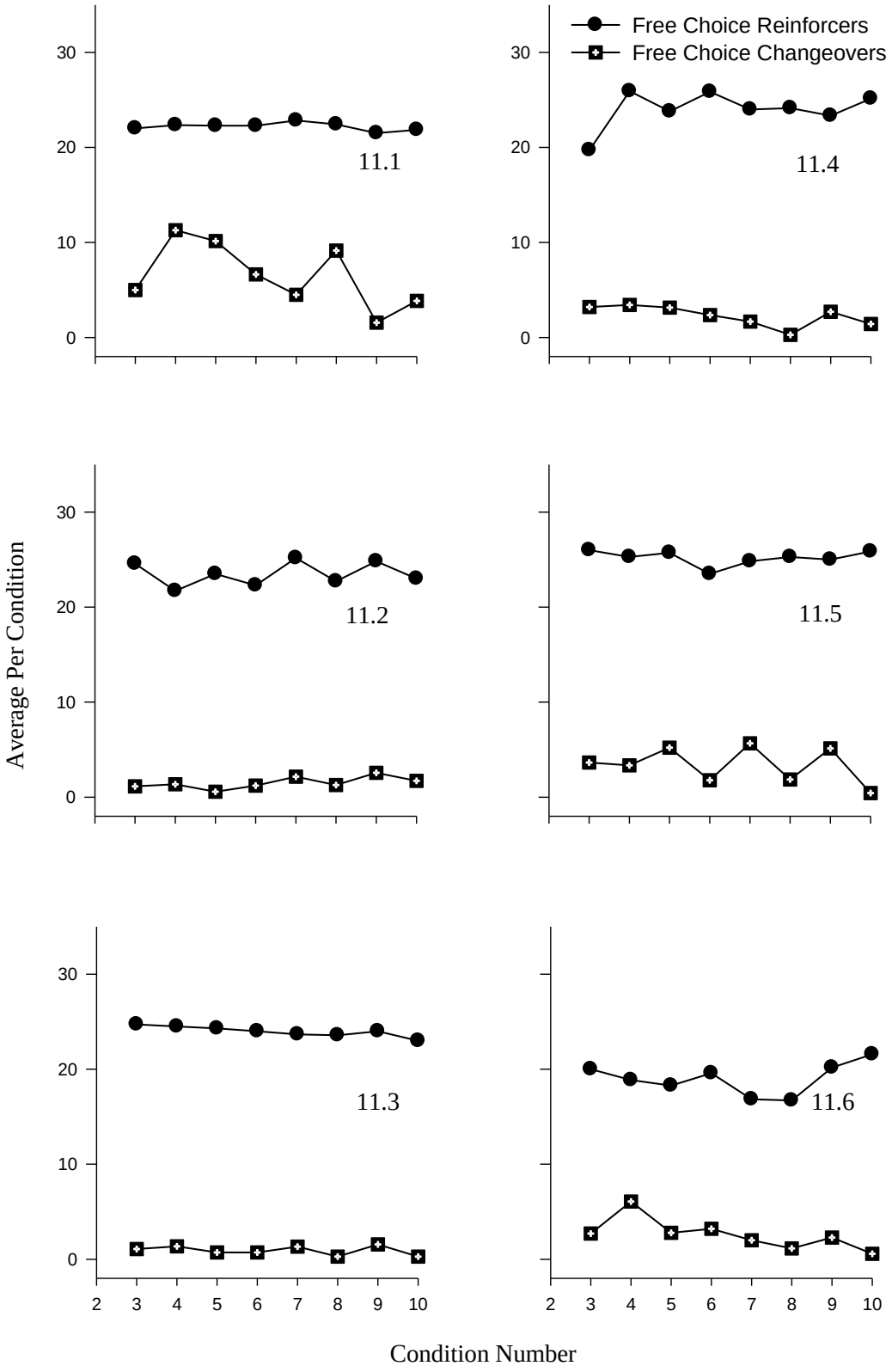


Figure 9: Average number of Reinforcers earned versus Average Number of Changeovers on Free-Choice Terminal Link

Ratio of entries to the terminal link

Figure 10 shows the entry ratio for the free-choice and forced-choice terminal links, plotted against subject number. The entry ratio is shown by proportion of reinforcers received from the left terminal link. As shown by the graphs, the entry ratios varied not only between conditions for each subject, but also across subjects.

Hen Weights

Graphs showing the daily weight of each subject for the duration of Experiment 1 are presented in Appendix B. For Hen 11.1 and 11.2 the daily weights remained within the (80% ± 5%) weight band for the duration of the experiment. Hen 11.3 remained within the weight band for the majority of the first experiment before increasing to above the weight band near the end of the experiment. Hen 11.4 largely remained within the weight band for the duration of the experiment, with short periods of time above and below the weight band. Hen 11.5 remained above the weight band for the majority of the experiment; however, this weight increase was due to reinforcement received during the experiment as no post-feed was provided. Hen 11.6 remained within the weight band for the majority of sessions, with some days below the lower weight band.

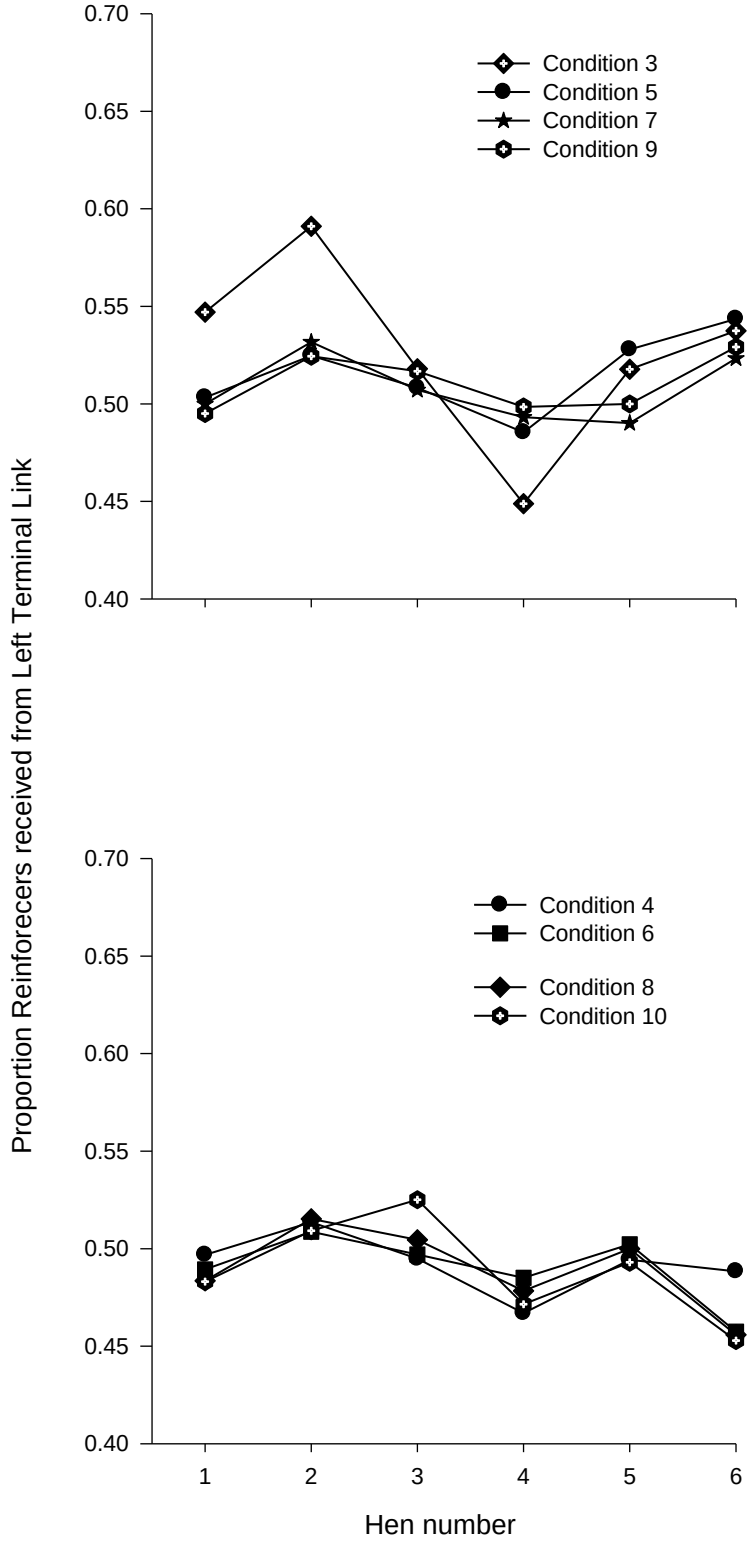


Figure 10: Average Entry ratios in Free-Choice and Forced-Choice Conditions across subjects

Discussion

Catania's (1975) results have been presented, shown in Figure 11, in the same format as the present experiment to allow appropriate comparisons to be made. In this experiment 5 out of the 6 subjects showed a pattern of responding similar to that of Catania's (1975). Of the present 6 subjects, one showed an average local variance similar to 2 out of 3 subjects from Catania (1975). Two of the remaining subjects in the present experiment showed an average local variance similar to that of Catania's third and final subject. The sixth subject, here, demonstrated a much lower average local variance than any of Catania's subjects.

In the present study, of 42 possible alternations in preference between Condition 3 and Condition 10, 38 alternations were in the predicted direction occurred (90.4%). In the relevant conditions from Catania's (1975) study of 21 possible alternations 20 (95.2%) occurred in the hypothesised direction. Thus a stronger effect is shown in Catania's study than in the present experiment. However, if the data from Hen 11.5 from the present experiment, who did not show preference for the free-choice option, is removed then of 35 possible alternations 33 (94.2%) occurred in the correct direction. Overall it can be concluded that this experiment successfully replicated preference for the free-choice option, shown by Catania's (1975) subjects, for most subjects in the present experiment.

In Catania's (1975) study prior to the data being collected for the ten conditions shown in Figure 11, 144 pilot sessions had been conducted with the subjects, which examined schedule parameters and other procedural details. The subjects from the present experiment were only exposed to 14 days of training on the baseline conditions, and were not exposed to the free-choice option at all prior to Condition 3, before the data presented in Figure 3 were collected. Therefore, it

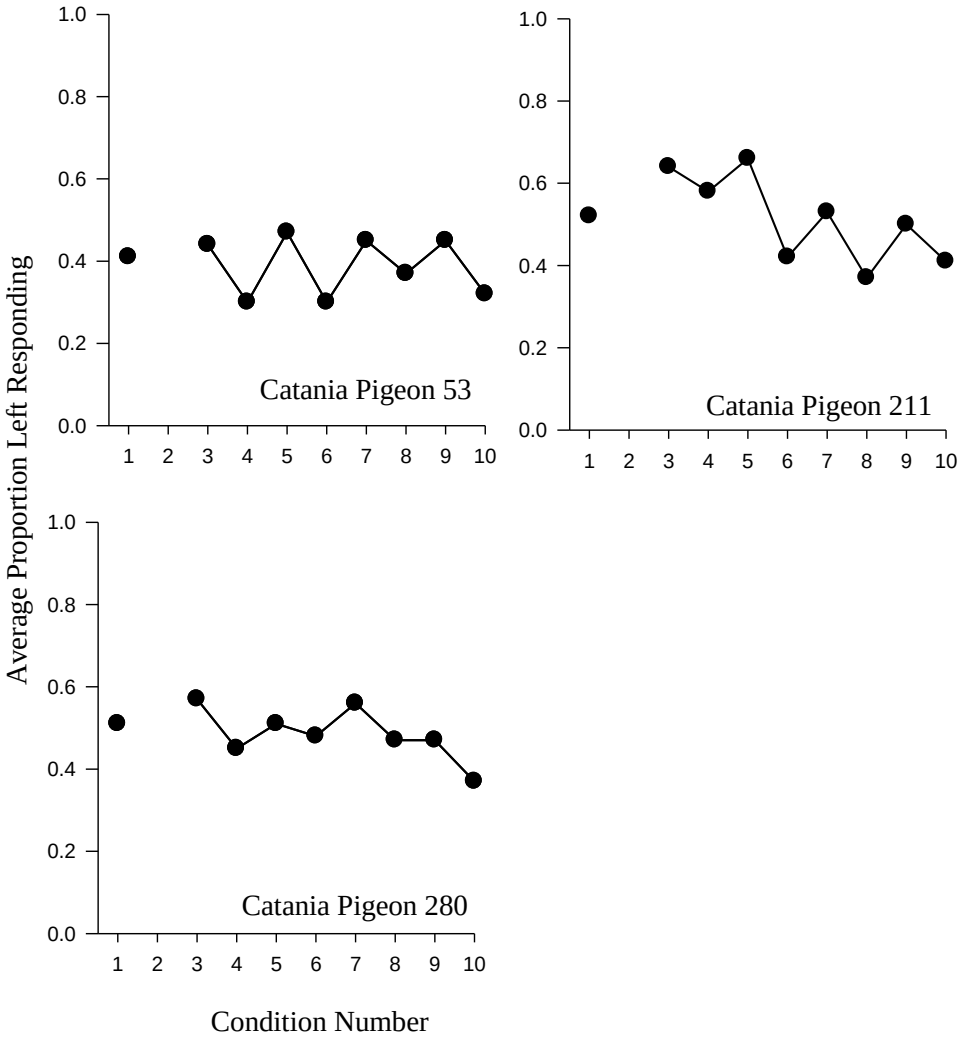


Figure 11: Average Proportion Responses on Left Initial Link Key across Successive Conditions from Catania (1975)

could be argued that the size of the effect shown in Catania's (1975) study compared to the present study could be attributed to the different amounts of prior exposure that the participants had had to the experimental procedure.

Following the decrease in number of sessions per condition, from 14 sessions to 7, 1 subject's preference for the free-choice option, which was previously evident, disappeared as shown by Figure 8. It can therefore be said that that subject may have required more exposure to each condition to develop a preference for the free-choice option. This supports the above argument that the amount of exposure to the condition can affect the strength of preference for the free-choice option.

Preference for the free-choice option, as demonstrated in the present study, is supporting by other previous research. As previously mentioned, Catania and Sagvolden (1980) were also able to replicate Catania (1975) results with pigeons, showing preference for choice when reinforcement on the free-choice and forced-choice options are held constant. Suzuki (1997; 2000) also demonstrated this effect with humans, showing the human subjects preferred the free-choice option, when reinforcement available in the free-choice option is equal to or greater than reinforcement available in the forced-choice option. Therefore, the present study adds to the body of research showing this effect and extends it to a new species.

Hayes et al. (1981) discuss that it may be worthwhile distinguishing between alternatives being available to an organism, and choice being exercised by the organism. When comparing the average number of changeovers to the amount of reinforcement earned on the free-choice terminal link per session, shown on Figure 9, for each subject, it is clear that the changeovers between the available keys in the terminal link occurred at a relatively low rate across all of the

conditions. This shows that the hens responded almost exclusively on one of the available keys during each of the terminal links. Thus it can be concluded that on average the subjects rarely used the choice that was made available to them by the experimental procedure. However, simply having the option to choose must still have some reinforcing effectiveness as a clear preference for the free-choice option is observed in spite of the choice not being utilised frequently.

There were individual differences in terminal link key responding between the subjects, both in terms of the biases that they developed, whether it be a key colour or key position bias, and in the number of terminal links in a session where they responded on both of the available keys. Although there were both key position and key colour biases present in terminal link responding in the present experiment, we can conclude that it had no impact on the overall results, demonstrating the preference for free-choice effect, as the procedure systematically altered the colour and position of the terminal link keys.

The present experiment found that the latency to first peck was longer in the free-choice terminal links, when responding was available on two keys, than in the forced-choice terminal where only one key was available for responding. Although the colour and position of the stimuli were different in the terminal links, the same numbers of stimuli were available, i.e., 2 lit keys, as in the initial link. During the initial link schedules the choice between the two keys resulted in significantly different consequences, although this choice was irrelevant in the terminal link schedules, the subjects responding may be affected by stimulus control from the initial link schedules.

Aside from the pilot sessions, procedurally the present study replicated Catania (1975). As with Catania's (1975) study during the present experiment there were no differences in immediacy to reinforcement. Both terminal links ran

on a FI 20-s schedule, for all 10 conditions. Nor were there any differences in the magnitude of reinforcement across all conditions. Therefore, as concluded by Catania (1975), any changes in responding during the conditions should only be a result of preference for the available options.

During the present experiment the initial links ran on an independent concurrent chain schedule. The subjects were therefore free to respond on either initial link freely, regardless of whether or not the variable interval timer had expired on the other key. This led to the possibility that entry ratios (number of reinforcers earned on either side) could become uneven, which in turn may have an effect on initial link response patterns. Figure 8 demonstrates that there was some variability in the number of reinforcers received from each terminal link across conditions. In order to rule out that this had any effect on the present experiment's results the following experiment investigated the effects of a method to balance the entry ratios for each subject.

Experiment 2

In the previous experiment the two available initial link keys ran on an independent concurrent chain schedule. The subjects were therefore free to respond on either alternative, and to gain terminal link entry regardless of the state of the VI schedule on the other initial link. This lead to the possibility that the entry ratios could become unequal, which may have affected preference for the available options, as the subject would be receiving reinforcement more frequently from one side than the other. In extreme cases it is also possible that under an independent concurrent schedule subjects could develop an exclusive preference; responding exclusively on one of the available options (Sumpter et al., 2002).

Recent studies, which have used concurrent chain procedures to evaluate preference, commonly utilise a dependent schedule design (Bron, Sumpter, Foster & Temple, 2003; Foster, Temple, Robertson, Nair & Poling, 1996; Landon, Davison, & Elliffe, 2003). The use of dependent schedules negates the possibility of an exclusive choice preference developing by keeping the relative rate of reinforcement even, as the animal is only able to respond on the initial link that is available (Sumpter et al., 2002). During a dependent schedule when one initial link times out the timer on the alternative option pauses until the available reinforcer is collected (Stubbs & Pliskoff, 1969 as cited in Sumpter et al., 2002), this ensures that each of the options are sampled at least occasionally (Sumpter et al., 2002).

It is possible however, when using a dependent schedule design, that in the occurrence of extreme preference between reinforcers, the behaviour can be maintained by the dependency alone. This is due to the fact that reinforcement for the lesser preferred option must be collected before the more preferred option can

become available. This possibility was investigated by Matthews and Temple (1979) who utilised a dependent concurrent chain schedule, in which one alternative lead to an empty feed hopper, the other lead to access to chopped hay. The results of their study showed that two of their five subjects continued to respond on both alternatives, even when one alternative resulted in an empty food hopper. The authors conclude that the dependent schedule may therefore have maintained some of the responding (Matthews & Temple, 1979). In this case responding on the lesser preferred option is required and does not reflect preference. In spite of this Matthews & Temple (1979) still believe that the dependent schedule is useful when assessing preference between two available reinforcers as it removes the issue of uneven entry ratios.

In this next experiment the original procedure was altered slightly, the initial links were now dependent VI 30-s schedules. The present experiment aimed to rule out uneven entry ratios as having an impact on the preference for free-choice effect shown in Experiment 1.

Method

Subjects

The same subjects were used as the previous experiment.

Apparatus

The apparatus was identical to the apparatus in the previous experiment.

Procedure

The key light colours and positions, for each of the ten conditions in the present experiment, were not altered from the original procedure as shown by Table 1. The number of sessions per condition are recorded on Table 3. The only change in procedure from the original experiment was to change the VI 30-s VI 30-s initial link schedules to run on a dependent schedule rather than running independently. As the schedules were run dependently in the present experiment, when access to a terminal link was available on one alternative, the timer stopped on the other schedule and remained unavailable until that alternative was completed (Sumpter et al., 2002).

Table 3: Number of sessions per condition during Experiment 2

Condition Number	1	2	3	4	5	6	7	8	9	10
Number of Sessions	7	7	7	7	7	7	6	7	10	7

Results

Proportion of Responses

Proportion of left responding, as calculated in Experiment 1, is plotted against condition number on Figure 12. Conditions 1 and 2 were the baseline conditions. Conditions 3, 5, 7 and 9 were those with the free-choice terminal link on the left side and Conditions 4, 6, 8 and 10 were those with the free-choice terminal link on the right side.

Data between the two baseline conditions showed a stable proportion of left responding for most subjects. The data for Hen 11.3 shows a slight decrease in proportion of left responses between Condition 1 and Condition 2. Hen 11.1, 11.2, 11.4 and 11.5 showed baseline levels of responding of approximately .45 to .55. Hen 11.3 and 11.6 showed baseline proportions of responding of approximately .6. For all of the subjects an increase in the proportion of left responses above baseline levels were observed following the introduction of the free-choice option on the left terminal link in Condition 3.

Systematic increases and decreases in proportion of left responding across successive conditions were observed for the majority of the conditions for Hen 11.1, 11.4, 11.5 and 11.6. These increases and decreases in proportion of left responding demonstrated a shift in responding toward the free-choice terminal link. Of 42 possible alternations in preference between Condition 3 and Condition 10, as described in Experiment 1, 33 alternations in the hypothesised direction occurred. The average local variance, as calculated in Experiment 1, was largest for Hen 11.4 (.069) and 11.6 (.064) and smallest for Hen 11.2 (.036) and 11.3 (.037).

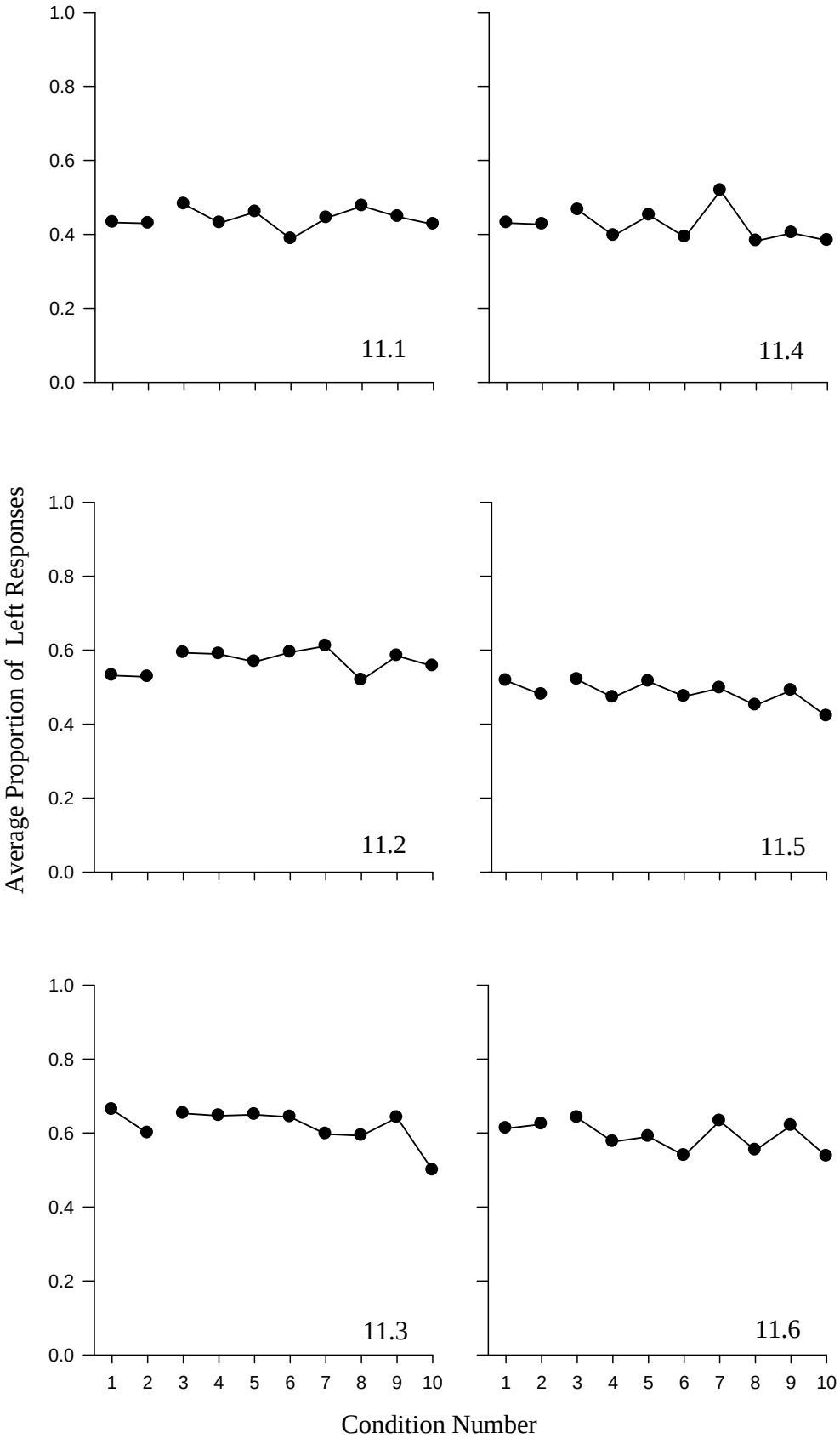


Figure 12: Average Proportion of Responding on Left Initial Link Key across Successive Conditions

Proportion of Time

Figure 13 shows the average proportion of time spent on the left initial link key, plotted against condition number, for each subject. For all 6 subjects the function of average proportion of time is similar to the function of average proportion of responding across most conditions. Of 42 possible alternations in preference between Condition 3 and Condition 10, 29 alternations in the hypothesised direction occurred.

Latency to first peck in Terminal Link

Figure 14 shows the average latency to the first peck in the free-choice and forced-choice terminal link for each of the conditions in Experiment 2. There was a clear overall trend that showed latency to the first peck was higher in the free-choice terminal link compared to in the forced-choice terminal link. Of the 48 conditions, for all subjects in the present experiment, latency to first peck was higher in the free-choice terminal link in 31 of the conditions. This effect is most evident for Hen 11.6, as the latency to first peck in the free-choice terminal links was consistently higher than, or equal to, the forced-choice terminal links in seven out of eight conditions. This effect was least evident for Hen 11.3 as the latency to first peck was only higher for the free-choice terminal links, compared to the forced-choice terminal links, in four out of eight conditions

Initial Link Changeover

Figure 15 shows the average number of changeovers that occurred between the two initial link keys, plotted against condition number for each subject. A clear downward trend is observed for all subjects, with the exception of Hen 11.2 which demonstrated a clear upward trend. The downward trend was most evident for Hen 11.5. Hen 11.4 and 11.5 demonstrated the largest range of

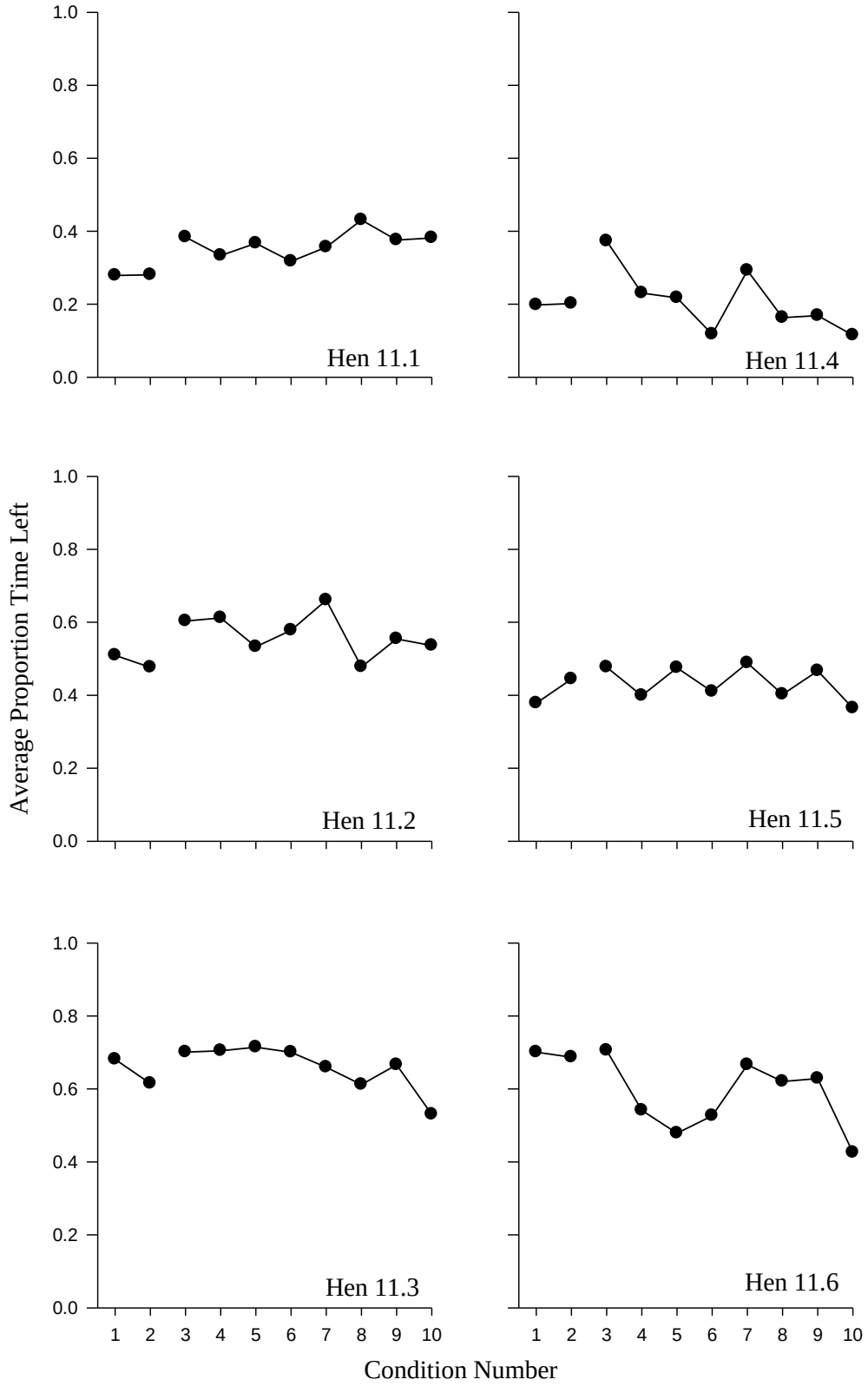


Figure 13: Average Proportion Time Spent of Left Initial Link Key across Successive Conditions

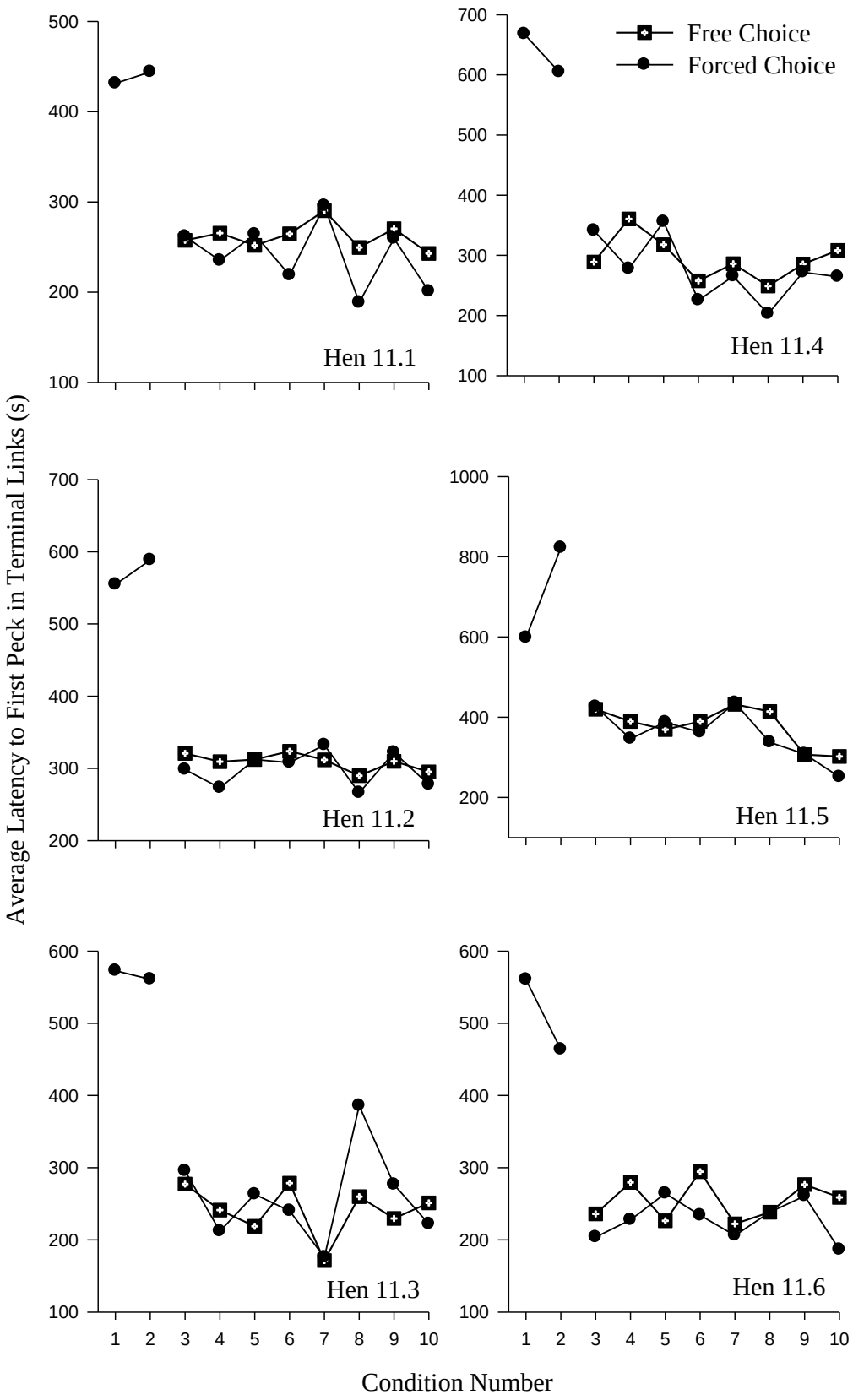


Figure 14: Average Latency to First Peck in Free-Choice and Forced-Choice Terminal Links across Successive Conditions

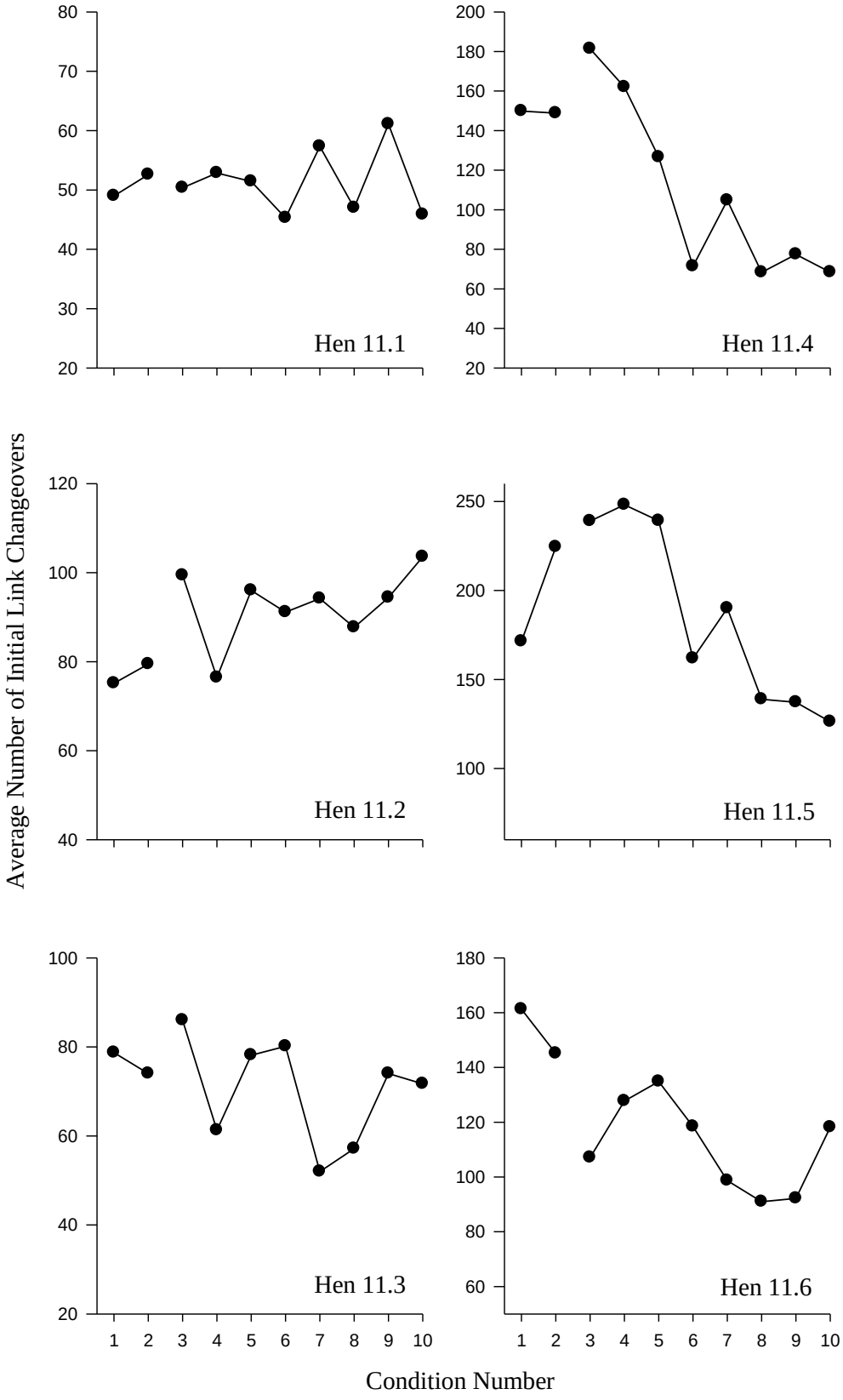


Figure 15: Average Number Initial Link Changeovers across Successive Conditions

initial link changeovers between conditions with a range of approximately 70-190 and 130-250 respectively. Hen 11.1 demonstrated the smallest range, approximately 45-65, between conditions. The number of initial link changeovers remained relatively stable across conditions for Hen 11.1 with no clear upward or downward trend being evident.

Terminal link changeover

Figures 16 shows the average number of changeovers that occurred in the terminal links plotted against condition number, for each subject. For the majority of the subjects changeovers occurred at a relatively low rate across all of the conditions. Hen 11.5 demonstrated the highest numbers of terminal link changeovers. Hen 11.5 also demonstrated the largest range, 2 to 10. The general trend of the data shows that the average number of changeovers per condition for 3 out of the 6 subjects remained relatively stable; for the remaining 3 subjects a slight upward trend was seen.

Black out key changeovers also occurred, at very low rates, in conditions where the forced-choice option was associated with the left terminal link. Of 24 forced-choice conditions, for all 6 subjects, black out key changeovers occurred in 18 conditions. As with changeovers in the free-choice terminal links, the general trend of the data showed that the average number of changeovers in the forced-choice terminal link remained stable for 3 of the 6 subjects. A slight upward trend in the average number of blackout key changeovers was seen for the remaining 3 subjects. The same subjects who demonstrated an upward trend in free-choice terminal link changeovers, also showed an upward trend in black out key changeovers.

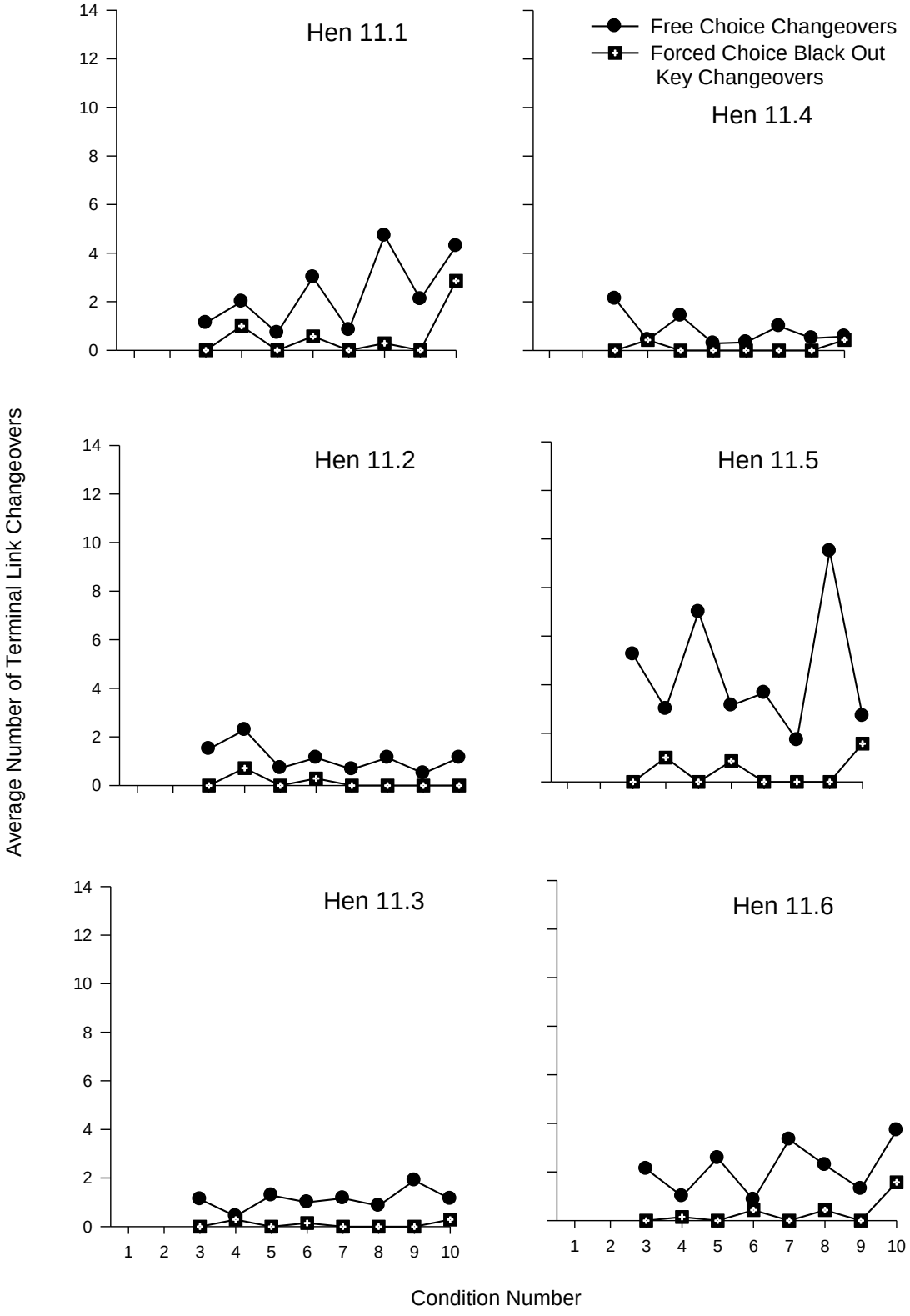


Figure 16: Average Number Terminal Link Changeovers across Successive Conditions

Free-choice terminal links compared to free-choice changeovers

Figure 17 shows the average number of terminal link changeovers compared to the average number of free-choice reinforcers earned per condition. Overall the number of terminal link changeovers were much lower than the number of free-choice reinforcers earned. This effect was shown by all subjects, across all conditions.

Ratios of entries to the Terminal Link

Figure 18 shows the proportion of reinforcement earned on the left terminal link. For all subjects, across all conditions, the entry ratio remained at an approximate value of .5.

Hen Weights

Graphs showing the daily weight of each subject for the duration of Experiment 2 are shown in Appendix B. For Hen 11.1 and 11.2 the daily weights remained within the (80% ± 5%) weight band for the duration of the experiment. Hen 11.3 began above the upper weight band, but over the course of the experiment returned to within the weight band. Hen 11.4 was within the weight band for the majority of the experiment, with a period in the middle of the experiment above the upper weight band. Hen 11.5 remained out of the weight band for the entire experiment; however, this weight increase was due reinforcement received during the experiment as no post-feed was provided. Hen 11.6 remained within the weight band for the majority of sessions, with some days below the lower weight band throughout the experiment.

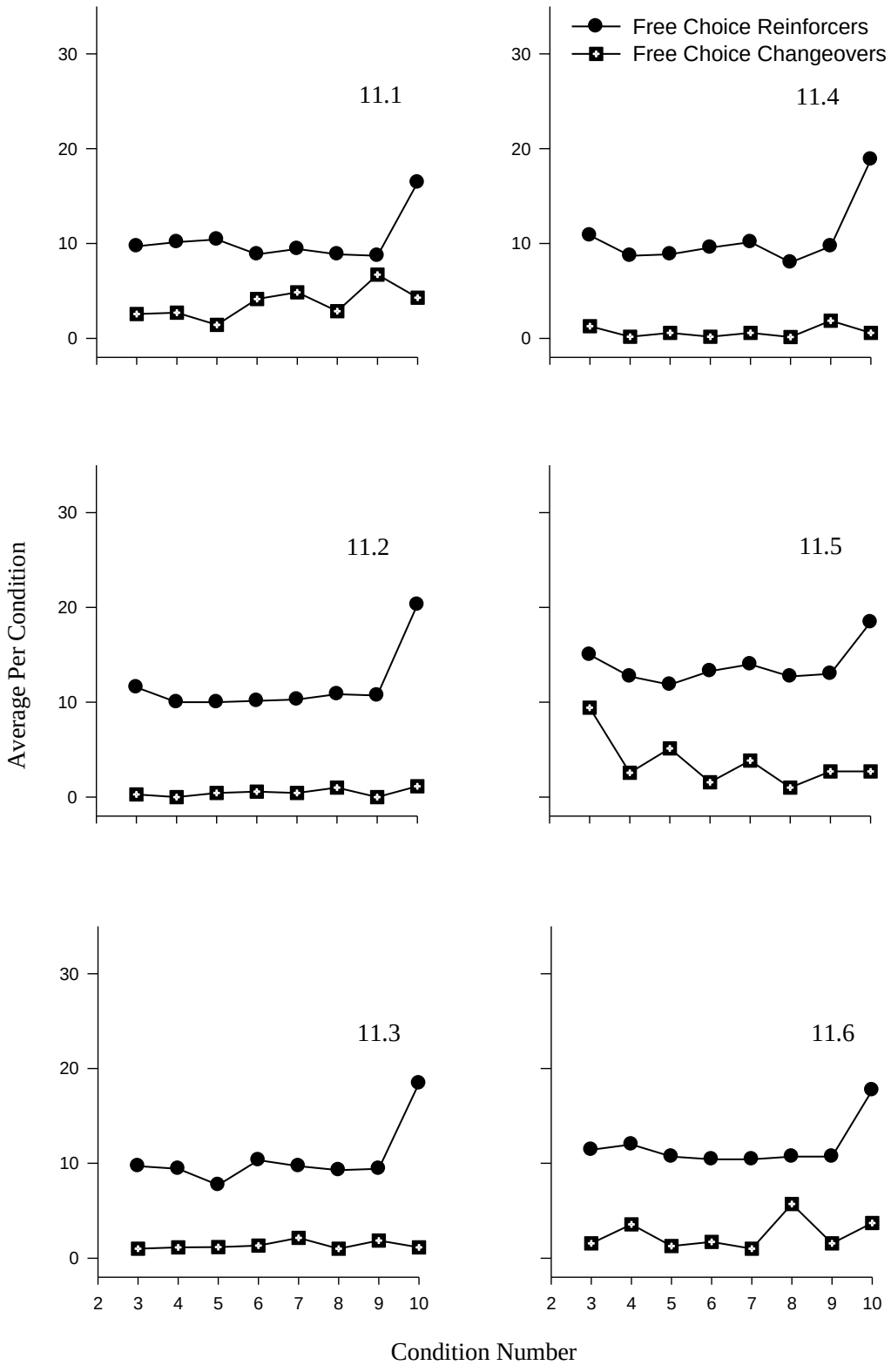


Figure 17: Average number of Reinforcers earned versus Average Number of Changeovers on Fre- Choice Terminal Link

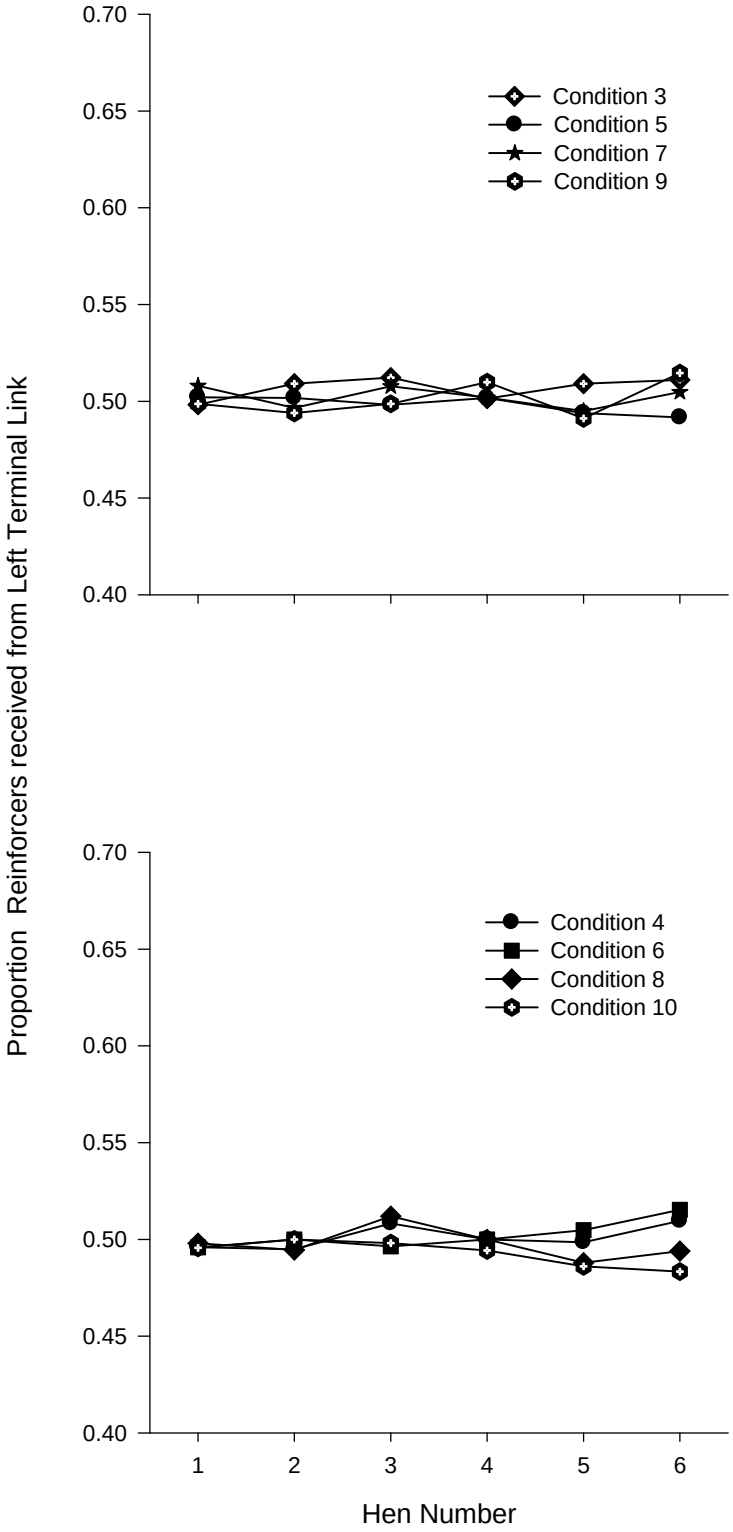


Figure 18: Average Entry ratios in Free-Choice and Forced-Choice Conditions across subjects

Discussion

When comparing the results from the present experiment to those from the previous experiment, it can be seen that the preference for the free-choice option was not as strong, shown by smaller average local variance, with the exception of the data from Hen 11.5 and Hen 11.4. In Experiment 1, of 42 possible alternations in preference, 38 occurred in the hypothesised direction. In the present experiment 33 of 42 alternations occurred in the correct direction. Thus not only was the effect less strong in the present experiment, it is also occurred slightly less often across subjects. Therefore, the introduction of the dependent schedule in the present experiment reduced the preference for free-choice effect demonstrated in Experiment 1. This may be a result of the schedule requirements, by introducing a dependent schedule, the subjects needed to respond regularly on the initial link associated with the forced-choice option in order to continue receiving reinforcement. Increased responding on the forced-choice option has therefore decreased the magnitude of preference shift shown by the subjects.

As expected due to the dependent schedule, the entry ratios for the present experiment, compared to the previous experiment, are much more stable. The purpose of Experiment 2 was to rule out uneven entry ratios as having an effect on the pattern of initial link responding shown in Experiment 1. To an extent, in spite of the schedule requirements, preference for the free-choice option was still evident after the introduction of the dependent schedule. We can therefore conclude that the effect shown in Experiment 1 was a result of preference for the available options.

The data shows that the change in procedure did not change other effects demonstrated in Experiment 1. Latency to first peck remained higher in free-choice terminal links compared to forced-choice terminal links. The number of

initial link and terminal link changeovers occurred at similar rates in Experiment 2 compared to Experiment 1. Therefore we are confident that the introduction of the dependent schedule has had no impact other than what was anticipated.

As stated above the introduction of the dependent schedule reduced the strength of preference for the free-choice option. Experiment 3 will attempt to retain the advantages of the dependent schedules, even entry ratio, while overcoming the disadvantage of a reduced preference ratio. To do this the length of the initial link schedule was altered in an attempt to reinstate the magnitude of preference shift demonstrated in Experiment 1.

Experiment 3

Research on concurrent chain schedules of reinforcement has shown that the length of the schedules reliably affects the extremity of the preference ratio of the initial links; the shorter the initial link time the larger the preference ratio (Berg & Grace, 2006; Christensen & Grace, 2008; Fantino, 1969; Jimenez-Gomez, Podlesnik & Shahan, 2009; Wardlaw & Davison, 1974).This has been termed the 'initial link effect'.

Fantino (1969) was the first to investigate the effect of initial link length on preference ratios by systemically varying the equal initial link schedule parameters from VI 30-s to VI 600-s. The results of their study showed that when the initial links duration was reduced preference for the richer VI terminal link schedule, as measured by the proportion of initial link responses, was more extreme. This effect was also investigated by Wardlaw and Davison (1974), who used a variety of initial link schedules (VI 27-s, VI 38-s, VI 49-s and VI 115-s), with a varying combination of terminal link schedules. In the terminal links; one schedule remained FI 5-s, while the other schedule was one of FI 5-s, FI 7.5-s, FI 10-s, FI 15-s or FI3 0-s. Each combination of terminal links was paired with each of the different initial link schedules. As with Fantino's (1969) study, Wardlaw and Davison (1974) found that preference was greater when the initial link time was shorter. This shows that the initial link effect is relevant in studies which use both VI and FI schedules in the terminal link.

Recent studies have also investigated this effect. Berg and Grace (2006) study used a successive-reversal design to investigate the effect of initial link duration on acquisition of preference in a concurrent chain procedure. In this study each condition consisted of twenty sessions, at the end of each condition the terminal link schedules were switched (i.e., from FI 8-s FI16-s to FI16-s FI 8-s).

The initial link duration was either VI 8-s (short) or VI 24-s (long); all possible combinations of transitions preceding and following the terminal link reversal were trialled across conditions (i.e., short-long, long-short, short-short and long-long). The results of their study indicated that changes in response allocation were faster when the initial link duration preceding the reversal was short rather than long, and when initial link duration following the reversal was long rather than short. The authors conclude that acquisition was fastest for the short-long transition, slower for short-short of long-long transitions and shortest for long-short transitions (Berg & Grace, 2006). The authors also conclude that the 'initial link effect' was obtained, as the preference for the shorter FI schedule in the terminal links (FI 8-s) was greater when the following duration was short compared to when it was long.

Christensen and Grace (2008) also investigated rapid response acquisition in concurrent chain schedules whilst manipulating initial link duration. Typically, in initial link effect research steady state procedures have been utilised, in which training continues with a given pair of terminal link schedules until response allocation becomes stable (Christensen & Grace, 2008). Often this requires 20 or more sessions before stability criteria are met and the terminal link schedules can be changed to the next condition. Christensen and Grace (2008) note that recent research has shown that a subject's response allocation can adjust rapidly when terminal links are frequently changed across sessions. Their experiment was split into two phases. In phase 1 the initial link remained VI 10-s until response allocation stability criterion were met. Phase 2 consisted of the initial links being changed across sessions in an ascending and descending sequence, with a range of values from 0.01 s to 30 s. This phase continued until each subject had completed the full ascending and descending pattern at least twice. The results of this study

showed that there was no effect of varying the initial link schedule from VI 0.01 – VI 30-s on the observed preference ratio compared to the steady state VI 10-s procedure in Phase 1. Christensen and Grace (2008) note that analysis of their results showed that overall the classic 'initial link effect' was observed. Christensen and Grace (2008) also present a figure in their procedure which predicts the log response ratio as initial link duration is increased from 5-30 s. After an initial increase, it appears that the peak in the curve occurs at approximately 10 s before the preference ratios begin to decrease as shown by Figure 19. The results of the actual experiment show a similar curve as the predicted values, with the peak occurring at approximately 10 s.

Overall the above studies show that there is a clear effect for shorter initial link schedules to result in larger observed preference ratios. However, the studies reported above have used unequal VI or FI schedules in the terminal links. This differs from the procedure in the current experiment as the available alternatives on both terminal links were FI 20-s schedules. It is not known whether this difference in procedure will not impact whether or not we observe the initial link effect; however, it can be assumed that it will have no impact.

In the present experiment the initial link schedules were reduced from VI 30-s to VI 10-s, which according to Christensen and Grace's (2008) model should be the initial link schedule which results in the highest preference ratio. The aim of the third experiment was to investigate whether the 'initial link effect' would be observed. That is the present experiment attempted to increase the observed preference ratio, shown by average local variance in the present experiment.

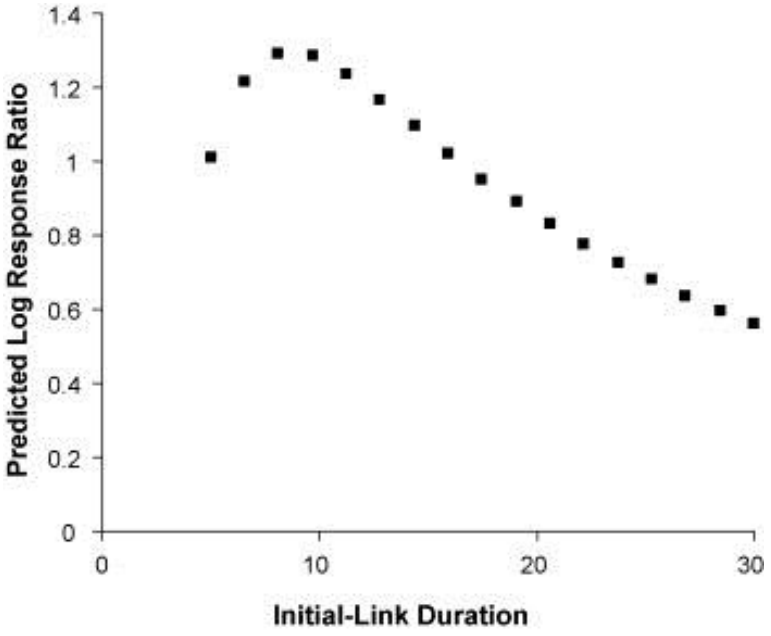


Figure 19: Predicted Log Response ratios plotted against initial link duration from Christensen and Grace (2008)

Method

Subjects

The same subjects were used as the previous experiments.

Apparatus

The apparatus was identical to the apparatus in the previous experiments.

Procedure

The key light colours and positions, for each of the ten conditions in the present experiment, were not altered from the original procedure as shown by Table 1. The number of sessions in each condition are shown on Table 4. Changes to the procedure in the present experiment include reducing the dependent VI 30-s VI 30-s initial link schedules to dependent VI 10-s VI 10-s schedules. The initial link time out, to end the experimental session, was also reduced from 15min to 5min, to regulate the number of reinforcers that can be earned per session to be in line with the number of reinforcers earned in previous sessions.

Table 4: Number of sessions per condition during Experiment 3

Condition Number	1	2	3	4	5	6	7	8	9	10
Number of Sessions	7	7	7	7	7	7	6	7	10	7

Results

Proportion of responses

Proportion of left responding, as calculated in Experiment 1, is plotted against condition number and presented on Figure 20. Conditions 1 and 2 were the baseline conditions, Conditions 3, 5, 7 and 9 were those with the free-choice terminal link on the left side and Conditions 4, 6, 8 and 10 were those with the free-choice terminal link on the right side.

Data between the two baseline conditions showed a relatively stable proportion of left responding for Hens 11.1, 11.2 and 11.5. The data for Hen 11.3, 11.4 and 11.6 shows an increase in proportion of left responses between Condition 1 and Condition 2. The majority of subjects show a baseline level of responding of approximately .5. Hen 11.6 showed baseline proportions of responding of approximately .6. For all of the subjects the baseline levels proportion of left responses were similar to those observed in Condition 3.

Clear systematic increases and decreases in proportion of left responding across successive conditions were observed for Hen 11.1 and to a lesser extent Hen 11.3 These increases and decreases in proportion of left responding demonstrated a shift in responding toward the free-choice terminal link. Of 42 possible alternations in preference between Condition 3 and Condition 10, as described in Experiment 1, 28 alternations in the hypothesised direction occurred. The average local variance, as calculated in Experiment 1, was largest for Hen 11.4 (.033) and 11.3 (.037) and smallest for Hen 11.2 and 11.6 (.013).

Proportion of time

Figure 21 shows the average proportion of time spent on the left initial link key, plotted against condition number, for each subject. For all 6 subjects the function of average proportion of time is similar to the function of average

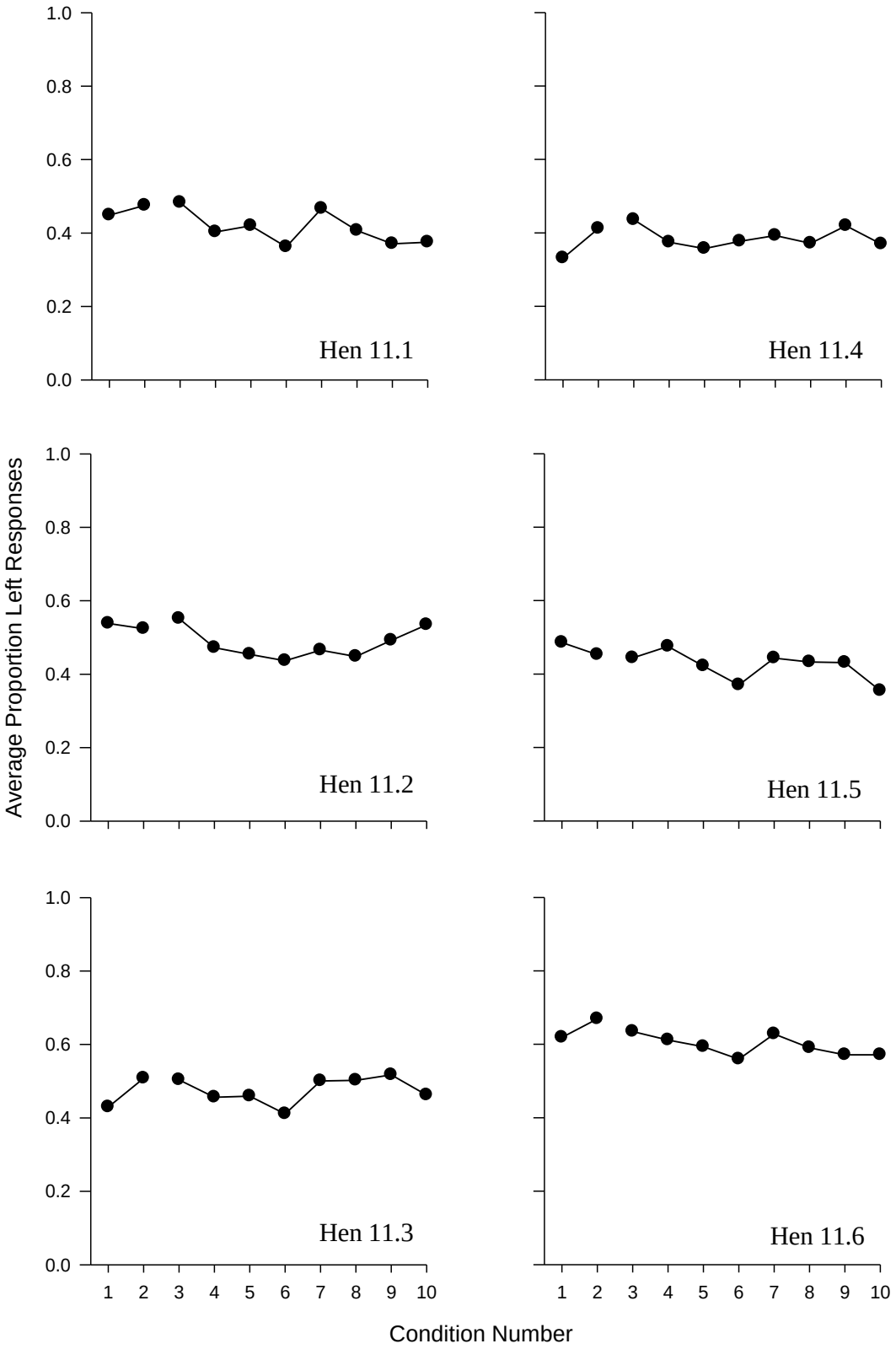


Figure 20: Average Proportion of Responding on Left Initial Link Key across Successive Conditions

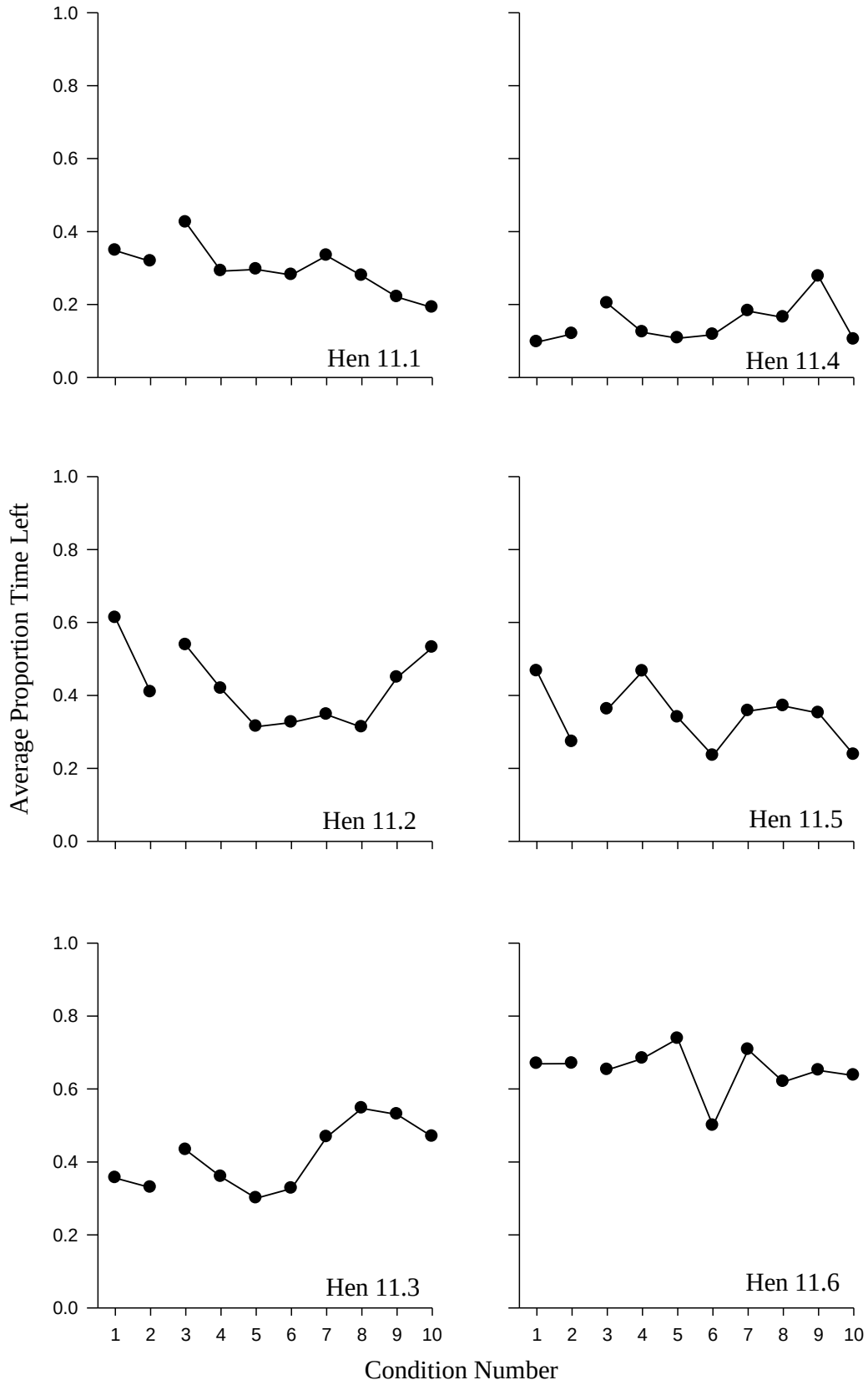


Figure 21: Average Proportion Time Spent of Left Initial Link Key across Successive Conditions

proportion of responding across all ten conditions. Of 42 possible alternations in preference between Condition 3 and Condition 10, 25 alternations in the hypothesised direction occurred.

Latency to first peck in terminal link

Figure 22 shows the average latency to the first peck in the free-choice and forced-choice terminal links, plotted against condition number for each subject. The overall trend shows that latency to first peck is longer in the free-choice terminal link compared to the forced-choice terminal link. This effect is shown for all hens across the majority of conditions. Of the 48 conditions, for all subjects in the present experiment, latency to first peck was higher in the free-choice terminal link in 31 of the conditions. This effect is most evident for Hen 11.6, as the latency to first peck in the free-choice terminal links was higher than, or equal to, the forced-choice terminal links in six out of the eight conditions.

Initial link changeovers

Figure 23 shows the average number of changeovers that occurred between the two initial link keys, plotted against condition number for each subject. Overall, stable levels of initial link changeovers can be observed for the majority of the subjects; this trend is most evident with Hen 11.2 and Hen 11.3. Hen 11.5 demonstrated the largest range of initial link changeovers between conditions with a range of approximately 20-50. The data for Hen 11.1 and 11.4 shows systematic increases and decreases in the number of changeovers across conditions; showing higher levels of initial link changeovers when the free-choice terminal link was associated with the left side.

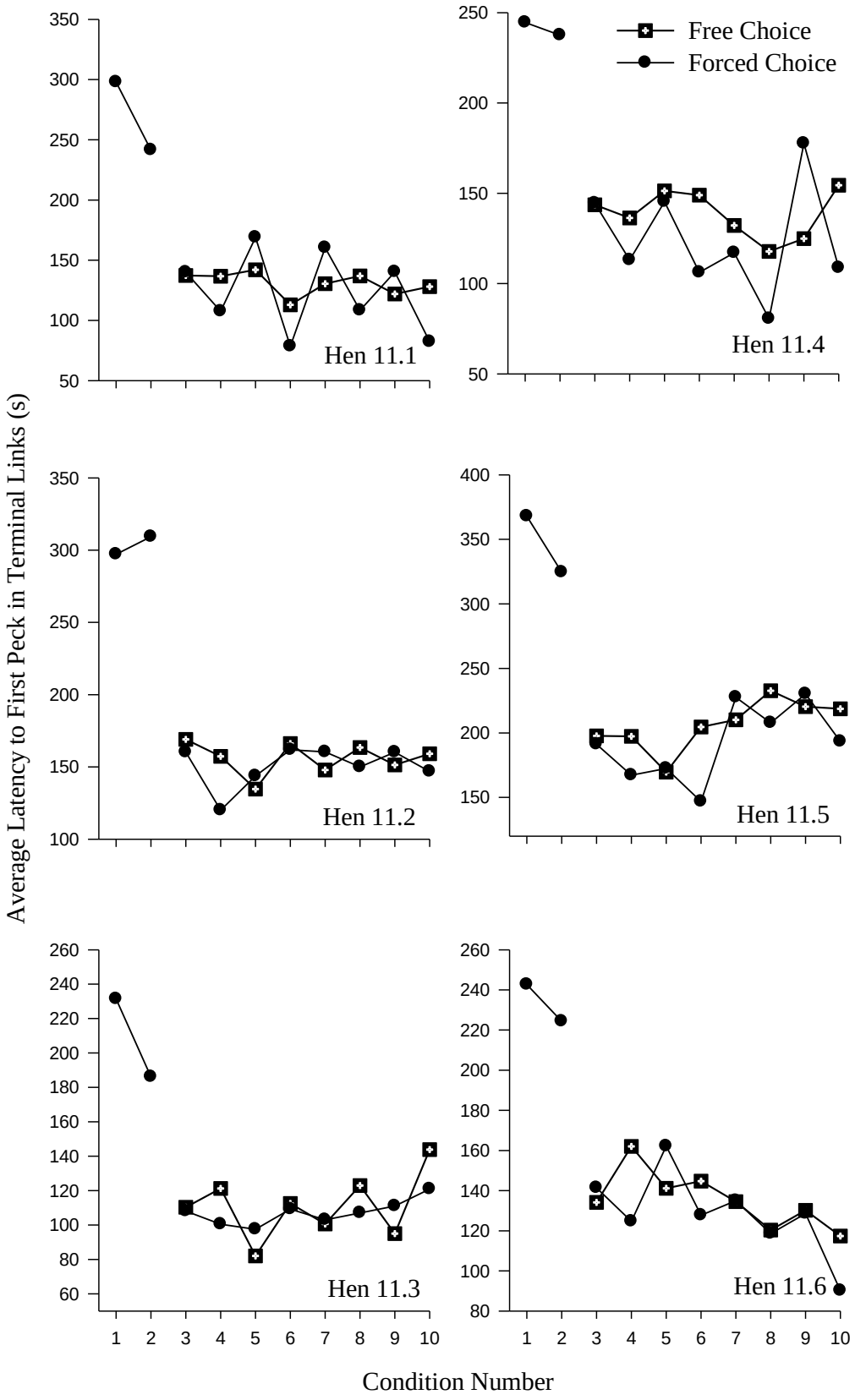


Figure 22: Average Latency to First Peck in Free-Choice and Forced-Choice Terminal Links across Successive Conditions

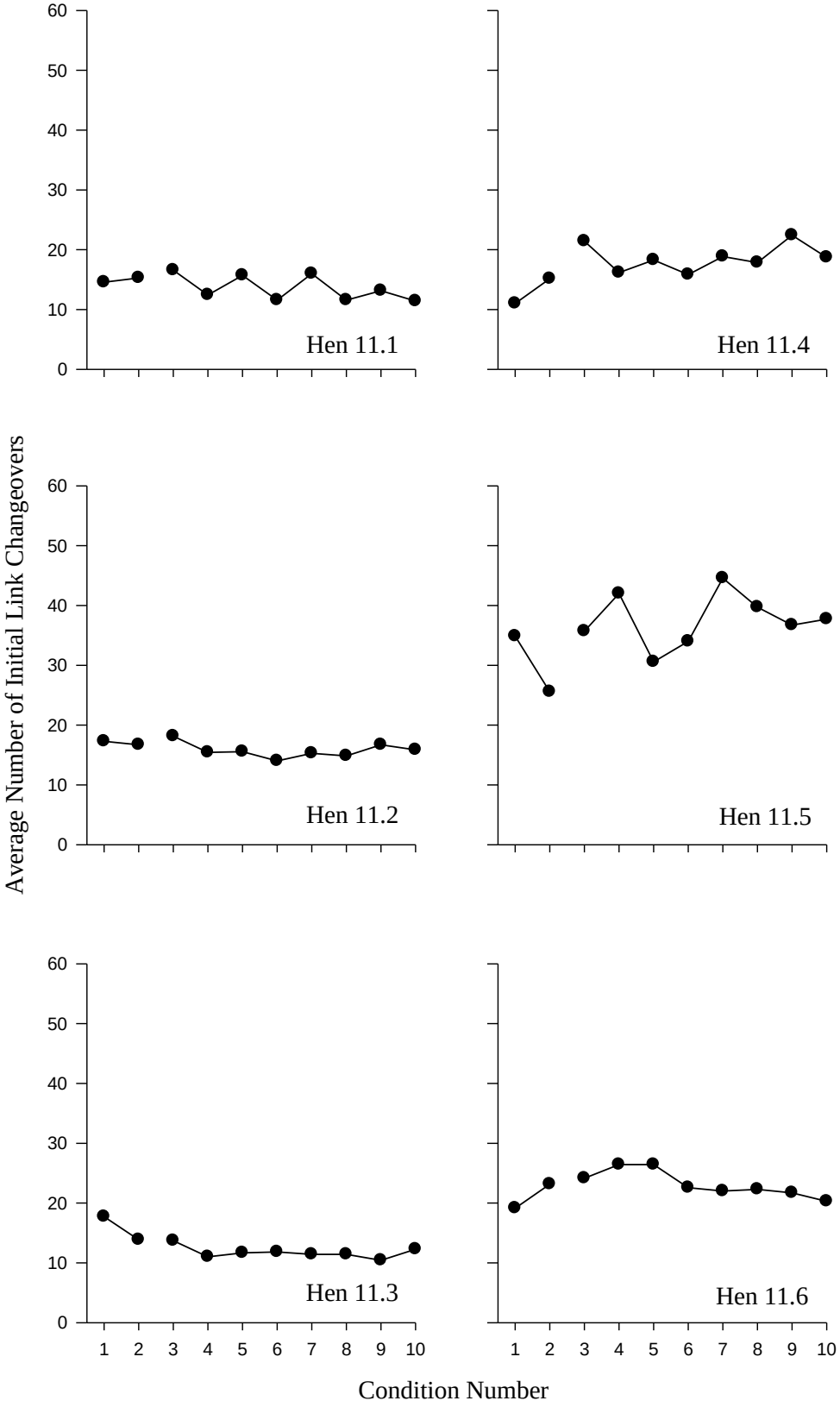


Figure 23: Average Number Initial Link Changeovers across Successive Conditions

Terminal link changeovers

Figures 24 shows the average number of changeovers that occurred in the terminal links plotted against condition number, for each subject. For the majority of the subjects changeovers occurred at a relatively low rate across all of the conditions. Hen 11.1 and 11.5 demonstrated the highest numbers of changeovers during the terminal links. Hen 11.5 demonstrated the largest range, 2-10, between conditions. The general trend of the data shows that the average number of changeovers per condition remained relatively stable for 4 of the 6 subjects. Of the remaining 2 subjects one demonstrated a clear upward trend, while the other demonstrated a clear downward trend in the number of free-choice terminal link changeovers.

During the forced-choice terminal link subjects also demonstrated black out key changeovers. Black out key changeovers only occurred in conditions where the forced-choice option was associated with the left terminal link for all subjects. Of 24 forced-choice conditions, for all 6 subjects, black out key changeovers occurred in 16 conditions. Hen 11.1 and 11.6 demonstrated the highest levels of black out key changeovers. The remaining subjects demonstrated much lower levels of black out key changeovers. As with changeovers in the free-choice terminal links, the general trend of the data shows that the average number of changeovers in the forced-choice terminal link remained relatively stable as the experiment progressed.

Free-choice terminal links compared to free-choice changeovers

Figure 25 shows the average number of terminal link changeovers compared to the average number of free-choice reinforcements earned per condition. Overall the number of terminal link changeovers was lower than the

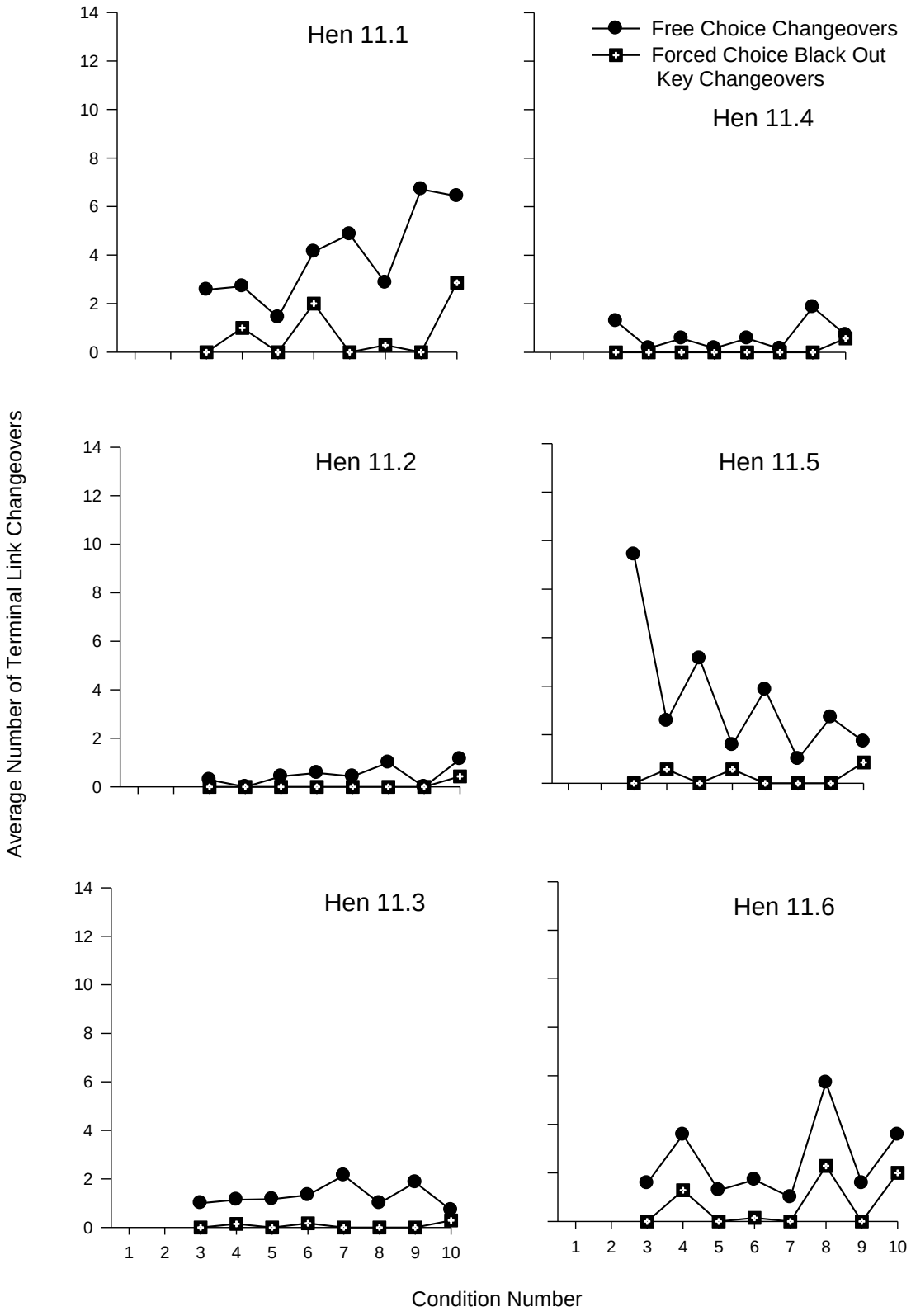


Figure 24: Average Number Terminal Link Changeovers across Successive Conditions

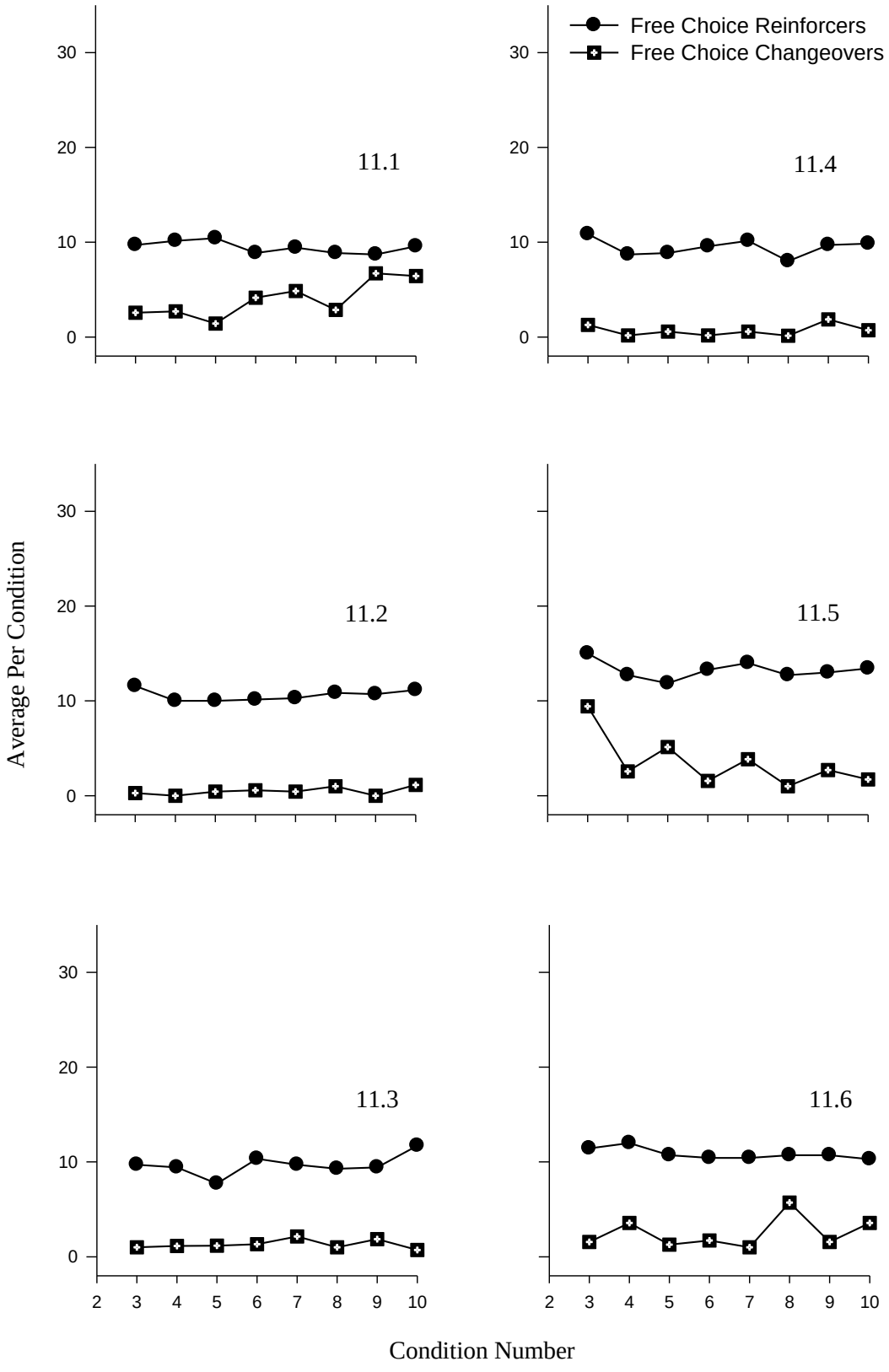


Figure 25: Average number of Reinforcers earned versus Average Number of Changeovers on Free-Choice Terminal Link

number of free-choice reinforcement earned. This effect was shown by all subjects, across all conditions.

Ratio of entries to the terminal link

Figure 26 shows the entry ratio for the free-choice and forced-choice condition, plotted against subject number. Entry ratios were relatively stable during conditions where the free-choice alternative was associated with the left terminal link. However, in spite of the dependant schedule, some variation in entry ratios is observed, both between subjects and across conditions, in particular during conditions where the free-choice alternative was associated with the right terminal link.

Average Local Variance

Figure 27 shows the average local variance for each subject, plotted against experiment number. It is clear that the introduction of the dependent schedule in Experiment 2 resulted in a decrease in average local variance for the majority of subjects, with the exception of Hen 11.4 and Hen 11.5. Following the introduction of shorter dependent initial link schedules (VI 10-s) in Experiment 3, a further reduction in average local variance was observed for Hens 11.1, 11.2 and 11.6. A reduction was also observed for Hens 11.4 and 11.5, who had previously shown an increased average local variance after the introduction of the dependent schedule in Experiment 2. A slight increase was observed for Hen 11.3, although it did not return to the levels observed in Experiment 1.

Hen Weights

Graphs showing the daily weight of each subject for the duration of Experiment 3 are shown in Appendix B. For Hen 11.1, 11.2, 11.3 and 11.4 daily weights remained within the (80% ± 5%) weight band for the duration of the

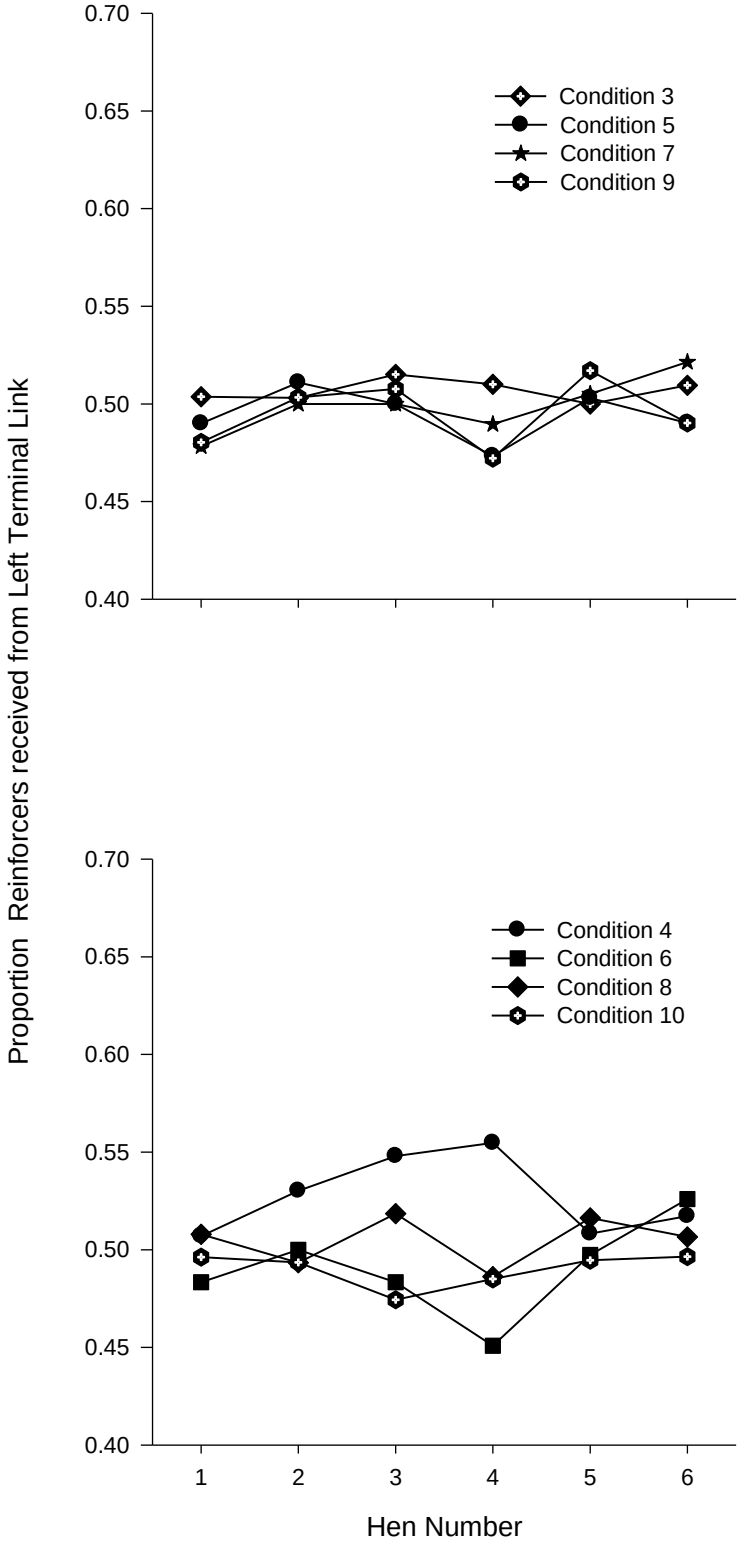


Figure 26: Average Entry ratios in Free-Choice and Forced- Choice Conditions across Subjects

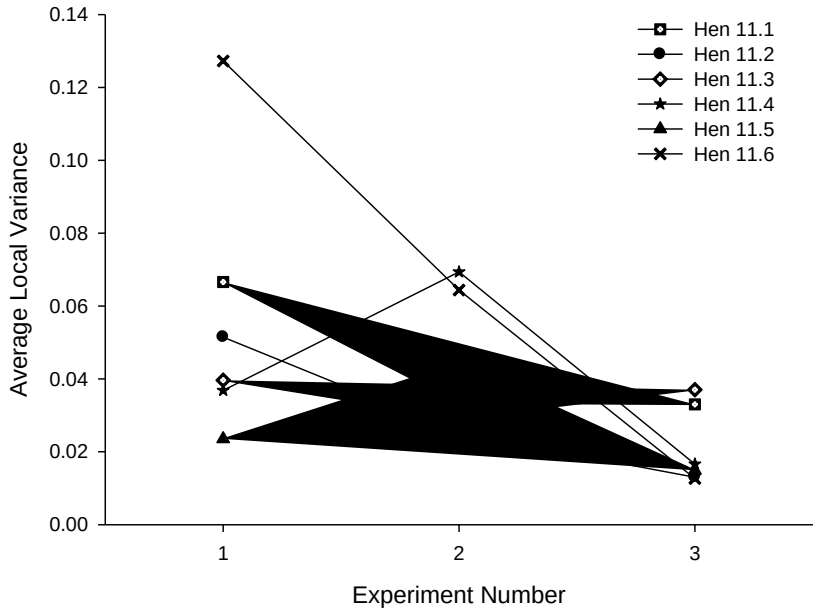


Figure 27: Average Local Variance for each Subject across Experiments

experiment, with the exception of 1-2 days. Hen 11.5 remained above the weight band for the entire experiment; however, this weight increase was due to reinforcement received during the experiment as no post-feed was provided. Hen 11.6 remained within the weight band for the majority of sessions, with a number of days below the lower weight band.

Discussion

The aim of Experiment 3 was to maintain the benefits of a dependent schedule, equal entry ratios, whilst investigating whether the initial link effect would be observed. The initial link effect shows that larger preference ratios, shown in the present experiment by the size of the local variance, will be observed for shorter compared to longer initial link schedules. In spite of retaining the dependent initial link schedule from Experiment 2, entry ratios into the terminal links became uneven in the present experiment.

Reducing the initial link schedule to VI 10-s failed to increase the observed local variance for the majority of the subjects in the present experiment, shown by Figure 27. A decrease in average local variance was observed for 5 of the 6 subject in Experiment 3. Therefore, we failed to replicate the initial link effect shown in previous research (Berg & Grace, 2006; Christensen & Grace, 2008; Fantino, 1969; Jimenez-Gomez et al., 2009; Wardlaw & Davison, 1974).

This failure may be due to the procedure we used in the present experiment. Christensen and Grace (2008) state that research investigating the 'initial link effect' often utilised a steady state design, in which training continues with a given pair of terminal link schedules until response allocation becomes stable. In the present experiment the subjects were immediately exposed to the shorter VI schedule, without any prior training, and each condition contained only seven sessions irrespective of performance. It is therefore possible that the subjects were not given sufficient exposure per condition, to the shorter VI schedule, to develop the pattern of responding which demonstrates preference for free-choice that was evident in Experiment 1.

Due to time constraints in the present experiment the optimal initial link time (VI 10-s), shown by Christensen and Grace (2008), was selected and utilised

across all experimental conditions in an attempt to increase preference for the free-choice option on a dependent schedule. It is possible that gradually exposing the subjects to the shorter VI initial link schedule in a descending pattern across training sessions may have may have reduced the failure to replicate the initial link effect, as previous research (Christensen & Grace, 2008; Fantino, 1969; Wardlaw & Davison, 1974) in this area has used a study design that systematically varied the length of the initial link schedule across sessions.

Previous research on the initial link effect has used unequal VI or FI schedules in the terminal links, consequently access to one of the terminal link always resulted in richer reinforcement than the other and so would normally be much more desired (Berg & Grace, 2006; Christensen & Grace, 2008; Fantino, 1969; Jimenez-Gomez et al., 2009; Wardlaw & Davison, 1974). This differs from the procedure in the current experiment as the available alternatives on both terminal links were FI 20-s schedules, resulting in 3 seconds access to reinforcement. It is possible that preference for the free-choice terminal links was not strong enough to be maintained when quicker responding was required in order to gain repeated access to reinforcement.

The data from Experiment 3 shows that the change in procedure did not change other effects demonstrated in Experiment 1 and Experiment 2. Latency to first peck remained higher in free-choice terminal links compared to forced-choice terminal links for the majority of conditions. The number of terminal link changeovers occurred at similar rates in Experiment 3 compared to the previous experiments. The only change observed was a reduction in the number of initial link changeovers, which was expected due the shorter initial link schedule. Therefore we are confident that the introduction of the dependent schedule has had no impact other than what was being investigated.

Summary

The initial aim of the present experiment was to replicate, and extend to a new species, a study by Catania (1975) which demonstrated that when all aspects of reinforcement are held constant, an organism will prefer choice over constraint. Experiment 1 successfully replicated Catania's (1975) findings, as 5 out of the 6 subjects used in the present experiment, showed a preference for the free-choice alternative over the forced-choice alternative.

In the second experiment Catania's (1975) procedure was altered so that the concurrent initial link schedules ran dependently rather than independently. The purpose of this change in procedure was to equalise the entry ratios, ensuring the subjects were receiving the same amount of reinforcement from each terminal link. This modification ruled out uneven entry ratios as having an impact of the preference for free-choice effect observed in Experiment 1, as in spite of the schedule requiring the subjects to respond on both initial link keys in order to continue to gain access to reinforcement, preference for the free-choice alternative was still observed for the majority of conditions for 4 out of 6 subjects.

For 2 out of the 6 subjects the introduction of the dependent schedule resulted in an increase in preference for the free-choice option, as shown by the average local variance, plotted of Figure 27. For the remaining 4 subjects the introduction of the dependent schedule resulted in a decrease in observed preference for the free-choice option, also shown by Figure 27. This decrease can be attributed to the requirements of the dependant schedule as the subjects were required to respond on the forced-choice initial link in order to continue receiving reinforcement.

The last experiment attempted to reinstate the magnitude of preference for the free-choice option, to those observed in Experiment 1, whilst maintaining the

benefit of the dependent schedule, even entry ratio. This was done by reducing the length of the initial link schedule. Although previous research has shown that shorter initial link durations result in a larger preference ratio, shown in the present study by larger local variance, the present experiment failed to replicate this effect. This may be due to the amount of exposure the subjects had to each condition while the shorter initial link schedule was in place. Future research may investigate this area, by systematically decreasing the length of the initial link schedule (VI 30-s down to VI 10-s), and increasing the number of sessions per condition. Therefore, increasing the amount of exposure the subjects have to the schedule and potentially allowing time for the preference for free-choice effect, which was evident for each subject in the previous experiments, to develop.

Although impractical to assume that all stimuli used as reinforcers for an individual hold the same value; the present research is relevant to the applied field as it shows that an organism innately prefers to have a choice. As noted by Lerman et al. (1997) frequent access to choice, of task or reinforcement, may be beneficial in an applied setting as it increases the likelihood that higher preferred tasks and reinforcers are made available and consequently can account for changes in preference over time. Access to choice ensures that a subject will not become habituated to a stimulus, as it allows the subject to select a reinforcer which is most reinforcing for them at that point in time. Therefore, access to choice of reinforcement may be used as a useful method to increase fixation time, increase responding and consequently increase learning when working in an applied environment.

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Appendix A

Table A1: Condition Average for Proportion of Pecks on Left Initial link Key Per Subject Per Experiment

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
	1	0.5695	0.6560	0.3853	0.4674	0.5703	0.3835
	2	0.6055	0.5822	0.3059	0.5600	0.5459	0.4035
	3	0.6465	0.6864	0.5676	0.3619	0.5247	0.5954
	4	0.4796	0.5446	0.4999	0.4380	0.4288	0.4746
Experiment	*5*	0.5106	0.5658	0.5708	0.4856	0.4715	0.6128
1	*6*	0.4360	0.5494	0.5039	0.4449	0.4529	0.4547
	7	0.4877	0.6147	*0.5606*	0.5129	0.4607	0.5934
	8	0.4418	0.5632	*0.5545*	0.4624	0.4417	0.4843
	9	0.4898	0.6011	*0.6115*	0.5070	0.4288	*0.5688*
	10	0.4416	0.5749	*0.6592*	0.4243	0.4353	0.4274
	1	0.43205	0.531394	0.66316	0.430874	0.517543	0.612384
	2	0.429462	0.527817	0.599626	0.426926	0.479725	0.62364
	3	0.48165	0.592891	0.65308	0.465905	0.520592	0.641785
	4	0.430767	0.589449	0.646596	0.396616	0.472244	0.576621
	5	0.460557	0.568524	0.649834	0.45134	0.515648	0.590214
Experiment	*6*	0.387789	0.594185	0.643104	0.392674	0.474898	0.539189
2	*7*	0.438544	0.616496	0.596339	0.519484	0.509955	0.630825
	8	0.476595	0.518973	0.593114	0.382049	0.450956	0.553645
	9	0.447526	0.584457	0.641552	0.403533	0.491003	0.619911
	10	0.427115	0.557083	0.499529	0.383502	0.421676	0.537169
	1	0.448517	0.538379	0.429578	0.331308	0.485736	0.618817
	2	0.475172	0.523771	0.507712	0.411706	0.452829	0.669304
	3	0.483013	0.55155	0.503577	0.436051	0.443993	0.634682
	4	0.402799	0.472476	0.456165	0.374591	0.475287	0.611629
	5	0.419717	0.453945	0.459184	0.357056	0.421733	0.593474
Experiment	6	0.362054	0.43656	0.411047	0.377139	0.370052	0.559681
3	7	0.466555	0.465614	0.500462	0.392663	0.443461	0.627867
	8	0.406737	0.448014	0.502321	0.371399	0.432702	0.59058
	9	0.370829	0.492228	0.516943	0.419417	0.431341	0.571209
	10	0.374948	0.534462	0.462212	0.369389	0.354777	0.571538

Table A2: Average for Proportion of Time on Left Initial link Key Per Subject Per Experiment

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*1*	0.5695	0.6560	0.3853	0.4674	0.5703	0.3835
	2	0.6055	0.5822	0.3059	0.5600	0.5459	0.4035
	3	0.6465	0.6864	0.5676	0.3619	0.5247	0.5954
	4	0.4796	0.5446	0.4999	0.4380	0.4288	0.4746
	5	0.5106	0.5658	0.5708	0.4856	0.4715	0.6128
	6	0.4360	0.5494	0.5039	0.4449	0.4529	0.4547
	7	0.4877	0.6147	*0.5606*	0.5129	0.4607	0.5934
	8	0.4418	0.5632	*0.5545*	0.4624	0.4417	0.4843
	9	0.4898	0.6011	*0.6115*	0.5070	0.4288	*0.5688*
	10	0.4416	0.5749	*0.6592*	0.4243	0.4353	0.4274
Experiment 2	*1*	0.43205	0.531394	0.66316	0.430874	0.517543	0.612384
	2	0.429462	0.527817	0.599626	0.426926	0.479725	0.62364
	3	0.48165	0.592891	0.65308	0.465905	0.520592	0.641785
	4	0.430767	0.589449	0.646596	0.396616	0.472244	0.576621
	5	0.460557	0.568524	0.649834	0.45134	0.515648	0.590214
	6	0.387789	0.594185	0.643104	0.392674	0.474898	0.539189
	7	0.438544	0.616496	0.596339	0.519484	0.509955	0.630825
	8	0.476595	0.518973	0.593114	0.382049	0.450956	0.553645
	9	0.447526	0.584457	0.641552	0.403533	0.491003	0.619911
	10	0.427115	0.557083	0.499529	0.383502	0.421676	0.537169
Experiment 3	1	0.448517	0.538379	0.429578	0.331308	0.485736	0.618817
	2	0.475172	0.523771	0.507712	0.411706	0.452829	0.669304
	3	0.483013	0.55155	0.503577	0.436051	0.443993	0.634682
	4	0.402799	0.472476	0.456165	0.374591	0.475287	0.611629
	5	0.419717	0.453945	0.459184	0.357056	0.421733	0.593474
	6	0.362054	0.43656	0.411047	0.377139	0.370052	0.559681
	7	0.466555	0.465614	0.500462	0.392663	0.443461	0.627867
	8	0.406737	0.448014	0.502321	0.371399	0.432702	0.59058
	9	0.370829	0.492228	0.516943	0.419417	0.431341	0.571209
	10	0.374948	0.534462	0.462212	0.369389	0.354777	0.571538

Table A3: Condition Average Latency to First Peck in Free-Choice Terminal Links Per Subject Per Experiment

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	194.9857	355.7214	225.7071	195.5286	275.2929	208.3643
	4	230.4071	294.5571	223.7786	275.6286	287.35	129.9071
	5	255.3	352.8714	239.0929	274.7214	272.6	203.3429
	6	287.5214	306.5143	307.55	361.0286	342.1429	199.1786
	7	325.9333	371.5	240.8333	347.6667	384.0167	235.3167
	8	296.5143	321.2571	332.9714	373.3571	366.9571	203.8571
	9	282.9857	358.0857	272.1143	317.5	349.3143	265.8143
	10	309.4	328.6	349.1857	401.2	361.3714	323.1286
Experiment 2	*3*	257.3875	320.8625	277.3875	288.8	419.975	236
	4	265.3714	309.3286	241.2571	360.4714	389.2286	279.7143
	5	251.8286	312.2857	218.9	317.9	369.0857	226.4
	6	264.7	323.7	278.5	257.5714	389.3714	294.4714
	7	290.3	311.8	171.5	285.9667	432.1333	222.2
	8	249.5286	289.9143	259.8571	248.9167	414.2857	238.2857
	9	270.24	309.82	229.62	285.48	306.73	276.7
	10	242.8714	295.2429	251.2571	308.2286	302.2143	258.9714
Experiment 3	3	137.3	169.0571	110.3	143.6143	197.6857	134.1571
	4	136.7	157.2714	121.2286	136.2857	197.3571	162.0429
	5	142.0286	134.6571	82.07143	151.3286	169.5714	141.1857
	6	112.9143	166.1714	112.55	148.9	204.6286	144.7
	7	130.4857	147.8571	100.6429	132.2	210.1714	134.5571
	8	136.9571	163.5	122.9143	117.7429	232.7	120.3857
	9	122.0143	151.3857	95.07143	124.9286	220.3429	130.2
	10	128.0429	159.1571	143.8143	154.4429	218.7286	117.4

Table A4: Condition Average Latency to First Peck in Forced-Choice Terminal Links Per Subject Per Experiment

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*1*	248.5286	429.3429	226.8857	249.7714	207.4286	243.4286
	2	272.4857	494.0571	300.5857	294.4143	286.2571	253.1429
	3	176.1571	234.8929	179.7	201.9857	245.05	110.2071
	4	113.3857	306.6143	231.5786	198.4786	216.4429	120.1286
	5	300.6214	296.0786	261.0643	302.5071	258.6857	122.1
	6	193.2643	339.4786	187.0429	271.9929	252.6	186.6571
	7	341.1167	291.8833	204.4333	326.8333	425.3	164.9167
	8	156.0286	303.7143	234.0286	268.4286	264.8	176.5714
	9	321.3714	291.8286	335.1571	375.4143	353.8571	198.7857
	10	185.3857	321.4286	314.2857	240.6714	327.4714	191.8714
Experiment 2	*1*	431.3714	554.7143	572.8714	667.8714	598.3286	560.5143
	2	444.0857	588.6429	560.8571	604.7	822.2714	463.7429
	3	261.5875	298.2875	295.3875	341.075	426.1625	203.8125
	4	235	273.2143	212.0857	277.7571	346.5	227.6714
	5	264	312.2143	263.1429	355.7571	387.3857	264.3571
	6	218.8143	308.1429	240.3143	225.4	362.3143	234.1
	7	295.75	332.5	175.8833	265.1333	435.7333	206.2167
	8	188.4286	266.2143	385.8286	202.85	337.4	238.3571
	9	259.34	321.94	276.74	271.86	308.1057	260.84
	10	200.8	277.4857	222.1286	264.5429	250.9429	186.4
Experiment 3	1	297.8714	297.1	231.4571	244.5143	367.9429	242.6429
	2	241.4571	309.2571	186.1429	237.5429	324.5714	224.4
	3	140.0429	160.1714	108.1	144.4857	191.2429	141.4
	4	107.6	120.0429	100.4143	113.0429	167.2714	124.6571
	5	169	143.7857	97.52857	145.2714	172.5143	162.1714
	6	78.5	161.9143	109.2333	106.2143	146.8857	127.7429
	7	160.2857	160.3857	103.0429	117.0571	227.6143	134.9857
	8	108.3429	150	107.0143	80.54286	207.7571	118.6286
	9	140.2143	160.2143	111	177.5857	230.2286	128.5571
	10	82.37143	146.8143	120.9	108.7571	193.2714	90.17143

Table A5: Condition Average Number of Initial Link Changeovers Per Subject Per Experiment

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*1*	46.85714	69.85714	50.71429	92.28571	84.14286	95.28571
	2	49.85714	63.42857	46.42857	93.85714	90.85714	65.57143
	3	39.71429	53.71429	73.21429	134.5	122.9286	60.42857
	4	44.71429	75.57143	96	157	127.4286	63.21429
	5	64.71429	68.57143	81.07143	159.2143	122.5	78.42857
	6	48.71429	67.78571	81.71429	162.9286	144	74.71429
	7	70.33333	76.33333	75.83333	156.1667	155.1667	58
	8	49.42857	91.42857	69.71429	107.5714	136.5714	68.57143
	9	55.85714	86.42857	59	113.4286	169.2857	85.42857
	10	51.28571	79.42857	68.57143	98.42857	190	96.28571
Experiment 2	*1*	49	75.14286	78.71429	149.8571	171.4286	161.2857
	2	52.57143	79.42857	74	148.8571	224.4286	145.1429
	3	50.375	99.375	86	181.375	239	107.125
	4	52.85714	76.42857	61.28571	162	248.1429	127.7143
	5	51.42857	96	78.14286	126.5714	239.1429	134.8571
	6	45.28571	91.14286	80.14286	71.42857	161.8571	118.4286
	7	57.33333	94.16667	52	104.6667	190	98.66667
	8	47	87.71429	57.14286	68.33333	138.8571	91
	9	61.1	94.4	74	77.4	137.2	92.2
	10	45.85714	103.5714	71.71429	68.42857	126.2857	118.1429
Experiment 3	1	14.57143	17.28571	17.71429	11	34.85714	19.14286
	2	15.28571	16.71429	13.85714	15.14286	25.57143	23.14286
	3	16.57143	18.14286	13.71429	21.42857	35.71429	24.14286
	4	12.42857	15.42857	11	16.16667	42	26.42857
	5	15.71429	15.57143	11.66667	18.28571	30.57143	26.42857
	6	11.57143	14	11.83333	15.83333	34	22.57143
	7	16	15.28571	11.42857	18.85714	44.57143	22
	8	11.57143	14.85714	11.42857	17.85714	39.71429	22.28571
	9	13.14286	16.71429	10.42857	22.42857	36.71429	21.71429
	10	11.42857	15.85714	12.28571	18.71429	37.71429	20.28571

Table A6: Average Changeovers in Free-Choice Terminal Links Per Subject Per Experiment (Conditions 3-10)

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	5	1.142857	1.071429	3.214286	3.642857	2.714286
	4	11.28571	1.357143	1.357143	3.428571	3.357143	6.071429
	5	10.14286	0.571429	0.714286	3.142857	5.214286	2.785714
	6	6.642857	1.214286	0.714286	2.357143	1.785714	3.214286
	7	4.5	2.166667	1.333333	1.666667	5.666667	2
	8	9.142857	1.285714	0.285714	0.285714	1.857143	1.142857
	9	1.571429	2.571429	1.571429	2.714286	5.142857	2.285714
	10	3.857143	1.714286	0.285714	1.428571	0.428571	0.571429
Experiment 2	*3*	1.125	1.5	1.125	2.125	5.25	2.125
	4	2	2.285714	0.428571	0.428571	3	1
	5	0.714286	0.714286	1.285714	1.428571	7	2.571429
	6	3	1.142857	1	0.285714	3.142857	0.857143
	7	0.833333	0.666667	1.166667	0.333333	3.666667	3.333333
	8	4.714286	1.142857	0.857143	1	1.714286	2.285714
	9	2.1	0.5	1.9	0.5	9.5	1.3
	10	4.285714	1.142857	1.142857	0.571429	2.714286	3.714286
Experiment 3	3	2.571429	0.285714	1	1.285714	9.428571	1.571429
	4	2.714286	0	1.142857	0.166667	2.571429	3.571429
	5	1.428571	0.428571	1.166667	0.571429	5.142857	1.285714
	6	4.142857	0.571429	1.333333	0.166667	1.571429	1.714286
	7	4.857143	0.428571	2.142857	0.571429	3.857143	1
	8	2.857143	1	1	0.142857	1	5.714286
	9	6.714286	0	1.857143	1.857143	2.714286	1.571429
	10	6.428571	1.142857	0.714286	0.714286	1.714286	3.571429

Table A7: Condition Average Changeovers in Forced-Choice Terminal Links Per Subject Per Experiment (Conditions 3-10)

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	5	1.142857	1.071429	3.214286	3.642857	2.714286
	4	11.28571	1.357143	1.357143	3.428571	3.357143	6.071429
	5	10.14286	0.571429	0.714286	3.142857	5.214286	2.785714
	6	6.642857	1.214286	0.714286	2.357143	1.785714	3.214286
	7	4.5	2.166667	1.333333	1.666667	5.666667	2
	8	9.142857	1.285714	0.285714	0.285714	1.857143	1.142857
	9	1.571429	2.571429	1.571429	2.714286	5.142857	2.285714
	10	3.857143	1.714286	0.285714	1.428571	0.428571	0.571429
Experiment 2	*3*	1.125	1.5	1.125	2.125	5.25	2.125
	4	2	2.285714	0.428571	0.428571	3	1
	5	0.714286	0.714286	1.285714	1.428571	7	2.571429
	6	3	1.142857	1	0.285714	3.142857	0.857143
	7	0.833333	0.666667	1.166667	0.333333	3.666667	3.333333
	8	4.714286	1.142857	0.857143	1	1.714286	2.285714
	9	2.1	0.5	1.9	0.5	9.5	1.3
	10	4.285714	1.142857	1.142857	0.571429	2.714286	3.714286
Experiment 3	3	2.571429	0.285714	1	1.285714	9.428571	1.571429
	4	2.714286	0	1.142857	0.166667	2.571429	3.571429
	5	1.428571	0.428571	1.166667	0.571429	5.142857	1.285714
	6	4.142857	0.571429	1.333333	0.166667	1.571429	1.714286
	7	4.857143	0.428571	2.142857	0.571429	3.857143	1
	8	2.857143	1	1	0.142857	1	5.714286
	9	6.714286	0	1.857143	1.857143	2.714286	1.571429
	10	6.428571	1.142857	0.714286	0.714286	1.714286	3.571429

Table A8: Condition Average Proportion of Reinforcement Received from Left Terminal Link Per Hen Per Experiment (Conditions 3-10)

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	0.547069	0.591065	0.517964	0.44878	0.517781	0.537428
	4	0.496785	0.5136	0.494845	0.46696	0.494286	0.488372
	5	0.503226	0.524721	0.508221	0.485423	0.527859	0.543524
	6	0.489362	0.508661	0.497006	0.485064	0.502269	0.457426
	7	0.5	0.53169	0.507143	0.493151	0.490132	0.523316
	8	0.483553	0.515244	0.504505	0.478395	0.5	0.455814
	9	0.495082	0.52439	0.516717	0.498471	0.5	0.529183
	10	0.483108	0.509146	0.525074	0.471471	0.492997	0.452899
Experiment 2	*3*	0.498246	0.509091	0.51227	0.501425	0.509091	0.511029
	4	0.496	0.494845	0.508264	0.5	0.498516	0.509579
	5	0.502058	0.501754	0.498208	0.501718	0.493902	0.491667
	6	0.495935	0.5	0.496429	0.5	0.504762	0.515267
	7	0.508	0.496552	0.507772	0.501887	0.494949	0.504808
	8	0.498024	0.494545	0.512	0.5	0.487973	0.493976
	9	0.498652	0.493917	0.498708	0.509859	0.491184	0.51462
	10	0.495614	0.5	0.498054	0.494253	0.486056	0.483333
Experiment 3	3	0.5037	0.5031	0.5152	0.5101	0.5	0.5096
	4	0.5069	0.5302	0.5479	0.5547	0.5083	0.5172
	5	0.4899	0.5109	0.5	0.4733	0.503	0.4902
	6	0.4833	0.5	0.4833	0.4508	0.4973	0.526
	7	0.4783	0.5	0.5	0.4897	0.5052	0.5214
	8	0.5079	0.4933	0.5185	0.4862	0.5163	0.5066
	9	0.4803	0.5034	0.5077	0.4722	0.517	0.4902
	10	0.4962	0.4935	0.4744	0.4851	0.4946	0.4965

Table A9: 14 Days Average versus First 7 Days Average Proportion of Responding on Left Initial Link Key Per Hen in Experiment 1 (Conditions 3-6)

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	0.547069	0.591065	0.517964	0.44878	0.517781	0.537428
	4	0.496785	0.5136	0.494845	0.46696	0.494286	0.488372
	5	0.503226	0.524721	0.508221	0.485423	0.527859	0.543524
	6	0.489362	0.508661	0.497006	0.485064	0.502269	0.457426
	7	0.5	0.53169	0.507143	0.493151	0.490132	0.523316
	8	0.483553	0.515244	0.504505	0.478395	0.5	0.455814
	9	0.495082	0.52439	0.516717	0.498471	0.5	0.529183
	10	0.483108	0.509146	0.525074	0.471471	0.492997	0.452899
Experiment 2	*3*	0.498246	0.509091	0.51227	0.501425	0.509091	0.511029
	4	0.496	0.494845	0.508264	0.5	0.498516	0.509579
	5	0.502058	0.501754	0.498208	0.501718	0.493902	0.491667
	6	0.495935	0.5	0.496429	0.5	0.504762	0.515267
	7	0.508	0.496552	0.507772	0.501887	0.494949	0.504808
	8	0.498024	0.494545	0.512	0.5	0.487973	0.493976
	9	0.498652	0.493917	0.498708	0.509859	0.491184	0.51462
	10	0.495614	0.5	0.498054	0.494253	0.486056	0.483333
Experiment 3	3	0.5037	0.5031	0.5152	0.5101	0.5	0.5096
	4	0.5069	0.5302	0.5479	0.5547	0.5083	0.5172
	5	0.4899	0.5109	0.5	0.4733	0.503	0.4902
	6	0.4833	0.5	0.4833	0.4508	0.4973	0.526
	7	0.4783	0.5	0.5	0.4897	0.5052	0.5214
	8	0.5079	0.4933	0.5185	0.4862	0.5163	0.5066
	9	0.4803	0.5034	0.5077	0.4722	0.517	0.4902
	10	0.4962	0.4935	0.4744	0.4851	0.4946	0.4965

Table A10: Condition Average for Proportion of Pecks on Left Initial link Key from Catania (1975) Per Subject Experiment 1

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	0.547069	0.591065	0.517964	0.44878	0.517781	0.537428
	4	0.496785	0.5136	0.494845	0.46696	0.494286	0.488372
	5	0.503226	0.524721	0.508221	0.485423	0.527859	0.543524
	6	0.489362	0.508661	0.497006	0.485064	0.502269	0.457426
	7	0.5	0.53169	0.507143	0.493151	0.490132	0.523316
	8	0.483553	0.515244	0.504505	0.478395	0.5	0.455814
	9	0.495082	0.52439	0.516717	0.498471	0.5	0.529183
	10	0.483108	0.509146	0.525074	0.471471	0.492997	0.452899
Experiment 2	*3*	0.498246	0.509091	0.51227	0.501425	0.509091	0.511029
	4	0.496	0.494845	0.508264	0.5	0.498516	0.509579
	5	0.502058	0.501754	0.498208	0.501718	0.493902	0.491667
	6	0.495935	0.5	0.496429	0.5	0.504762	0.515267
	7	0.508	0.496552	0.507772	0.501887	0.494949	0.504808
	8	0.498024	0.494545	0.512	0.5	0.487973	0.493976
	9	0.498652	0.493917	0.498708	0.509859	0.491184	0.51462
	10	0.495614	0.5	0.498054	0.494253	0.486056	0.483333
Experiment 3	3	0.5037	0.5031	0.5152	0.5101	0.5	0.5096
	4	0.5069	0.5302	0.5479	0.5547	0.5083	0.5172
	5	0.4899	0.5109	0.5	0.4733	0.503	0.4902
	6	0.4833	0.5	0.4833	0.4508	0.4973	0.526
	7	0.4783	0.5	0.5	0.4897	0.5052	0.5214
	8	0.5079	0.4933	0.5185	0.4862	0.5163	0.5066
	9	0.4803	0.5034	0.5077	0.4722	0.517	0.4902
	10	0.4962	0.4935	0.4744	0.4851	0.4946	0.4965

Table A11: Average Local Variance Per Subject Per Experiment

	Hen Number	*11.1*	*11.2*	*11.3*	*11.4*	*11.5*	*11.6*
	Condition Number						
Experiment 1	*3*	0.547069	0.591065	0.517964	0.44878	0.517781	0.537428
	4	0.496785	0.5136	0.494845	0.46696	0.494286	0.488372
	5	0.503226	0.524721	0.508221	0.485423	0.527859	0.543524
	6	0.489362	0.508661	0.497006	0.485064	0.502269	0.457426
	7	0.5	0.53169	0.507143	0.493151	0.490132	0.523316
	8	0.483553	0.515244	0.504505	0.478395	0.5	0.455814
	9	0.495082	0.52439	0.516717	0.498471	0.5	0.529183
	10	0.483108	0.509146	0.525074	0.471471	0.492997	0.452899
Experiment 2	*3*	0.498246	0.509091	0.51227	0.501425	0.509091	0.511029
	4	0.496	0.494845	0.508264	0.5	0.498516	0.509579
	5	0.502058	0.501754	0.498208	0.501718	0.493902	0.491667
	6	0.495935	0.5	0.496429	0.5	0.504762	0.515267
	7	0.508	0.496552	0.507772	0.501887	0.494949	0.504808
	8	0.498024	0.494545	0.512	0.5	0.487973	0.493976
	9	0.498652	0.493917	0.498708	0.509859	0.491184	0.51462
	10	0.495614	0.5	0.498054	0.494253	0.486056	0.483333
Experiment 3	3	0.5037	0.5031	0.5152	0.5101	0.5	0.5096
	4	0.5069	0.5302	0.5479	0.5547	0.5083	0.5172
	5	0.4899	0.5109	0.5	0.4733	0.503	0.4902
	6	0.4833	0.5	0.4833	0.4508	0.4973	0.526
	7	0.4783	0.5	0.5	0.4897	0.5052	0.5214
	8	0.5079	0.4933	0.5185	0.4862	0.5163	0.5066
	9	0.4803	0.5034	0.5077	0.4722	0.517	0.4902
	10	0.4962	0.4935	0.4744	0.4851	0.4946	0.4965

Table A12: Average Local Variance Per Subject from Catania (1975)

	Pigeon 53	*Pigeon 211*	*Pigeon 280*
Experiment 1	0.131429	0.124286	0.068571

Appendix B

See attached disc

Figures B1- B3: Daily weight of each Subject for Experiment 1, 2 and 3

Figures B4-B11: Proportion of responses on free-choice terminal link keys for all subjects Condition 3-10 in Experiment 1