CONTINGENCY CONTROL OF SPATIAL RESPONDING

A thesis

submitted in partial fulfilment

of the requirements for the degree

of

Masters of Applied Psychology

(Behaviour Analysis)

at

The University of Waikato

by

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KO TE TANGATA

THE UNIVERSITY OF

WAIKATO

Te Whare Wānanga o Waikato

2014

Abstract

This study aimed to investigate fluency in domestic hens. Three experiments involved a simple grid task to see if correct responses, or components such as pecking, could become fluent for reinforcement, whilst incorrect components decreased. This was unsuccessful in the first experiment with a high rate of incorrect and unnecessary pecking observed, so a three second white screen timeout following incorrect pecks was introduced in Experiment 2. This was also unsuccessful, so a three-second black screen timeout following incorrect pecks was introduced in Experiment 3. This was continued along with a black screen timeout following repeated correct pecks on the grid that were unnecessary for reinforcement. Although incorrect pecks decreased with the introduction of the black screen, they did not fade out completely and repeated correct pecks remained at a much higher rate than necessary for reinforcement. Fluency was not achieved, because the contingencies still allowed for reinforcement to be earned despite this unnecessary responding. It is thought that in fluency and precision teaching procedures, the use of the time-restriction is important to increase the speed of correct responses required for reinforcement in order to drive down unnecessary and incorrect components.

Acknowledgements

Sincere thanks must go to my supervisors, Dr James McEwan and Prof Mary Foster for their support, patience and guidance throughout this project. Special thanks also go to Rob Bakker, for all the hours spent working on "checkers", as well as Jennifer Chandler, for animal welfare and equipment support. I would also like to thank my hens, and my fellow Masters and PhD students. This project would not have been completed without all of your help and for that I am truly grateful.

To my friends and extended family both here and overseas, your messages of encouragement meant so much; sorry I cannot name every single one of you! To Emma and Carl, my wonderful "in-laws", thank you for always asking and never doubting for a second that I could do this. Thank you to Jack, and the rest of the Pudney family, for teaching me so much, for your patience and latterly for the use of the "Hobbit" room.

To my brother David and sister Emily, the coolest set of twins I have ever known, I'm so grateful for your support whilst I continue to delay leaving university, and I promise that I will one day! Mum and Dad, there are no words to thank you enough for all your support, proof reading and love during this, and every other project I have set my sights on.

Finally, thank you to the person that always stands by me, even when I am stressed and upset, and for the things you have sacrificed as I had to study. Thank you for motivating me to carry on writing, but most of all, thank you for continually supporting me through everything. Love you always Rich.

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Introduction

In order to complete a task or acquire a skill most would agree that being able to perform that task or skill accurately is a measure of the competence level of that task. However, there have been concerns regarding the measurement of accuracy (Binder, 2003). To demonstrate this, let us imagine that Jimi Hendrix's ability to play so many notes on a guitar in one solo made him a very accurate guitar player. What distinguishes his level of competence though, from a teenager who idolises Hendrix, and has learnt to play every single note of one of his solos accurately?

Traditionally speaking, competence at tasks has been defined by accuracy, usually based upon the percentage correct formula which is easy to calculate and used all around the world; for grade calculation, training programs and even early behavioural research in the area of education and task performance (Binder, 1996; Binder, 2003).

The problem with percentage-correct accuracy analysis though, is that distinguishing between different levels of ability is virtually impossible (Binder, 2003). Returning to the example of playing guitar solos, percentage correct is calculated by dividing the number of correct notes by the total number of notes played. If both players played all notes correctly, then both players would score 100%, suggesting that they can perform on the same level because they both meet the same accuracy criteria.

However, it would be possible to distinguish between the performance levels of these two guitar players if another accuracy measurement was considered, perhaps speed or time. Most teenagers, whilst potentially able to replicate all of Jimi Hendrix's notes accurately will not initially be able to play them with such speed. If the accuracy measure was calculated based upon the number of correct notes played per minute (hereon referred to as rate/per min), one would expect the teenager's score to be several percent lower than that of his idols. This demonstrates that achieving the appropriate speed for a particular task is essential to considering accuracy levels and is an important measure of competence. It is this measure of competence; the combination of speed and accuracy known as fluency, or behavioural fluency (Binder, 1996) which will be the central focus of this thesis.

The concept of fluency relates back to the original discoveries of free-operant conditioning, with Skinner (1938) recording the frequency or rate of a particular behaviour over a period of time (Binder, 1993; Binder, 1996; Doughty, Chase, & O'Shields, 2004; Lindsley, 1996). Recording the rate or frequency of a response has long been one of the most common measures of determining reinforcer-effectiveness (Lattal, 1995), probably due to the emphasis of its importance as a dependant variable by Skinner (1938), as cited in Doughty et al. (2004). High rate-building procedures are also known to be some of the most successful ways of increasing behaviour (Doughty et al., 2004) and many behavioural principles and techniques originate in the work that Skinner and his colleagues conducted using response rate measures (Binder, 1993).

However, when the application of behavioural principles to education and training first began, Binder states that few response rate measures were used, and greater emphasis was had on percentage correct and accuracy only measures (1993; 1996). This was likely due to the need for general educators at the time to relate to the demonstrations of the early behavioural educators, and is thought to be the reason why fluency did not emerge within behaviour analysis until the 1960's (Binder, 1996).

Around that time, Ogden Lindsley and colleagues applied functional behavioural analysis to those with severe special needs and problem behaviours, using the frequency measure rate/per min as the basic measurement (Binder, 1993). This work led to the development of precision teaching training and the idea that accuracy and speed are essential for competent performance at a task (Binder, 1993). Since then, fluency has also been described as a combination of quality and pace (Binder, 1996), and is considered an outcome of learning (Doughty et al., 2004).

Probably the most popular rate building method known to achieve fluency is that of precision teaching. This involves the use of frequency measures of behaviour and the standard behaviour chart (now known as the standard celeration chart, or SCC) to record individuals progress and arrange their curriculum based upon the data collected (Binder, 1996). Targets are set and adjusted along the way until the pre-determined level of fluency is achieved (Doughty et al., 2004).

An example of this would be to have an aim of playing 30 notes on the guitar in one minute. If this task was to be taught through precision teaching, a SCC would be used to display the number of correct notes and incorrect notes played during each one minute session every day, thus producing the performance frequencies and data upon which decisions can be made (Lindsley, 1992). Over time, one would expect the number of correct notes to increase whilst the number of incorrect notes decreased. The aims are gradually increased, so initially a learner may set a target of 10 correct notes per minute. In this way, incorrect responses can decrease, before the speed of the correct responses is increased. It is the celeration of correct responses that is the focus of this method (Cooper, Heron, & Heward, 2007). Once the target level of responses has been reached, fluency has been achieved (Doughty et al., 2004). One of the distinct advantages of this method is that aims can be custom-made to accommodate different abilities and learner speeds (Lindsley, 1992).

Plotting SCC's usually involves self-monitoring and enables both teachers and learners to gauge improvement at a task promptly, if they are plotted every day and aims are reviewed accordingly (Lindsley, 1992). Reinforcement may be provided as an incentive once each aim is reached prior to achieving fluency at the task (Doughty et al., 2004).

Fluent behaviours are ones that can be performed at a very high rate, without effort or error, regardless of distraction and retained for long periods of time (Lindsley, 1996). Fluency is perhaps best described by the effects or outcomes that it produces (Binder, 1996; Lindsley, 1996), with acronyms for these outcomes developed by Haughton (1980). Outcomes originally included retention, endurance, application, and performance standards, or REAPS (Lindsley, 1996). Stability and adduction were later added following Lindsley's (1996) practical use of fluency building procedures with graduate students, and the acronym RESAA is now often used to describe the outcomes retention, endurance, stability, application and adduction (Doughty et al., 2004). Several other acronyms now feature in the literature to describe key features and outcomes of fluency, practice, performance goals and performance results attained by fluency of a particular task (Lindsley, 1992).

Doughty et al. (2004) conducted a literature review on studies that examined the outcomes of fluency. They found that the majority of studies focused on retention; defined as the ability to maintain high rates of responding after a period of time has elapsed since training (Doughty et al., 2004). For example, a learning and retention study was carried out by Shirley and Pennypack (1994) who taught two subjects two spelling lists, one list trained with rate (time and accuracy) criteria and the other with accuracy only criteria. They found that there was a small difference in the retention ability with the list trained with rate criteria, but for only one of the students (Shirley & Pennypack, 1994). Doughty et al. (2004) caution the reliance on some of the retention focused studies due to methodological issues and inconclusive or limited data. However, earlier literature, for example Binder (1996), strongly highlights the importance and successes in the retention of skills through fluency.

Endurance is an outcome which has received a lot less literature attention (Brady & Kubina, 2010; Doughty et al., 2004). It is defined as the ability to maintain high response rates during longer trials than those used in training (Doughty et al., 2004). Brady and Kubina (2010) taught three students with attention deficit hyperactivity disorder (ADHD) multiplication facts by one of two means; either endurance building practice trials (three trials with a duration of 20 seconds each) or whole time practice trials (one trial one minute in duration). Students with this particular disorder were chosen due to previous studies which had suggested that attention span, which is often lacking in those with an ADHD diagnosis, could be quantitatively measured and referred to as endurance (Brady & Kubina, 2010).

The results supported the hypothesis; when re-tested using 1-minute trials, all three participants recorded more multiplication facts after training by three 20-second trials than after training by 1-minute trials. This demonstrates not only the importance of endurance as an outcome measure of fluency, but also as a technique to building fluency in those whose learning is often impaired due to their inability to attend to a task for a greater length of time (Brady & Kubina, 2010).

Stability refers to the continued high rate of responding despite environmental distracters (Doughty et al., 2004). If a particular task is learnt really well, it should be replicable regardless of what is happening elsewhere. A good example of this is given by Lindsley (1996), who describes the ability of army personnel to learn and recall names, locations, emergency exit procedures, drills and other important information whilst the noise and stress of war goes on around them. Whilst the ability to continue responding at a high rate despite distracters seems like the ideal outcome, it can be difficult to prove experimentally. This is because the inability to recall previously trained behaviours in settings where distractions occur may not be due to the distraction itself (Doughty et al., 2004). Other contributors, such as the amount and exact type of practice, effects of reinforcement and a person's previous experience and resilience to distracters can influence the results.

Application, as a fluency outcome, is the generalisation of the learnt skill to new environments or situations (Doughty et al., 2004). This definition differs slightly from Haughton's original definition as the "integration of component response classes into composite response classes" (Binder, 1996, p. 178). Johnson and Layng (1992) later described the effect of building composite response classes as response adduction. In this case, application will refer to generalisation and adduction to the appearance of a new behaviour which has not been directly taught, when components of that behaviour have been taught to fluency (Doughty et al., 2004).

One population in which application of learnt skills can be a very important outcome is people with a diagnosis of autism. Kubina and Yurich (2009) developed a model to demonstrate how fluency building techniques can be used with both children and adults with autism. Although the skill deficits related to an autism spectrum diagnosis differ greatly from person to person, deficits in the ability to generalise skills across environments, people and other related stimuli is relatively common (Kubina & Yurich, 2009; Weiss, Pearson, Foley, & Pahl, 2010; Wenar & Kerig, 2000). Therefore, given that precision teaching and fluency building techniques have been successful in generalising skills across environments, it seems paramount that such teaching methods are applied with this population (Kubina & Yurich, 2009).

In fact, all of the outcomes that define fluency can be learning deficits in those with autism, and fluency building techniques could be widely used to improve task retention, endurance, stability and adduction with this population. Weiss et al. (2010) highlight the need for fluency techniques to be trialled in more situations to empirically validate the likelihood of this success.

A good example of response adduction was demonstrated by Chapman, Ewing, and Mozzoni (2005). In their study, Chapman et al. (2005) created a teaching program for five children who had suffered traumatic brain injuries (TBI). One participant's target behaviour was to stand up and walk 20 feet unaided. This was achieved by breaking the task down into sequential components and shaping successive approximations to fluency until the target behaviour, or composite skill, could be performed (Chapman et al., 2005).

Another participant made 30 Say All Fast, a Minute Every Day, Shuffle (SAFMEDS) autobiographical flash cards. Widely used in precision teaching since the 1970's (Lindsley, 1996), SAFMEDS cards usually consist of one key word on the front, and the answer on the back. A number of points is awarded for each card, and these are then plotted as the number of correct responses or incorrect responses, on a SCC (Chapman et al., 2005; Potts, Eshleman, & Cooper, 1993).

Despite encountering research limitations, the study enabled each participant to not only achieve fluency in their target skill but also to increase levels of self-esteem and satisfaction, demonstrating the benefits of self-monitoring and ability for people to gain confidence in themselves as they see the celeration of their scores and abilities (Chapman et al., 2005). One of the most interesting things about this study is that it highlights the potential for precision teaching and fluency training to be successful not just in academic teachings, but also in physical and cognitive rehabilitation and development (Chapman et al., 2005). Also, with various limitations on the time children (and others) are able to spend in rehabilitation, the ability to implement treatment not just effectively, but quickly, whilst still using data-based decisions is highly beneficial (Chapman et al., 2005).

The studies described above are just a select few of the vast body of applied literature that exists in this area (Porritt, Van Wagner, & Poling, 2009). There is, however, very limited experimental literature that uses animal subjects to explore the same topic. This is somewhat surprising given the extent to which animal research and laboratory based experiments have dominated in the experimental analysis of behaviour (Porritt et al., 2009).

Following their literature review, Doughty et al. (2004), suggested that more controlled research into precision teaching and further research on its outcomes would be highly beneficial as we seek to understand how fluency generates its outcomes. This more controlled research could enable the development of more “efficient and effective techniques” (Doughty et al., 2004, p. 20) for the development of fluency, to benefit education, a highly important task of all fields of behaviour analysis. Kubina (2005), in his response to Doughty et al. (2004), also supports this need for further experimental research on behavioural fluency.

Due to practical and ethical considerations, conducting more tightly controlled research can be difficult with human participants (Porritt et al., 2009). Ethical considerations include maintaining effective reinforcers for the duration of the experiment and controlling establishing operations that could influence reinforcer effectiveness during the session. Furthermore, the continued exposure to relatively long experimental sessions across an extended period is not possible with human participants.

Practical considerations can include basic participant retention and reliability of participation, as well as researchers having limited knowledge of an individual's prior learning experience that could affect task performance. Human participants are also able to practice and generalise behaviour outside of the experimental session, and that can make it very difficult to control how the task is learnt. Using animals however, enables the researcher to control many of the above described issues that can occur in human research. In order to carry out more controlled research into fluency and precision teaching, procedures using animals as subjects seem to have some clear advantages in this area.

Porritt et al. (2009) used animals as subjects in a fluency study that used a repeated acquisition procedure. Porritt et al. (2009) suggested that variables which are also known to influence response rate, might also influence the accuracy of learning certain discrimination tasks. They investigated whether conditions which required higher rates of responding produced higher levels of accuracy than conditions which required lower rates of responding (Porritt et al., 2009). Establishing operations, and the number of trials and rate of reinforcement were maintained at the same level throughout the course of their experiment (Porritt et al., 2009).

In Porritt et al.'s (2009) study, six pigeons were trained to respond to red, green and white keys alone, then exposed to repeated presentations of extensions. This involved a three-link chain schedule, in the first component three keys were red, and the correct key, either left, right or centre, advanced the chain to the next link, in which all three keys were green. A peck on the correct key in this link triggered the next link in the chain. The keys were all white, and a peck on a correct key in this link turned off the keys and activated the magazine for reinforcement. The position of correct keys in each link of the chain differed from one another and this remained constant throughout a session, but was alternated between sessions. Responses on incorrect keys throughout the links of the chain caused the key lights and house lights to go out immediately for 1-second, as a timeout. Position sequences which had been consistently responded on during training were selected for the experiment, and distractor sequences were trained to avoid subjects responding based upon the location of a previous response (Porritt et al., 2009).

Sessions consisted of three parts, the first being a retention component, the second being a distractor component and the third being the training of new response sequences. Retention was measured because the first part of each session presented the same sequence as the last part of the previous session. The experiment ran three conditions, a no-delay, within-chains delay and between-chains delay which altered the level of responding required (Porritt et al., 2009). In the no-delay condition, the links were arranged as described above. In the within-chains delay condition, a 5-second period in which the key lights were turned off occurred between each correct response and the next link of the chain. In the between-chains delay condition, a 15-second period in which the key lights were turned off occurred between the final link in each chain and the first link of the next chain. The no-delay condition was alternated, first with the within-chains delay condition, and then with the between-chains delay condition (Porritt et al., 2009). Reinforcement was provided on a variable interval (VI) 50-second schedule, ensuring that it remained constant throughout all conditions (Porritt et al., 2009).

Porritt et al. (2009) found that the no-delay condition, which produced higher rates of responding, also produced greater accuracy when compared to the within-chains delay. Retention was also better for the no-delay condition (Porritt et al., 2009). In comparison, the no-delay condition produced greater accuracy when compared to the between-chains delay, but it did not produce greater retention (Porritt et al., 2009). This led to the conclusion that the condition which produces the highest rates of responding (the no-delay condition), also produced higher levels of accuracy (Porritt et al., 2009).

Precision teaching theorists have argued that being able to respond at a high rate improves the accuracy and fluency outcomes of that particular behaviour (Binder, 1996; Doughty et al., 2004; Lindsley, 1996; Porritt et al., 2009). Porritt et al.'s (2009) results support this statement by demonstrating that higher rates of responding do produce greater levels of accuracy, whilst controlling other variables (Porritt et al., 2009).

As previously discussed, it is difficult to control many variables when using human research participants, and despite Porritt et al.'s (2009) contribution, there is still substantial opportunity for fluency work with animals. Therefore, it was decided that this study would use domestic hens as subjects to test its primary hypothesis.

Whilst it is clear that fluency has good outcomes, it does not appear to be clear what generates this fluency. One possible process of change is that a response becomes more efficient; that is to say only necessary parts or components of a response that are reinforced persist, and can be increased to a high rate. Components that are not reinforced diminish. Very often in fluency and precision teaching studies, a way of increasing the efficiency of responses is setting a target for a certain number of correct responses during 1-minute practice sessions (Lindsley, 1992). This number is often increased once incorrect responses have decreased. However, it is not clear what function this 1-minute time restriction actually has. One suggestion is that such high rate behaviour in a short time is difficult to achieve if there are many unnecessary responses occurring. The time restriction may force out these unnecessary responses to allow maximum time for correct responding.

Any attempt to investigate this explanation, that would involve the use of a simple response such as a key peck, is difficult because the response itself is already very simple or atomic. For example, in a response such as a key peck, there are very few components of that behaviour left to diminish with practice. This makes demonstrating the changes in efficiency of that task very difficult indeed.

The present study is an attempt to investigate if reinforced responses, or components thereof, can become more fluent with the reduction of non-reinforced responses, without a time restriction. The development of a simple grid sequence task for domestic hens will enable this. Pecks on any part of the squares presented as stimuli will hereon be referred to as correct pecks, and any pecks elsewhere on the screen, other than the squares, will be known as incorrect pecks. Individual pecks will be the individual components which make up the larger response to the stimuli. Accuracy and speed of responses will be measured, but within the time to complete the grid to earn reinforcement, (hereon referred to as grid time), to enable a measure of fluency.

Experiment 1

Method

Subjects

The subjects were six domestic hens, all under two years old as of the start of this study. The hens were housed in individual cages with light in the hen rooms controlled on a 12 hour light and dark cycle. The hens had free access to water at all times, were weighed daily and kept at a body weight of 90-95% of their free-feeding body weight. In the home cage the hens were fed using a commercial laying pellet. During the experiment, wheat was used as a reinforcer. As well as pellets and wheat, the hens received grit weekly and vitamins when necessary as part of their usual feeding routine.

Apparatus

Squares were displayed on a computer screen; the size, colour, duration of presentation and the position of the squares was controlled by software. An experimental chamber 600mm long by 450mm wide was made of plywood, at one end of which a 210mm by 330mm computer screen was positioned 250mm from the floor of the chamber. A hole 180mm below the screen and 100mm wide allowed the hens access to the magazine when it was raised for reinforcement. The magazine itself was operated automatically and situated outside of the chamber. The walls inside the chamber were painted white and a black rubber mat was situated on the floor of the chamber to enable easy removal for cleaning.

To the right of the operant chamber a computer, a USB connected interface and the magazine power operated the experimental program and was used to record all responses, reinforcers and other data specified during each condition. This equipment was used for the duration of the experiment.

Figure 1. The interior of the experimental chamber.

Procedure

Part 1. Shaping and Training

The hens were placed individually in the chamber for one session for up to a maximum of 40 minutes. They were presented with a 2x2 grid on the screen, with two red squares and two green squares, as shown in Figure 1. The hens needed to peck once on both of the red squares in any order to receive reinforcement. After five days the decision was made to reduce the target to one red square in order to more accurately shape the initial behaviour.

The hens were then presented with one red square on the screen which they had to peck for reinforcement on a CRF schedule as a basic shaping technique. Once all the hens were responding well and earning all available reinforcers, a green square was displayed next to the red square as exposure to other stimuli, but it had no function for reinforcement. A second green square was added to more closely resemble an experimental session which would begin with a 2x2 grid of red and green squares. After almost 30 days of training in these conditions, the hens were moved onto the experimental phase.

Part 2. Experimental Procedure

The hens were presented once again with a 2x2 grid, with the reinforcement requirement still being a peck on each of the red squares, in any order. The green squares were to be ignored. After 32 days on this condition, the green squares were changed to match the black background in colour, but pecks on them were still recorded. This change was made due to high rates of pecking on the green squares in an attempt to reduce this number. Pecks on the red squares were termed correct pecks, with pecks on the green and then black squares, termed incorrect pecks. Pecks off the grid, but still on the screen were also recorded, and referred to initially as border pecks. After a further 14 days, the condition was changed to a 2x3 grid of black and red squares, with the same reinforcement requirement of pecking each red square in any order. In each condition the grids increased in size, as did the number of squares required for reinforcement, as shown in Table 1.

Hen 9.6 took longer to respond to training and required more shaping in order for her to eat from the magazine when it was raised for reinforcement. Once she was pecking enough to earn all available reinforcement, she returned to the same condition as the other hens.

Condition Number	Matrix Size	Number of Days	Reinforcer Requirement
1	2x2	46	2 red squares
2	2x3	30	3 red squares
3	3x3	14	5 red squares

Table 1. The conditions presented in experiment 1.

Results

2x2 Condition

Figure 2 shows the average number of correct (red square) and incorrect (green square) pecks daily for each of the birds. On average, all the hens made 3 correct pecks per grid completion, which was one more than required. Every hen earned all 40 reinforcers during every session. Average incorrect pecks ranged between 1 and 3 for all of the hens, though this started off greater for hen 9.3, and increased during the middle of the experiment for 9.5. The vertical line indicates where the green squares were changed to black to match the colour of the background. 9.2 and 9.5 showed a slight increase in both correct and incorrect pecks for the few days immediately after the change to black squares.

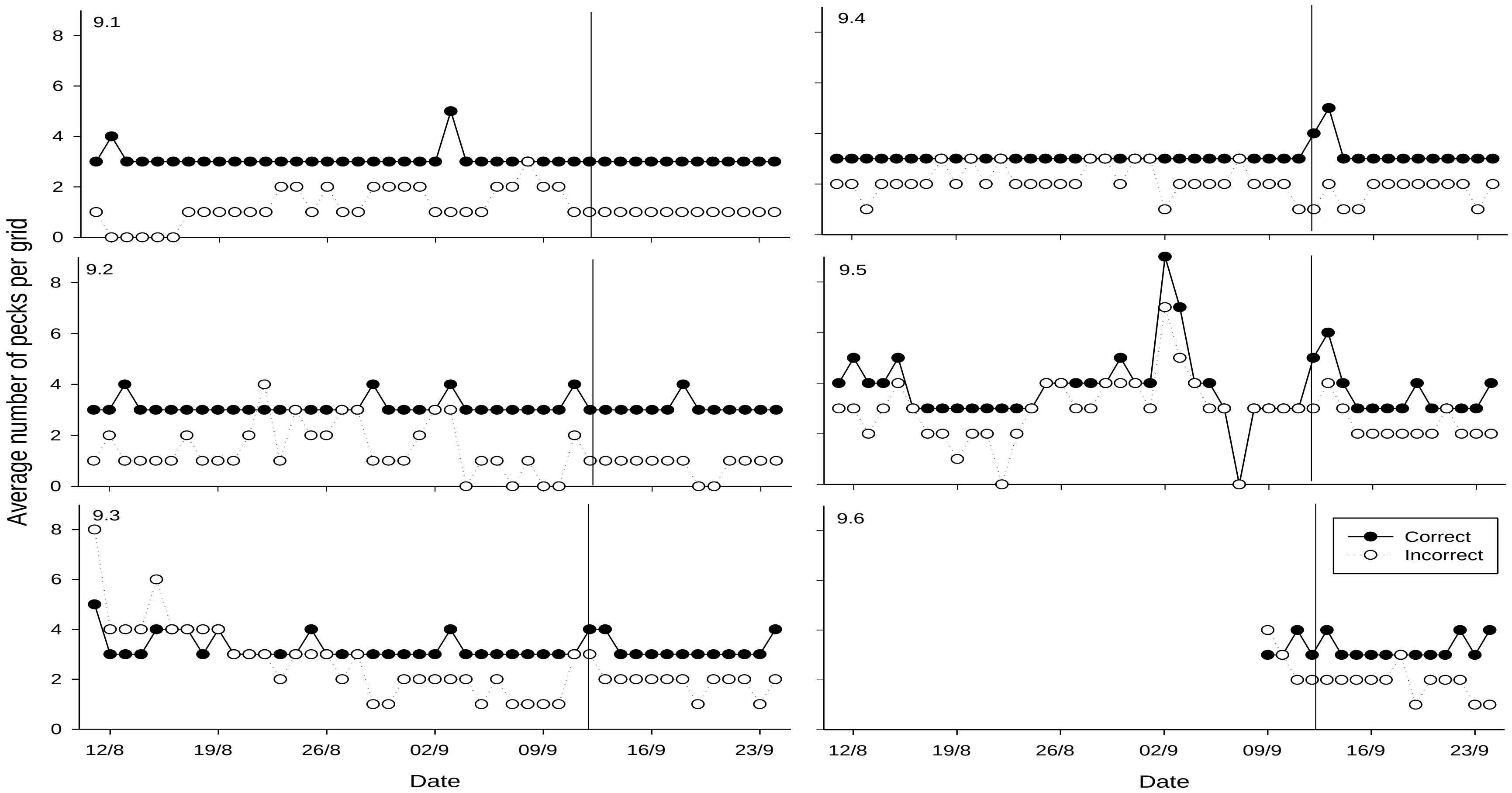


Figure 2. The average number of pecks per grid for all hens during the 2x2 grid condition, with correct pecks are shown in black and incorrect pecks are shown in white.

Figure 3 displays the peck locations for the most accurate hen (9.1) on the first and last day of the condition. Pecks off the grid were recorded as border pecks, and added to the incorrect pecks to determine the total number of incorrect pecks. The proportion of correct pecks to incorrect pecks increased, from .71 and .29 respectively, to .73 and .27.

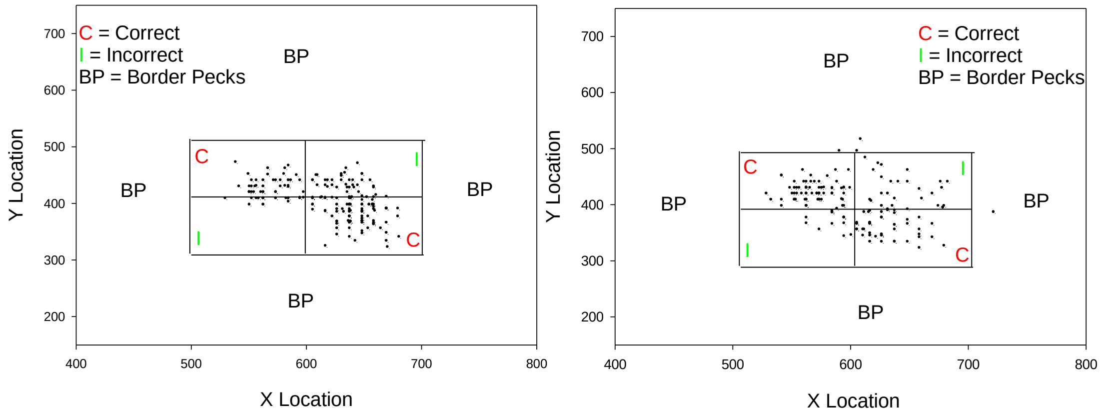


Figure 3. The peck locations for 9.3 on the first (left graph) and last (right graph) day of the 2x2 condition.

In contrast, hen 9.3 demonstrated very little accuracy at the task, as shown in Figure 4. The proportion of correct pecks to incorrect pecks did increase, but from .25 and .75 respectively, to .38 and .62. As the graph shows, 9.3 also continued to respond greatly outside of the grid.

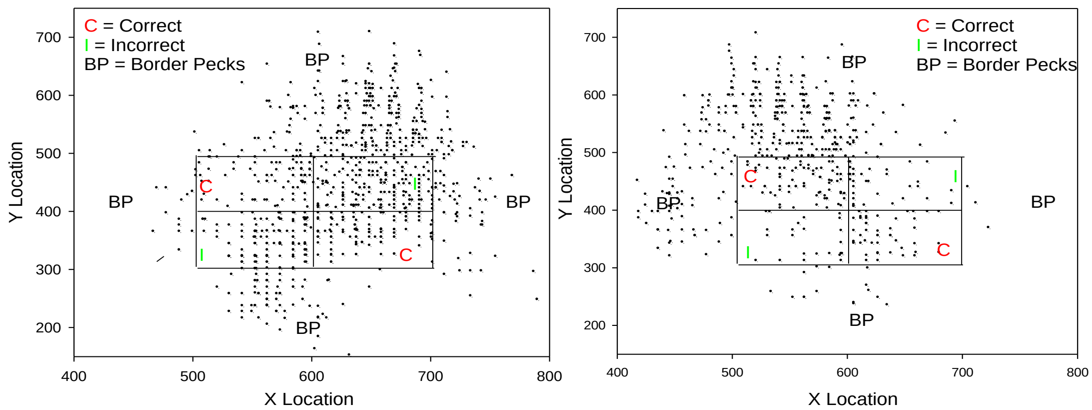


Figure 4. The peck locations for 9.3 on the first (left graph) and last (right graph) day of the 2x2 condition.

2x3 Condition

Figure 5 shows the average number of correct and incorrect pecks daily for each bird across all of the 2x3 condition. Four of the six hens had a high rate of pecking overall on the first day of this condition, demonstrated on the graph. Hens 9.3 and 9.6 maintained an average number of correct pecks per grid of between 6 and 7, with 9.1 having the lowest average of 6.2667 correct pecks per grid. This was still more than twice the required rate for reinforcement. All hens earned all 40 reinforcers during each session. Hens 9.1, 9.2 and 9.6 had the lowest incorrect pecks per grid, ranging from 1.89 to 2.48, but incorrect pecks did not fade out completely for any of the hens.

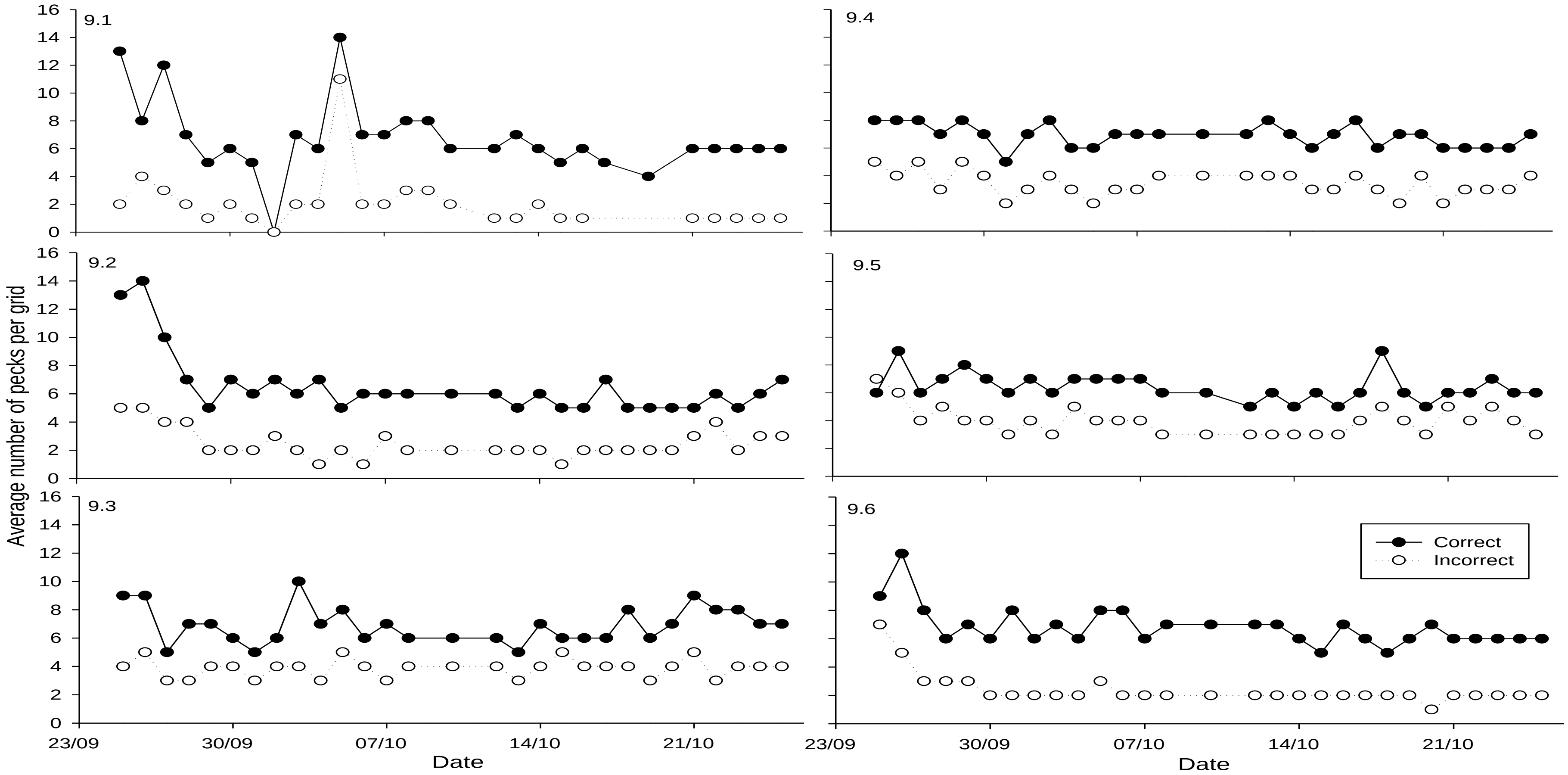


Figure 5. The average number of pecks per grid for all the hens during the 2x3 grid condition, with correct pecks shown in black and incorrect pecks in white.

3x3 Condition

Once again, there was an increase in the number of pecks at the start of the condition especially for hens 9.1, 9.2 and 9.6. However, the average number of correct pecks had more than halved within five days of starting the condition. Whilst number of pecks increased for the other hens compared to the previous condition, they remained relatively stable throughout the fourteen day condition period, as can be seen in Figure 6. The average response rate did not reduce beyond 10 to 15 correct pecks per grid, more than three times the rate required for reinforcement. Every hen earned all 40 reinforcers during each session. Despite a slight decrease in incorrect pecks for hens 9.1 and 9.5, all other birds' incorrect pecks remained stable throughout this condition, with little reduction in the number of pecks noticeable. The average number of incorrect pecks across the condition ranged from 4.36 for hen 9.1, to 14.71 for hen 9.5 .

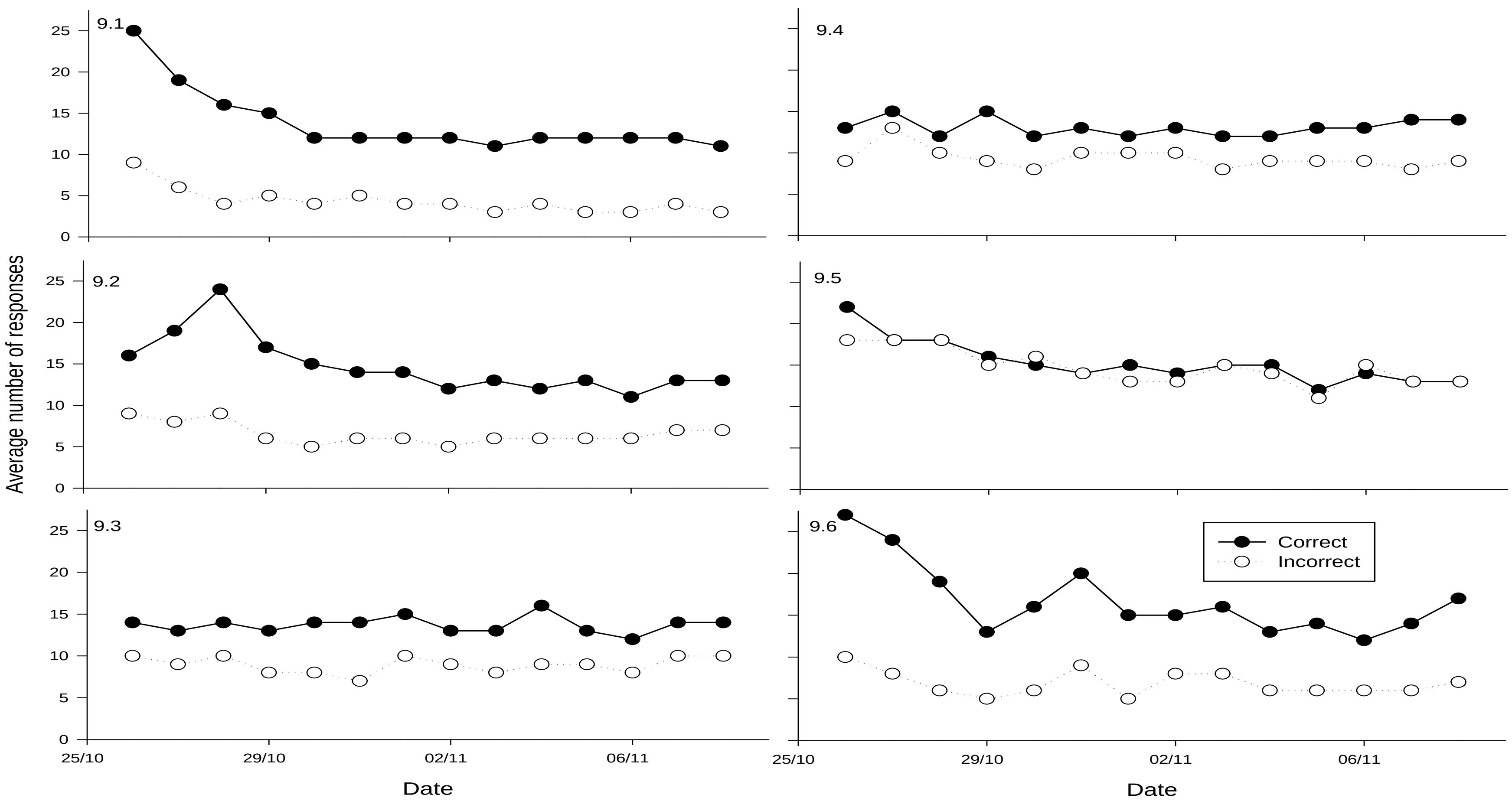


Figure 6. The average number of pecks per grid for all the hens during the 3x3 grid condition, with correct pecks shown in black and incorrect pecks shown in white.

Comparison Data

As well as an increase in the number of pecks as the grid size increased, there was also an increase in the total session time as shown in Figure 7. Corresponding with the high rate of responding at the beginning of each session was an increase in the session time, which usually decreased throughout the condition. As the number of pecks increased, so too did the time taken to complete each grid. The grid time is the latency from the time the grid appears on the screen to the time when all red squares have been pecked to earn reinforcement. An average of all 40 grid times throughout the session was calculated automatically at the end of each session, recording the average task completion time for each bird every day. The grid time for each hen for the first five and last five days of each condition is shown in Figures 8, 9 and 10. Hen 9.1 performed consistently faster in all three conditions than any of the other birds. All of the hens average grid completion times remained relatively stable throughout the 2x2 condition, with the most noticeable reduction in time occurring for all hens on the 3x3 condition.

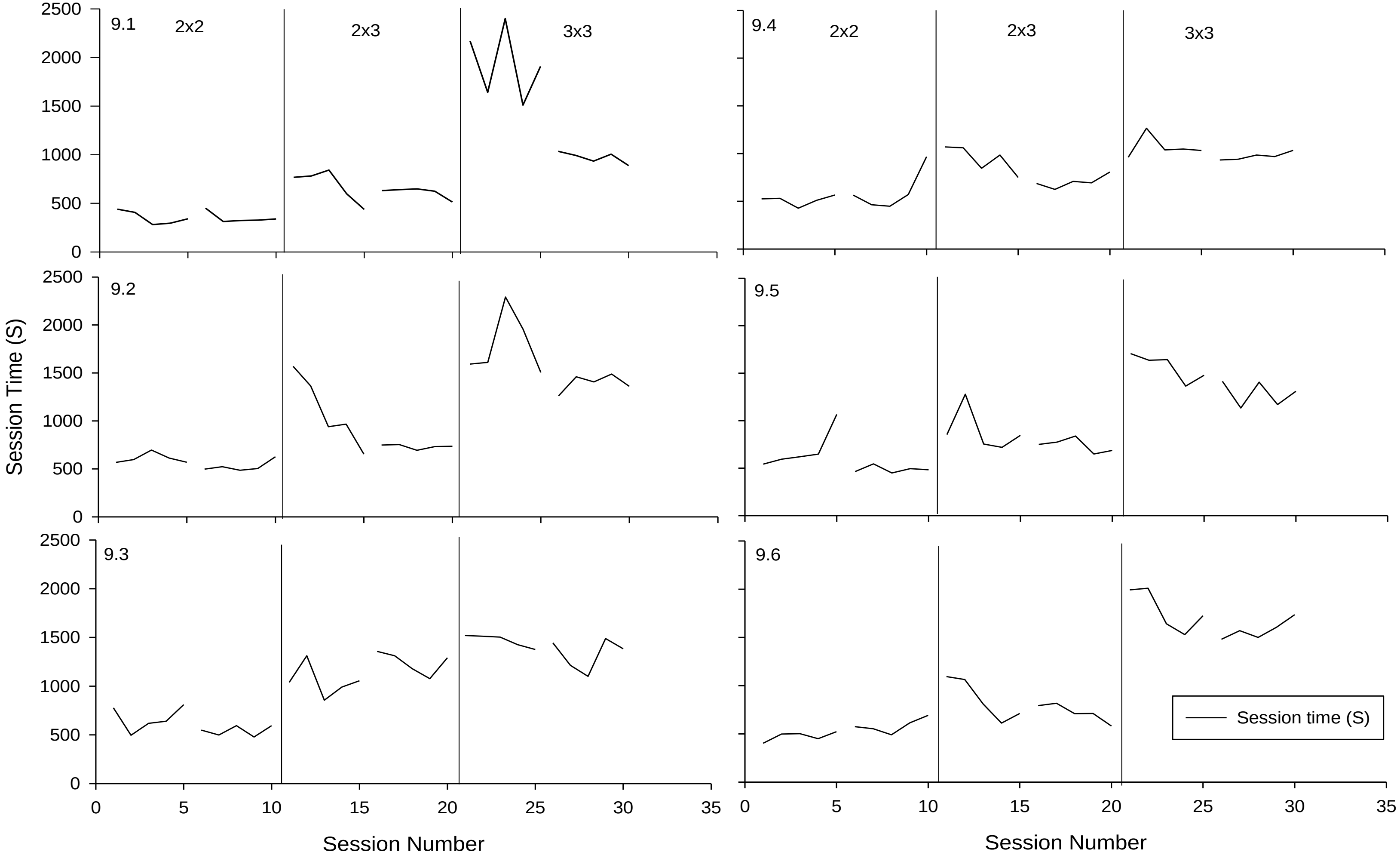


Figure 7. The total session time (S) for all hens across the first five and last five days of the three grid sizes in Experiment 1.

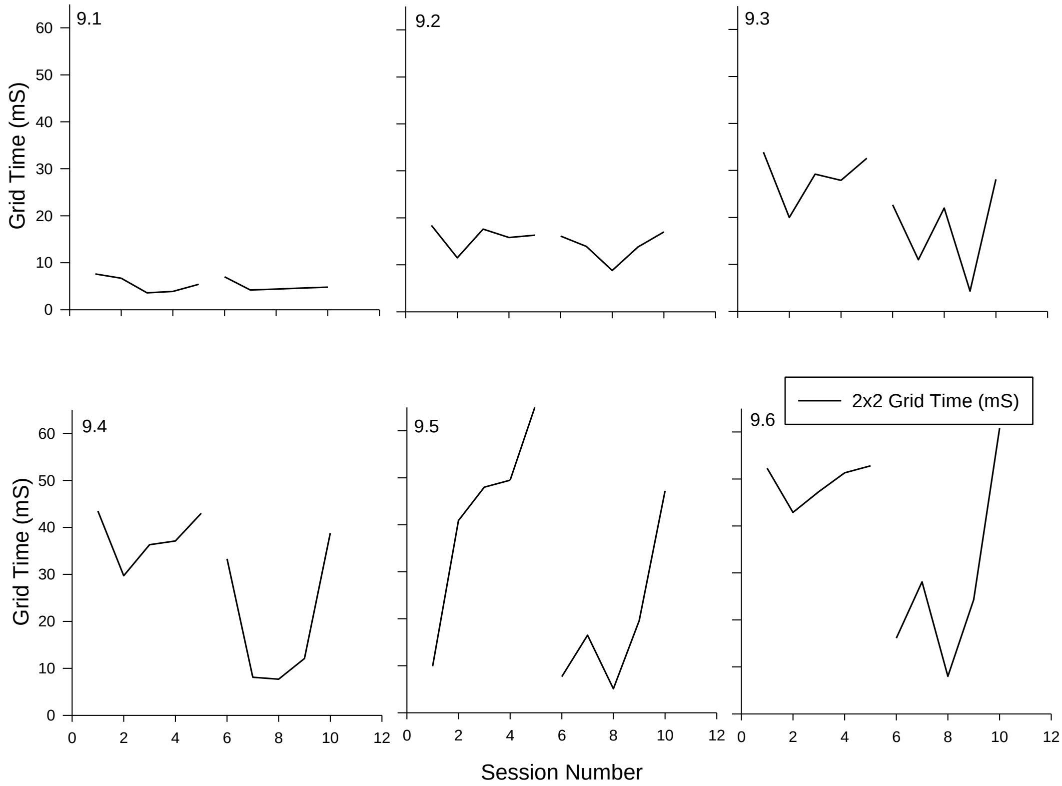


Figure 8. The average grid time for all hens on the first five and last five days of the 2x2 grid condition.

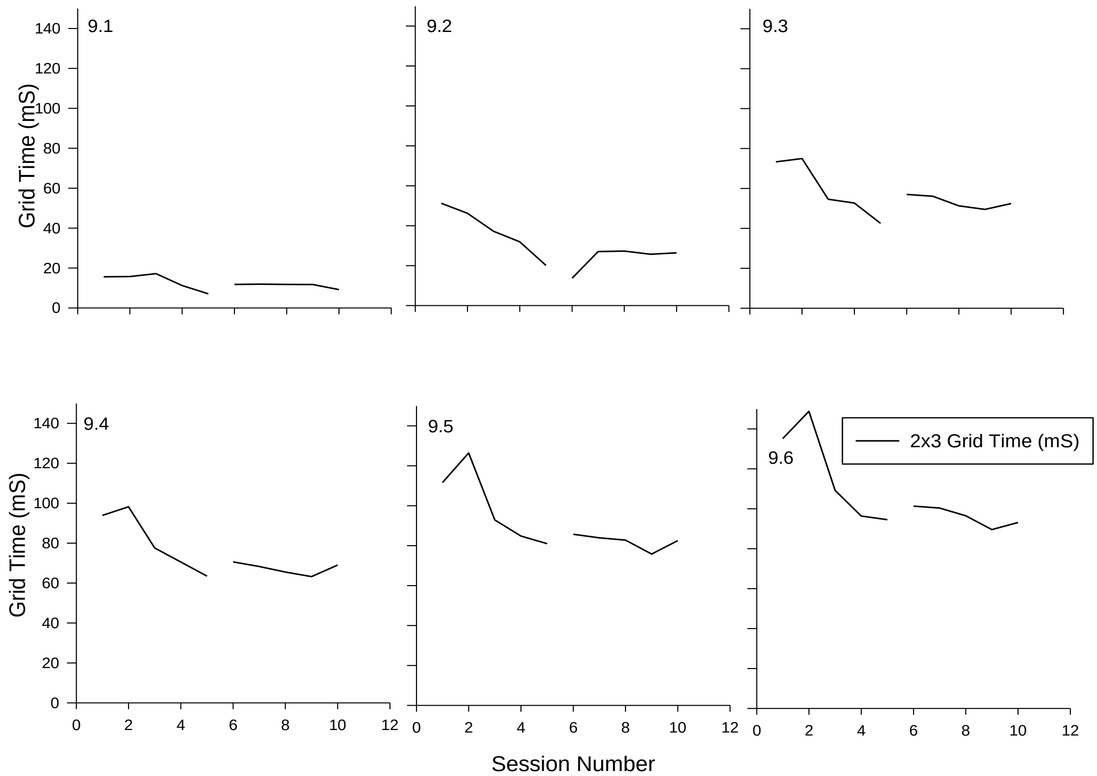


Figure 9. The average grid time for all hens on the first five and last five days of the 2x3 grid condition.

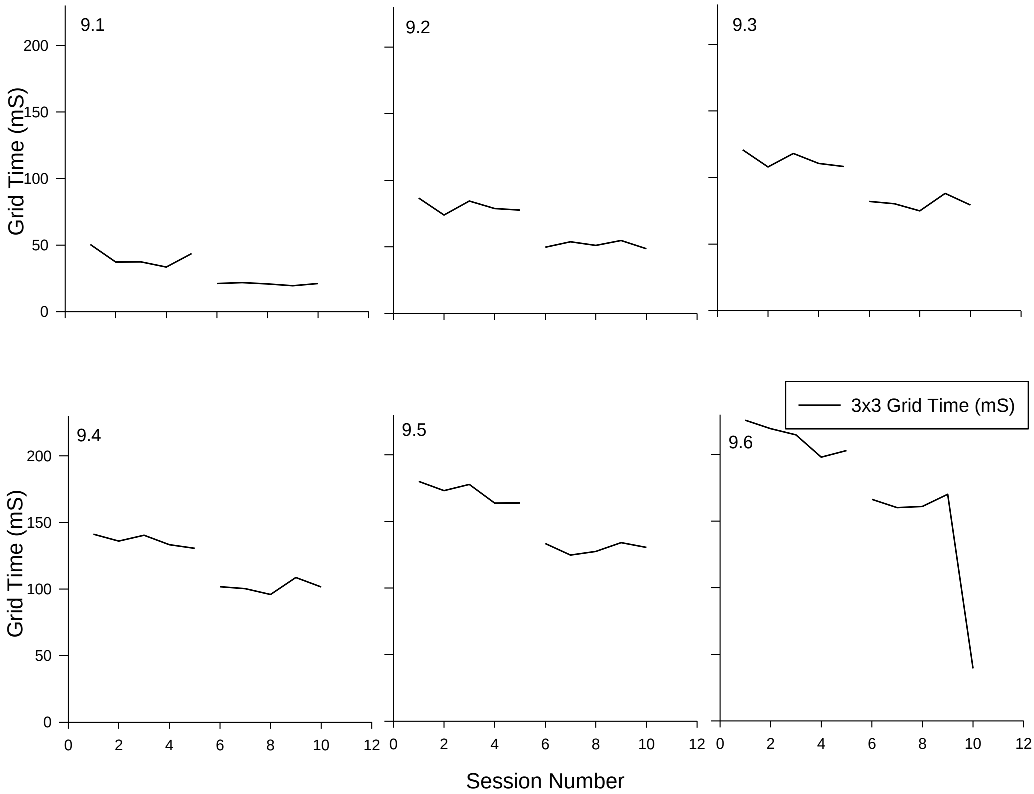


Figure 10. The average grid time for all hens on the first five and last five days of the 3x3 grid condition.

Discussion

This experiment aimed to examine fluency in hens. It was predicted that responses on the red squares of the grid, which were considered correct, would become more fluent as they were reinforced, while all other pecks, which were incorrect and unnecessary, would fade out.

The hens did not become fluent at this task. During the 2x2 condition, incorrect components of the response did not reduce, and although they were lower for some hens, they never faded out completely. There was no identifiable change in responding when the green squares were changed to black to resemble the background. There were also an excessive number of pecks on the grid, far more than that required for reinforcement. From here on, these will be known as repeated pecks, to distinguish these unnecessary pecks on the grid from incorrect pecks off the grid.

The large number of incorrect pecks suggests that the contingencies arranged for the first condition were not sufficient to drive down the number of incorrect pecks. Every hen earned all available reinforcers each day, despite the levels of unnecessary pecking and there was no negative consequence for extra pecks. After one peck on each square, regardless of what else they had done, reinforcement was delivered so there was no reason for them to reduce the number of non-critical pecks.

In a further attempt to reduce these incorrect pecks, the grid size was increased twice, first to 2x3 and then to 3x3. It was predicted that a larger grid would take the hens longer to complete, leading to a greater proportion of correct pecks. However, that was not successful, the number of incorrect pecks actually increased. The number of repeated pecks on the red squares also increased. All 40 reinforcers were earned by each hen during every session, so there was no reason for incorrect pecking to reduce as they were still earning reinforcement.

The grid time, or the time it took to earn reinforcement increased as the grid size increased, as did the session time, which was expected as there was an extra requirement for reinforcement. Despite an increase, all of the hens managed to earn all 40 reinforcers before the maximum session time of 40 minutes was reached.

Overall, attempts in this experiment to drive out incorrect pecking by increasing the size of the grid were unsuccessful. Incorrect pecks did not fade out, and repeated pecking on the red squares did not become more accurate, so fluency was not achieved in this experiment. This was due to the arrangement of the reinforcement contingencies. Reinforcement was provided, even when high numbers of other pecks persisted. To remove these incorrect pecks, a response cost of some description needs to be in place. It may be that punishment for incorrect pecks could be successful at reducing them.

Experiment 2

Introduction

Across all conditions in Experiment 1, there was a large number of incorrect pecks occurring besides those on the red squares. By changing the procedure slightly, it is predicted that the amount of pecking on other areas of the screen other than the red squares will reduce. To do this, a white screen will be added as a timeout. Timeout is an effective behaviour management tool, used to reduce unwanted behaviour by removing opportunities to earn or access positive reinforcement whenever the unwanted behaviour occurs (Cooper et al., 2007). As previously discussed, high rate behaviour associated with fluency is not easy to achieve if there are many unnecessary pecks occurring.

A timeout in an experimental chamber would usually involve a blackout, in which all key or screen lights and the house light are dimmed for a designated period. It is thought that blackouts are effective because the darkness is paired with occasions where responding is not necessary, that is to say during reinforcement or at the end of an experiment. Therefore, the blackout itself becomes a signal that reinforcement is not available for responding. The colour white was chosen specifically in this experiment because black was already a feature within the experiment on which the hens were pecking – all other pecks besides those on the red squares occurred on a black screen. It was thought that black may actually signal a further opportunity to respond, rather than an opportunity not to respond.

Method

Subjects

The subjects used were the same domestic hens from the previous experiment.

Apparatus

The apparatus used was the same as the previous experiment.

Procedure

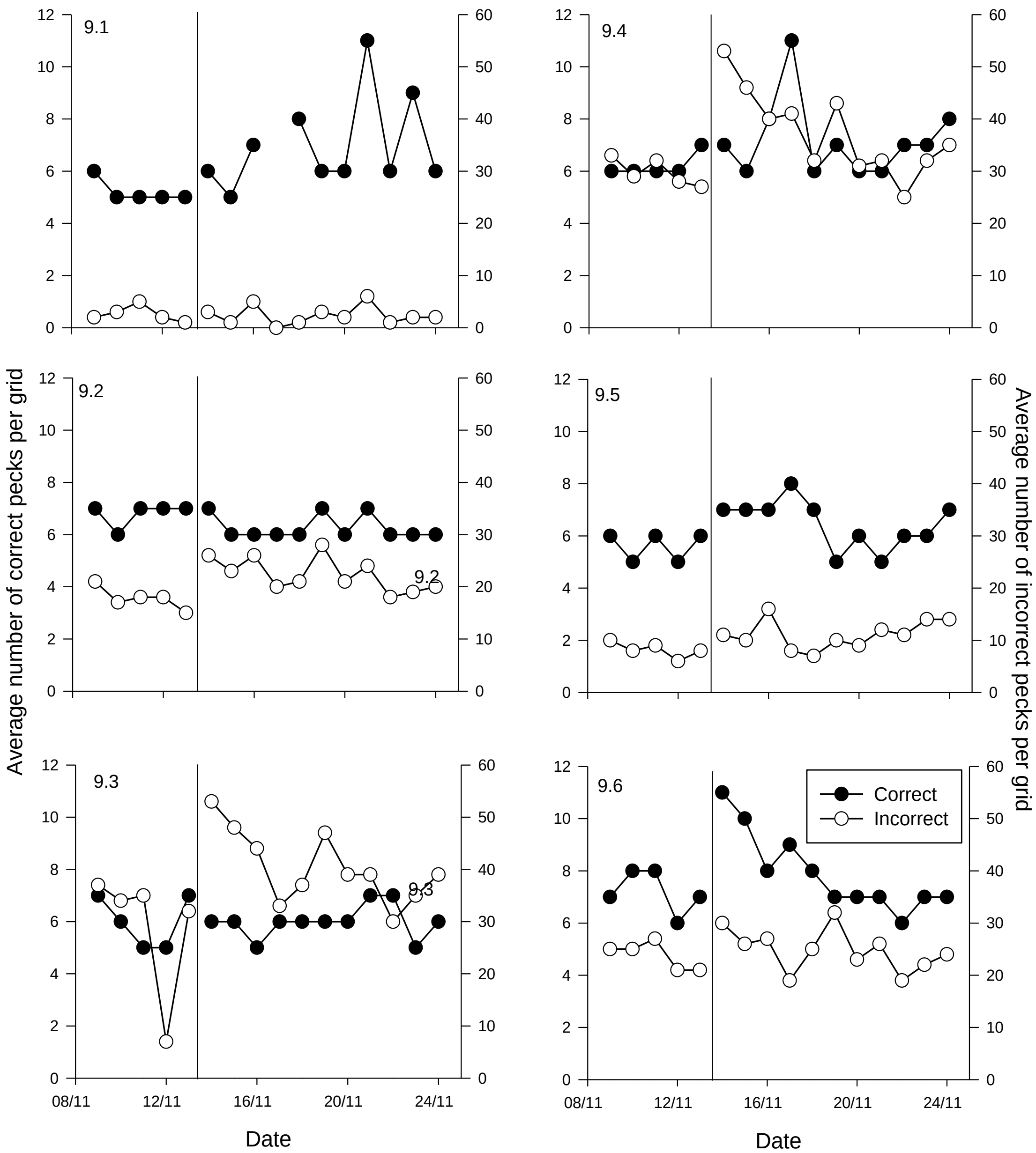
During this experiment, incorrect pecks on the screen triggered a white screen that was present for 3 seconds. All other features of the experiment remained the same. Red squares could still be responded upon multiple times, and the maximum number of reinforcers was still 40, with a maximum of 40 minutes session time. Experimental sessions were conducted every day. The hens were presented with a 2x3 grid without the white screen to generate five days of baseline data following the large amount of pecking seen on the 3x3 grid in the previous experiment. The grid was then maintained at a 2x3 size with the white screen triggered by any peck besides those on the red squares.

Results

9 days into this experiment, 9.1 fell ill and this affected her responding on certain days. Missing data points from this point forward for this particular bird are due to the removal of data on days where she failed to respond.

Figure 11 shows the average number of correct and incorrect pecks per grid per session throughout the whole experiment, with the vertical line demonstrating the introduction of the white screen. Incorrect pecks are all pecks that occurred besides those on the red squares. For all the birds other than 9.1, the graph demonstrates an increase in incorrect pecks following the introduction of the white screen. An increase in the number of correct pecks, that is pecks on the red squares of the grid, was also noticed in four of the birds following the introduction of the white screen.

A large amount of pecking was also occurring during the presentation of the white screen. The total number of these responses each day is shown in Figure 12. Any pecks during this time did not contribute to reinforcement, the total number of incorrect pecks or increase the time that the white screen was present.



F*igure 11*. The average number of pecks per grid for all the hens before and after the introduction of the white screen timeout. Correct pecks are shown in black and incorrect pecks in white.

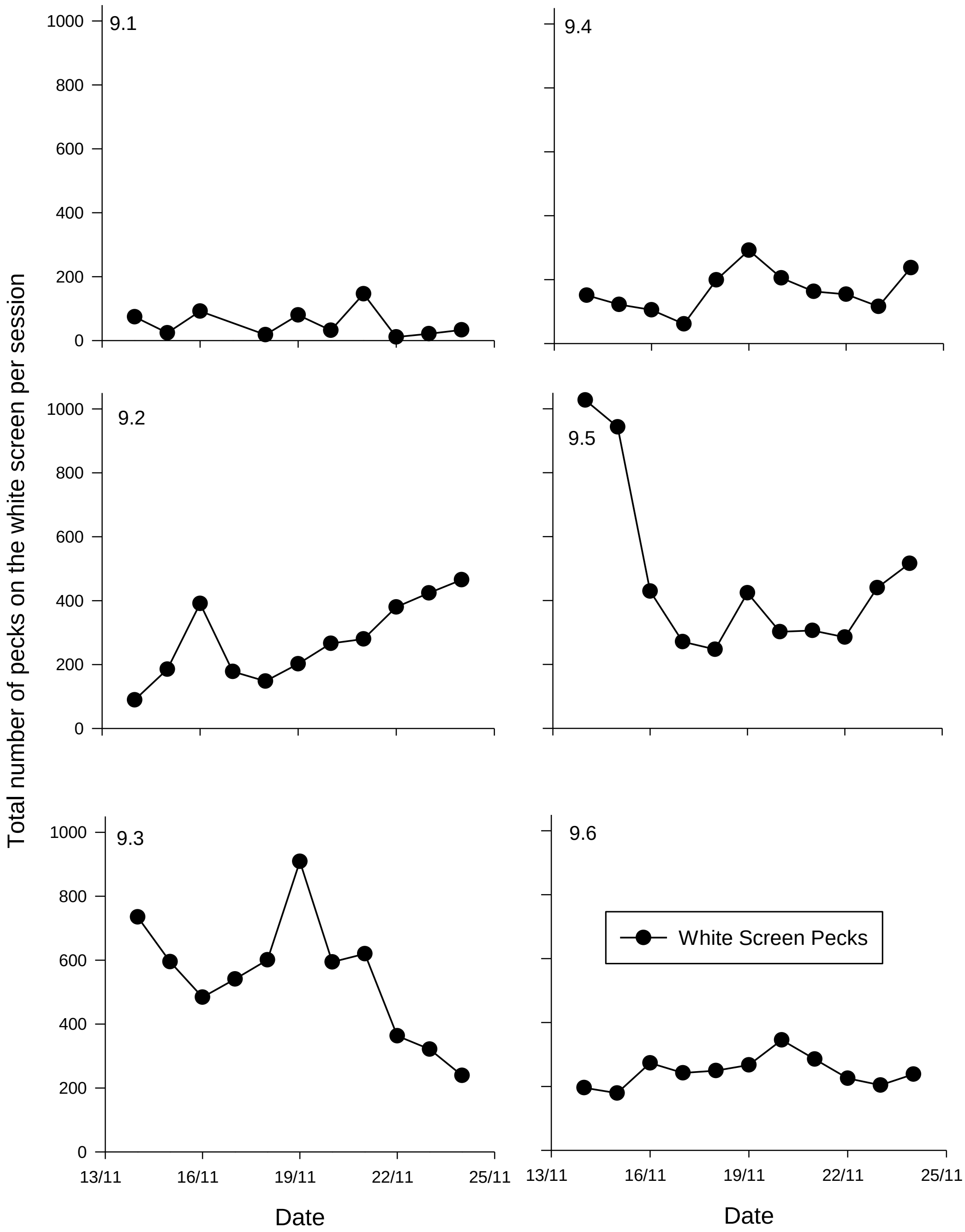


Figure 12. The total number of pecks on the white screen for all hens throughout each session of Experiment 2.

Figure 13 displays the average grid time and the session time throughout the whole condition, with the condition break showing the introduction of the white screen. There was an increase in the total session time for most of the hens when the white screen was introduced, which was understandable as the white screen was displayed for three seconds every time it was activated. The grid time however actually reduced; even though the number of responses increased. White screen display time was not calculated in the average grid time.

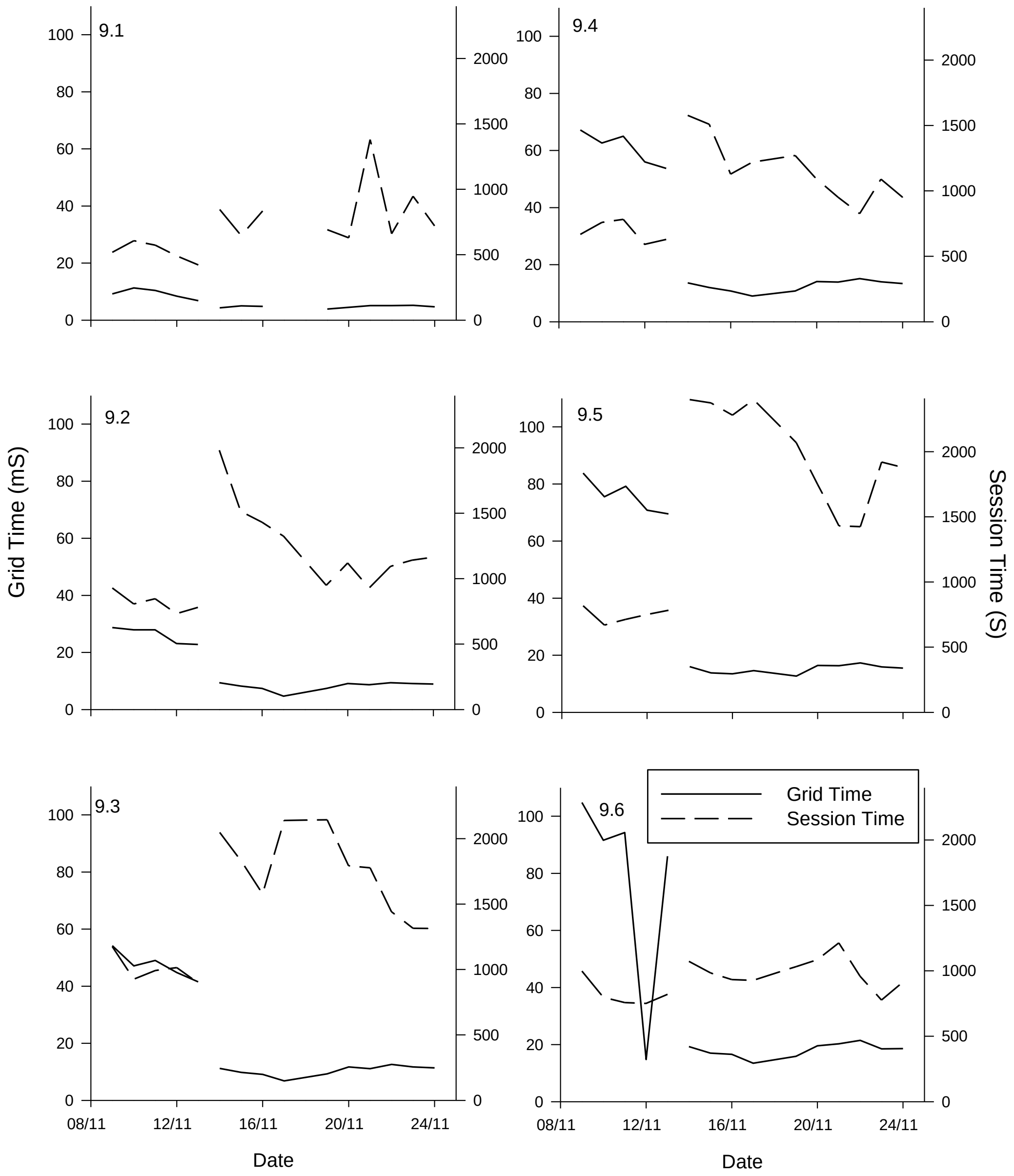


Figure 13. The average grid time (mS) and total session time (S) for all hens throughout each session of Experiment 2.

Discussion

This experiment aimed to reduce the number of incorrect pecks occurring off the grid by introducing a 3-second white screen after any incorrect peck as a timeout. It was predicted that this would decrease the number of incorrect pecks occurring, however this did not work.

The white screen had the opposite effect to the prediction; it actually increased incorrect pecks compared to the baseline data. All of the hens still earned all reinforcers, and repeated pecks on the red squares were recorded as even higher than the previous experiment. Once again, the contingencies arranged even with timeout were not sufficient to drive down the number of incorrect pecks.

One unexpected finding was the amount of pecking that occurred actually on the white screen. There was no response cost associated with pecking on the white screen, but there was also no opportunity to earn reinforcement. It seems the white screen was ineffective as a timeout perhaps because throughout this and the previous experiment, any stimuli lit on the screen, such as red and green squares, had signalled opportunity to peck for reinforcement. Therefore instead of signalling that responding would be ineffective, the white screen actually signalled opportunity to respond for reinforcement.

Previously, Dunn (1990) has emphasised that for timeout to be effective, it needs to be associated with the correct stimulus otherwise it will not work, hence the initial concern of using a black screen which had been paired with increased pecking. In both this and the previous experiment, the screen went black when the magazine opened for reinforcement, and it went black at the end of each experimental session, so the hens did have some exposure to black signalling a time to stop responding.

Turning the screen white also created complications of its own. As the hens pecked, the screen would get quite dirty, producing marks which on a black screen were only visible from certain angles. However, when the screen went white, these marks were clearly illuminated from behind. Prior experience with hens has indicated that they will often fixate on spots or imperfections and high rates of pecking such marks have previously been observed. Therefore, when the screen went white, signaling an opportunity to respond in its own right, there were also many little marks at which the hens could peck. The lack of success at achieving fluency due to an ineffective white screen led to the design of experiment 3.

Experiment 3

Introduction

Based upon the conclusions made from the last experiment, there was little change in the amount of incorrect pecks, due to the fact that the white screen was not effective as a timeout. Therefore, a black screen was introduced instead, chosen because of the previously discussed association between traditional blackouts and periods within an experiment where no responding is required. It is predicted that incorrect pecks, which will trigger a 3-second black screen as a timeout, will decrease, producing more fluent pecking at the grid.

Method

Subjects

The subjects used were the same domestic hens from the previous two experiments.

Apparatus

The apparatus used was the same as the previous two experiments.

Procedure

Condition 1.

All aspects of the experiment remained the same, except for the 3-second white screen, which was changed to a black screen to appear immediately following any incorrect peck. The reinforcement requirement was still one peck on each of three red squares. This condition ran for 13 days.

Condition 2.

All of the hens were still pecking far more than required on the red squares. Therefore the decision was made to increase the presentation of the black screen; every time a peck occurred on a red square that had already been pecked, the black screen time out was presented for 3-seconds. All other criteria remained the same, and the matrix size remained at 2x3. This condition ran for 23 days.

Results

Figure 14 displays the average number of correct and incorrect pecks per grid per session across the whole experiment. The average number of pecks are presented on the same graph for both conditions, represented by the vertical line, in order to more accurately compare the results between them. 9.1's health condition also deteriorated throughout the course of this experiment, leading to some inconclusive data. This was removed from further analysis and will not be presented here for that reason.

The average number of incorrect pecks more than halved for hens 9.3, 9.4 and9.5 with the change from the white screen to the black screen, as shown in the first 5 data points on the graph. 9.6 still maintained higher levels of incorrect pecking, but these also reduced compared to the previous experiment. The average number of correct pecks on the red squares changed little during the experiment, even with the introduction of the black screen timeout on repeated correct pecks.

Responding during timeout continued throughout the first condition, as shown in Figure 15. For 9.2, 9.3 and 9.5, the number of pecks on the black screen reduced slightly compared to the number of responses on the white screen in the previous experiment. However, 9.4 and 9.6's pecks on the black screen were actually higher than the white screen. 9.1's data was not included as she completed very few sessions during the first condition of experiment 3. Procedure issues encountered in this experiment meant that black screen pecks could not be detected into the second condition to see if this produced further changes.

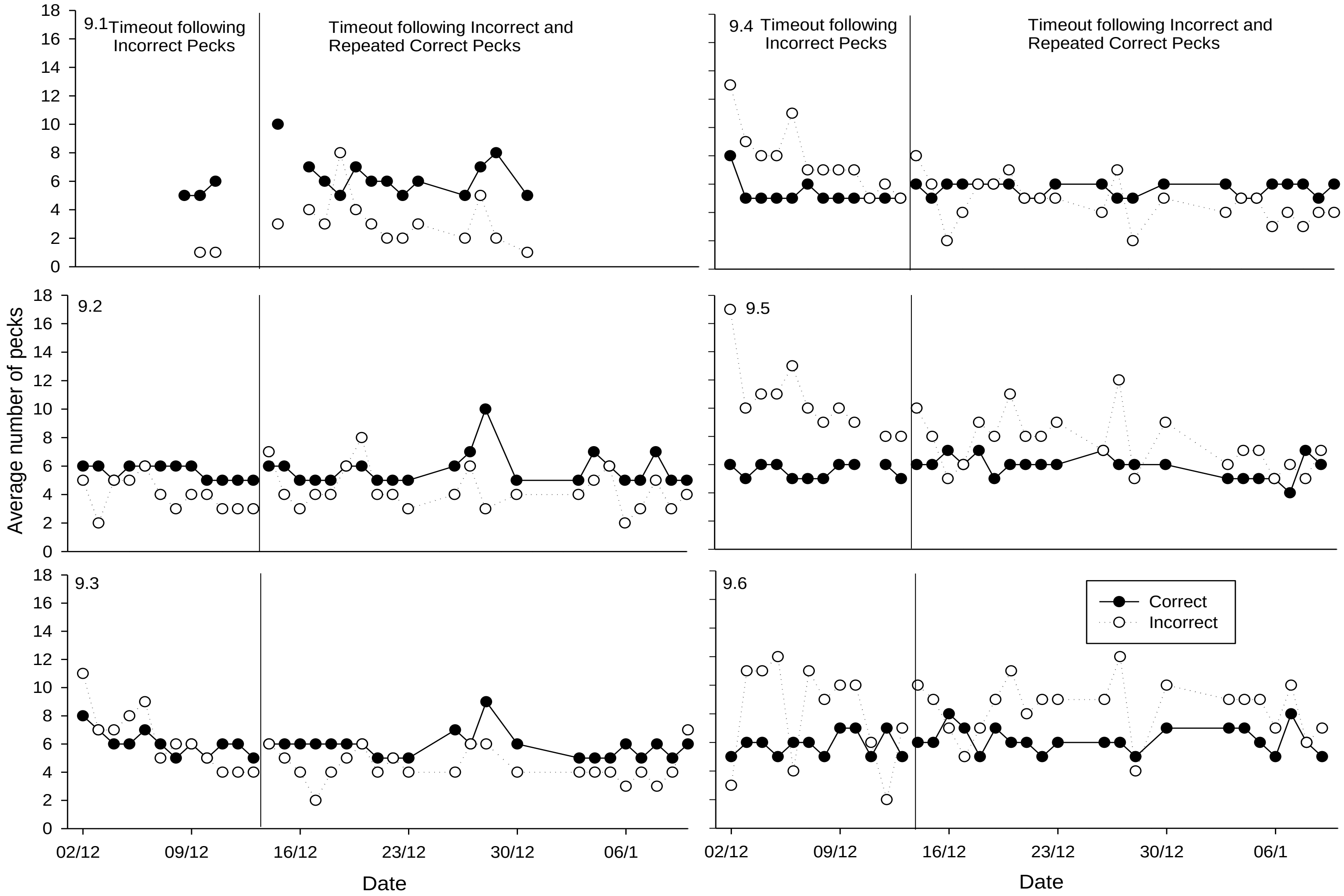


Figure 14. The average number of pecks per grid for all hens during the two timeout procedures used in Experiment 3. Correct pecks are shown in black and incorrect pecks in white.

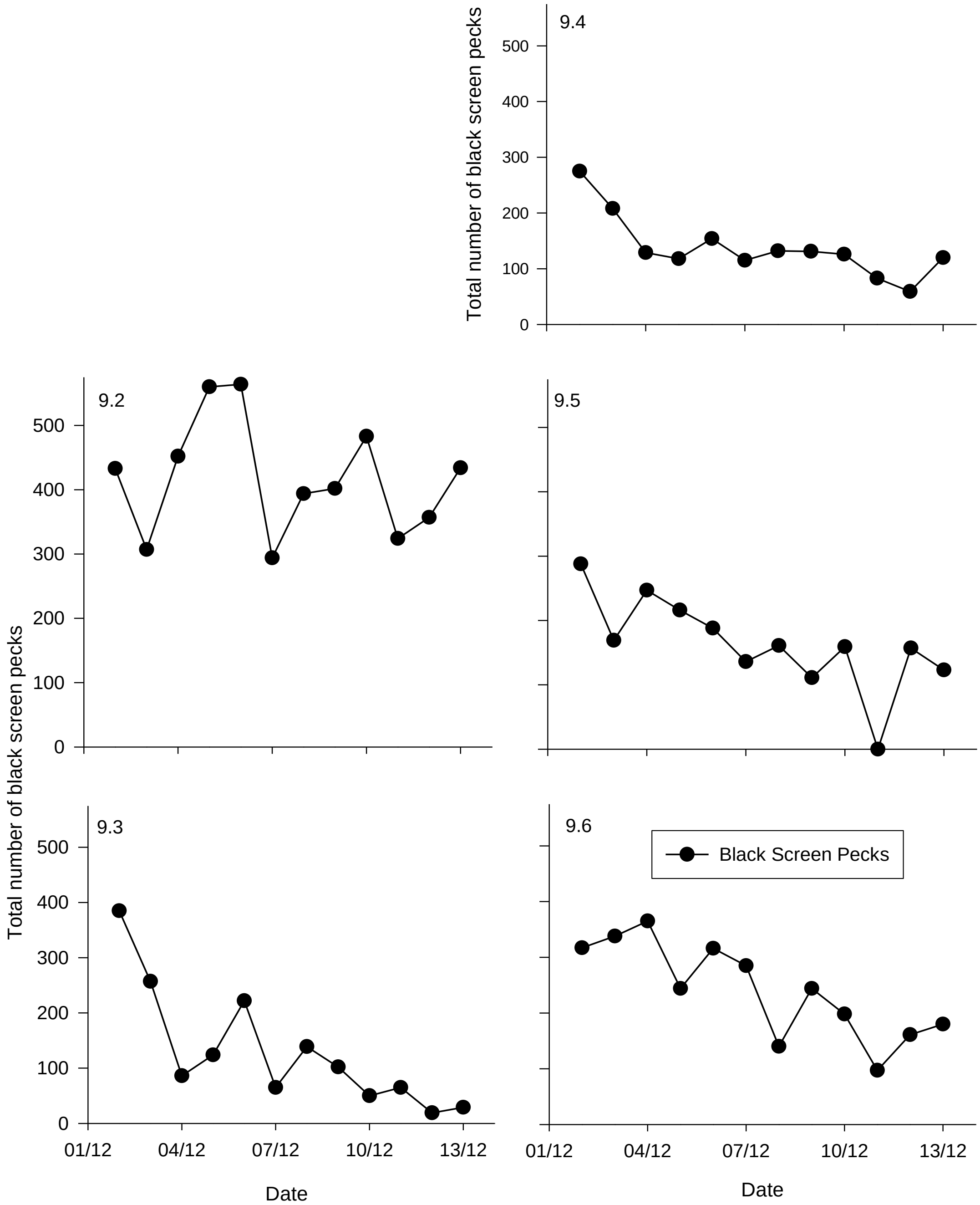


Figure 15. The total number of pecks for 5 of the hens on the black screen during the first condition of Experiment 3.

Figure 16 displays the grid time and session time for all the hens across the whole experiment. The session time increased with the introduction of the black screen after repeated correct pecks, which was to be expected, given the extra 3 seconds every time the screen went black. The grid completion time however reduced for all the hens following the introduction of the black screen after repeated correct pecks. The trends displayed for 9.1 are inconclusive due to a lack of data.

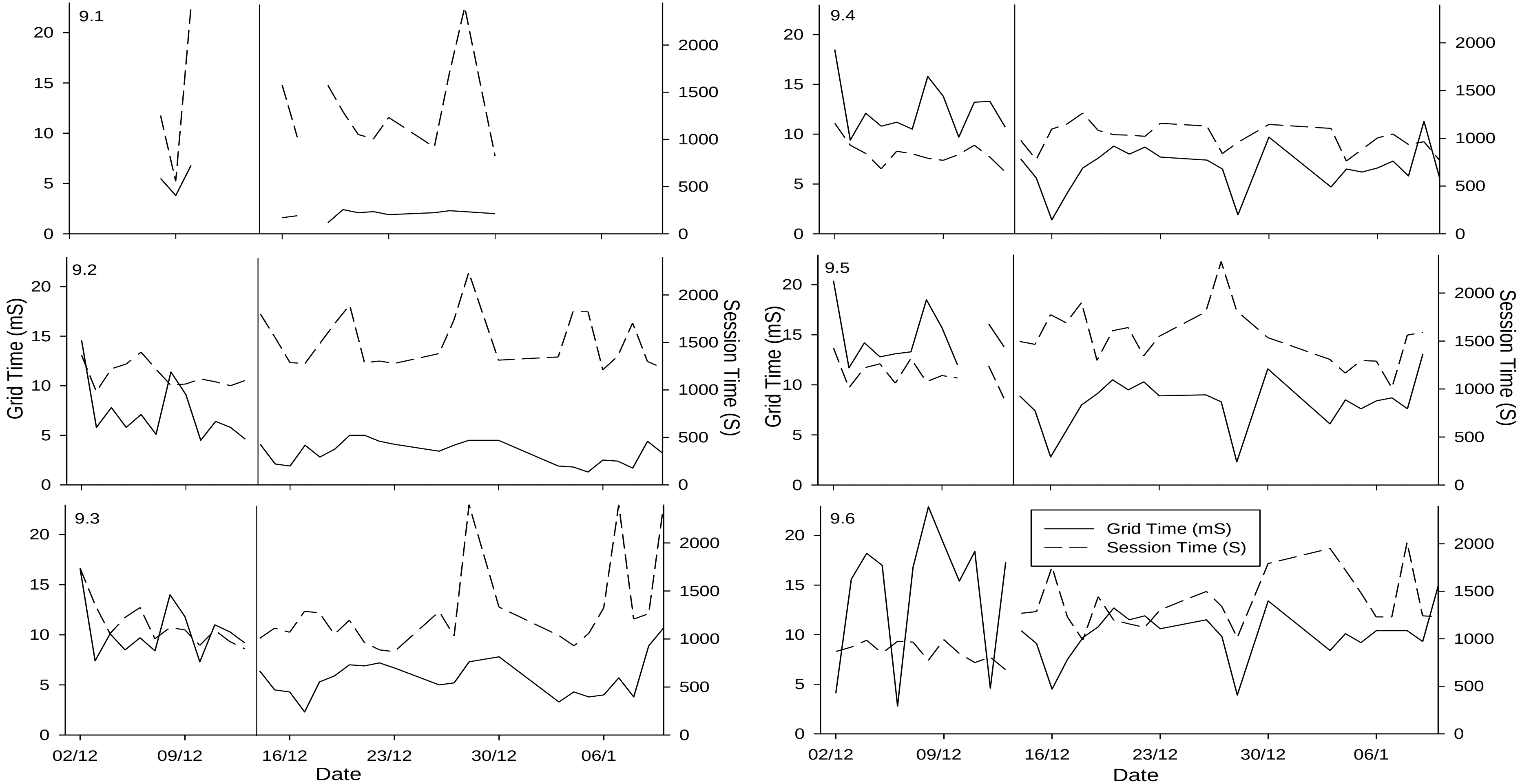


Figure 16. The average grid time and total session for all hens during both timeout procedures used in Experiment 3.

Across Experiment Comparisons

Figure 17 shows the average number of correct pecks for each bird during each experimental condition. The first part of each bar gives the number of correct pecks that were actually required, demonstrating the consistently high levels of pecking observed throughout. The average number of incorrect pecks for each bird during each experimental condition is displayed in Figure 18.

All birds had an opportunity to complete 40 grids for reinforcement within each session, so the number of times a grid was completed without any incorrect pecks gives another measure of accuracy as well as the average correct number of pecks per grid. These grids were termed 'error-free'. Figure 19 shows the number of error-free grids each bird completed. It is split into 3 sections, the first showing the first five and last five days of the initial 2x3 condition in Experiment 1 and the second section showing the first five and last five days of the 2x3 grid white screen experiment. The third section shows the first five days of the black screen on incorrect pecks and the first five and last five days of the black screen on repeated correct pecks, as these conditions overlapped. The number of error-free grids increased for all hens, particularly with the introduction of the black-screen. 9.4 completed the most error-free grids in one session (13) and 9.5 completed the least overall, reaching a maximum of 6 error-free grids. 9.2, 9.3 and 9.6 all showed a reduction in the number of error-free grids completed after the introduction of the black screen on repeated correct pecks.

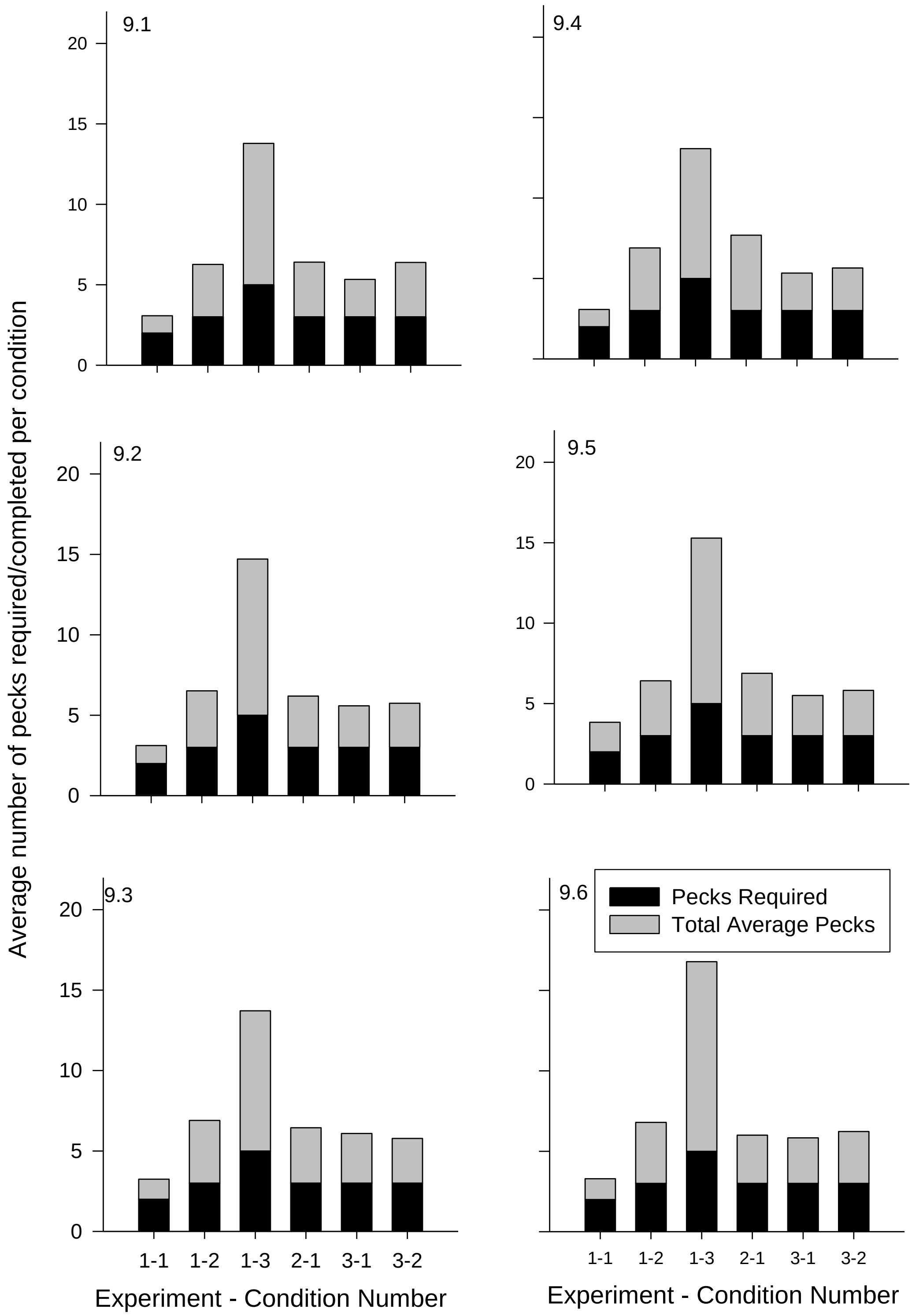


Figure 17. The number of pecks required and the average number of pecks actually completed for all hens across all experiments; the three grid sizes used in Experiment 1, the 2x3 grid used with the white screen timeout in Experiment 2, and the 2x3 grid used during the black screen timeout on incorrect and repeated correct pecks in Experiment 3.

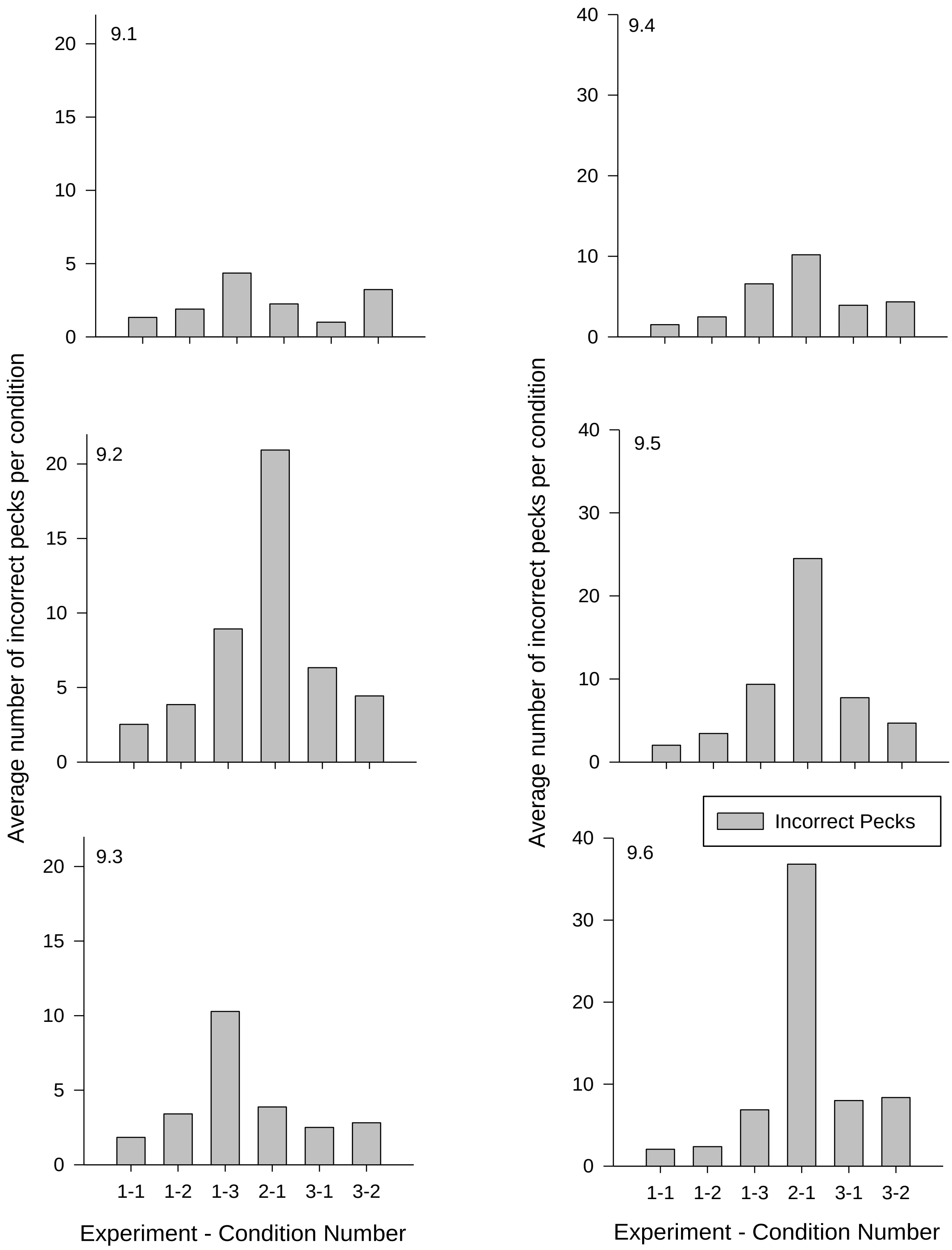


Figure 18. The average number of incorrect pecks per grid for each hen across all experiments; the three grid sizes used in Experiment 1, the 2x3 grid used during the white screen timeout in Experiment 2, and the 2x3 grid used during the black screen timeout on incorrect and repeated correct pecks in Experiment 3.

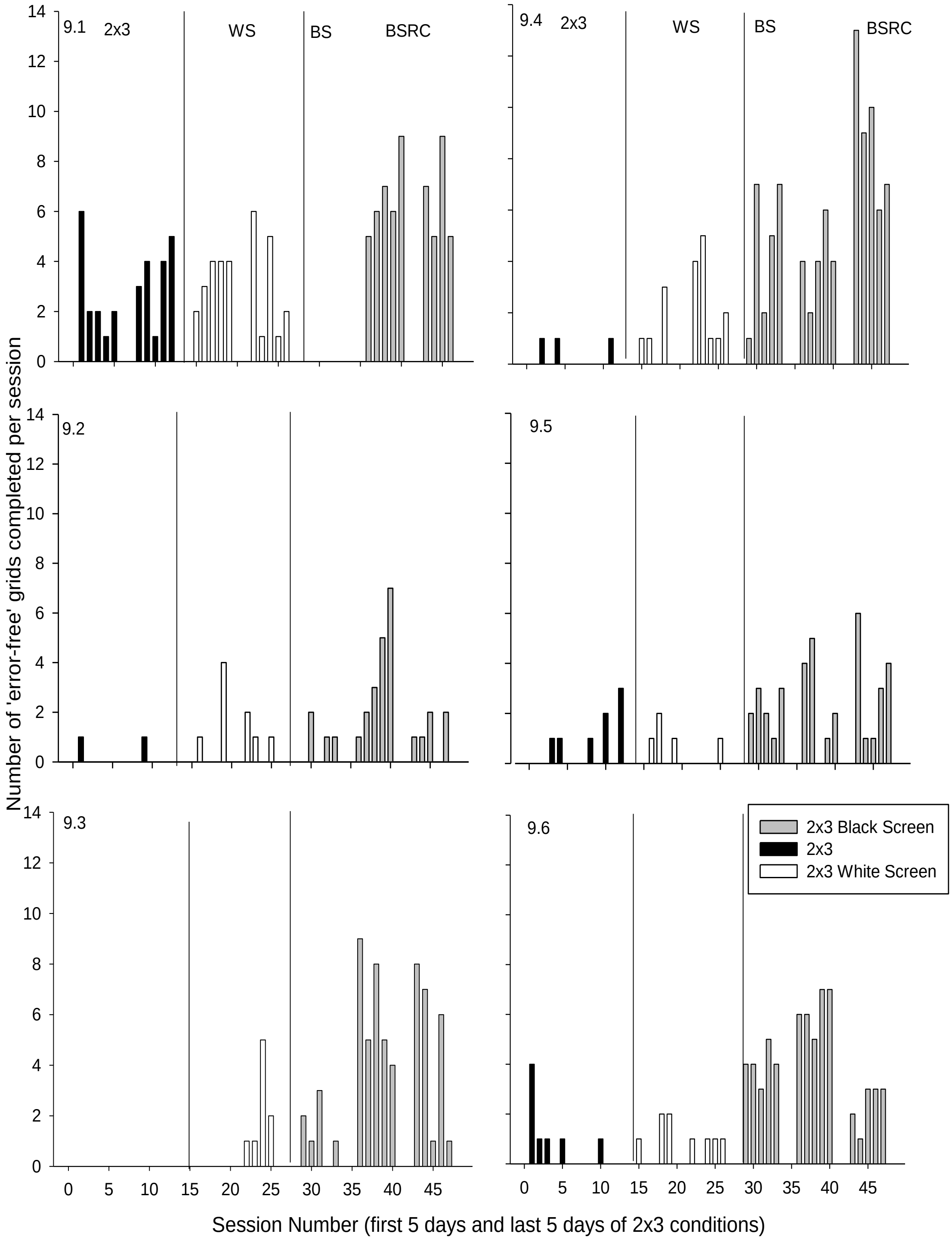


Figure 19. The total number of error-free grids (grids with no incorrect pecks at all) completed for each bird on the first five and last five days of the 2x3 grid, the 2x3 grid with a white screen timeout on incorrect pecks, and the 2x3 grid with a black screen timeout on incorrect pecks and repeated correct pecks.

Discussion

The first part of this experiment aimed to reduce the number of incorrect pecks by using a black screen as a timeout. The second part of this experiment extended this timeout procedure to repeated red square pecks. All other unnecessary pecks on the red squares besides the initial peck required for reinforcement also triggered a black screen. It was predicted that this would bring down excess levels of pecking overall to produce fluency.

The black screen timeout was far more successful at reducing the number of incorrect pecks than the white screen timeout. However, incorrect pecks did not fade out completely and unnecessary pecks on previously pecked red squares seemed to be unaffected by the introduction of the black screen. Therefore, fluency was not achieved in this experiment.

Pecking did continue on the black screen during the first condition of this experiment, however for all of the hens this was a rate lower than that of pecks on the white screen. The grid time was very similar to the previous experiment during the first condition when the black screen timeout was on incorrect pecks only. Despite lower numbers of incorrect pecks, the hens did not complete the task any faster. Grid time did decrease during the second part of the experiment however, even though levels of repeated pecking on the red squares did not reduce. Whilst the contingencies arranged in this experiment were more successful at reducing numbers of unnecessary pecks overall, all reinforcers were still earned despite the continued pecks, leading to the conclusion that the contingencies were still not sufficient to produce fluent behaviour.

One suggestion for being unable to drive down incorrect pecks sufficiently might be that timeout was introduced too late. Incorrect pecks and repeated pecks on the red squares were very well established by the start of this experiment. In Porritt et al.'s (2009) study, a timeout procedure was used on incorrect pecks from the beginning of their training phase. Whilst a correct key triggered the next set of stimuli to appear or for the magazine to be raised for reinforcement, an incorrect key immediately turned off all lights for a 1-second timeout (Porritt et al., 2009). This would have created a similar but shorter effect to that of the black screen on incorrect pecks in the current study.

Porritt et al. (2009) found that mean accuracy levels were quite high during training, suggesting that the use of a one second timeout in training might have been effective at preventing responding on incorrect keys. If the present study was repeated, introducing a black screen timeout during the training phase might reduce numbers of incorrect pecks earlier, before the behaviour is well established through reinforcement. That might enable greater success at producing fluency in hens.

Summary

The present study was an attempt to investigate if reinforced responses, or individual pecks within them, could become more fluent if unnecessary pecks were driven out. Overall, the three experiments were not successful at producing fluency.

Experiment 1 found that while all reinforcers were earned, incorrect pecks continued at a high rate with no cost to the animal. High rates of pecking on red squares which was unnecessary for reinforcement were also observed. Introducing a white screen timeout in experiment 2 was not successful at reducing incorrect pecks at all, because white had never been paired with an opportunity to stop responding. High rates of repeated pecks on the red squares was still observed. In experiment 3, the black screen timeout was more successful at reducing incorrect pecks, but they did not fade out completely. Further, introduction of the black screen following repeated pecks on the red squares was not successful at all at reducing these numbers.

It is concluded that fluency was not achieved in this experiment, because although the hens were capable of completing the task, the reinforcement contingencies continually meant that there was no reason for the high number of unnecessary pecks to stop. This is because all reinforcers could still be earned. Although the introduction of a punishment increased the session time due to the continued 3-second black screen presentation, it seemed there was still sufficient time for the hens to earn reinforcement whilst continuing to produce high numbers of incorrect and unnecessary pecks.

As discussed earlier, one successful precision teaching method is that of SAFMED cards. Used widely in education (Lindsley, 1992) and investigated in the applied literature (Brady & Kubina, 2010) these cards in particular rely on the use of 1-minute timings to produce fluent behaviour. Participants are usually required to aim for as many correct responses as possible in these 1-minute practice sessions (Lindsley, 1992). It has been suggested that the 1-minute timing functions as a restriction, to drive down incorrect parts of a response, to enable high numbers of correct responses or components of that response, required for reinforcement.

The present study demonstrates that unnecessary components of responses, or pecks, cannot be driven down without punishment, and even then whilst reinforcement can still be earned, punishment is not successful. It seems that a form of time restriction, such as the one used in precision teaching procedures might be important to producing fluency. The reinforcement contingencies arranged in the present study still allowed reinforcement to be earned even when large numbers of unnecessary pecks occurred, because there was no time pressure to decrease unnecessary pecks for reinforcement. A time restriction, such as the 1-minute timings used in precision teaching, forces high rates of correct responses. There is no time for unnecessary or incorrect responses to occur because the time available has to be spent responding correctly for reinforcement.

Despite the lack of success at producing fluent behaviour, the present study has demonstrated, along with Porritt et al. (2009) that it is possible to use animals, specifically pigeons and now hens, in an experimental manner to investigate fluency.

Furthermore, there are other variables which could be manipulated to identify how fluency generates its outcomes, and whether these outcomes are achievable in experimental research as well as applied literature. This could include driving down incorrect responses during training as previously discussed, and the use of inter-trial-intervals (ITI's). An ITI would explicitly signal when each grid was completed and when the next one was to begin. Investigation into whether different lengths of ITI's affected fluency levels would be highly beneficial to ensure the most efficient procedures are occurring during education with precision teaching procedures, where ITI's are not always used.

To conclude, the present study was an attempt to produce fluency in hens. Although this was not successful, it appears that unnecessary components of a response will not be driven down without punishment, or the use of a time restriction which forces the increase of the speed of response components necessary for reinforcement, leaving no time for unnecessary responding.

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