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An Investigation of Catania's Concept of the Operant.

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Abstract

Catania (1973), in discussing the concept of the operant suggested responses should not be classified based on arbitrary criteria such as response function or topography alone, and rather should focus on the continuous distribution of responding. Catania (1973) hypothesised that response distributions would resemble a normal curve, even when reinforcement was provided for only those responses that occurred between two limits. Six domestic hens were used in a series of experiments in order to investigate Catania's (1973) suggestion. In the first experiment the hens pecked at a flat screen with an infra-red device was mounted in front the screen to detect response location. Pecks in defined regions of the screen resulted in 3-s access to wheat. Over conditions, different quadrants of the screen were active. The whole screen remained white throughout each session except when the reinforcement was being delivered. The hens responded on a fixed-ratio 5 schedule for 40 reinforcers per session. Over sessions the distribution of the locations of responses shifted to being centred over the active quadrant. Proportions of correct responses increased across sessions but incorrect responses persisted throughout. In Experiment 2 the screen was divided into ten 30-mm regions of which one was active in each condition while the whole screen remained white. The active region was moved in steps from the left to the right and from the right to the left of the screen over eleven conditions with eight sessions in each conditions and a fixed-ratio 5 schedule. In general, in each condition the proportion of correct responses increased to around 0.4. In each condition the distribution of response location shifted to being centred over the active region, resembling a normal distribution. In most cases, response rates on the active region were higher than for the inactive regions, hens usually responded

on several regions at a moderate rate. In Condition 12 the active region was coloured red and this resulted in a narrower distribution of response locations, and higher proportions of correct response than other conditions for most hens. A large number of incorrect response persisted throughout this condition. These findings provide some evidence that supports Catania's (1973) hypothetical response distributions. The argument is made that Catania's (1973) concept of the operant could be a way to organise responses into a class and also that it provides a means of classifying response while maintaining the continuity of behaviour and, therefore, avoids the use of arbitrary criterion.

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“We divide behavior into hard and fast units, and are then surprised to find that the organism disregards the boundaries we have set.”

- (Skinner, 1953, p. 94)

Research in behaviour analysis requires accurate descriptions of the responses that are to be studied (Peterson, Holmer & Wonderlich, 1982). Typically, response classes have been used to form ‘hard and fast’ collections of responses in order to make experimentation and analysis of behaviour accessible. Various authors have suggested the use of response topography, function or both as a means of classifying the responses that will be studied (Schick, 1971). In-depth debates about the most appropriate way to define behaviour and responses have led to no agreement. At this stage most response classes used do not appear to incorporate the continuity of behaviour.

The continuity of behaviour was discussed by Skinner (1953). He explained how the reinforcement of a property of a response, causes an increase in frequency of all responses that have *any* property in common with the reinforced response, resulting in a new array (or continuous distribution) of responses (Skinner 1953). Skinner (1953) pointed out that response generalisation, response induction and transfer simply describe the continuous characteristic of responses. That is, if responding was not continuous, and every two responses had either identical properties or entirely different properties these phenomena (generalisation, induction and transfer) would not be observed. Instead, responses have many different properties each of which can occur over a wide distribution, i.e., in an operant chamber each response occurs with a different frequency, rate,

intensity, location and so on. Skinner (1953) emphasised the importance of the continuity of behaviour when he stated that this property must not be forgotten.

Historically when Skinner (1938) discussed the concept of the operant he focused on the functional aspects of responses, and used this to define a response class. That is, Skinner (1938) proposed that one should select a consequence or environmental event that typically follows the response of interest, and utilise this consequence in order to sort responses into a class. All responses that precede the specified consequence then become a class of responses, known as a response class or an operant. Although Skinner (1938) has acknowledged that topographical properties have been used successfully as determinants of response classes, his concept of the operant class relies solely on the function of the response and makes no reference to topography. Skinner is not alone in his views, many authors (Johnston & Pennypacker, 2009; Novak & Pelaez, 2004; Staddon, 1967) tend to prefer the use of function to define response classes. Functional operants have been used successfully in experimental psychology to analyse behaviour, however, Skinner who highlighted the importance of response continuity in 1953, did not incorporate this characteristic when he developed his concept of the operant.

Several authors have pointed out difficulties with Skinner's account of an operant class, usually the complications arise because of the resulting insufficient and arbitrarily defined class (Catania, 1973; Palmer, 2003; Schick, 1971; Sidman, 1994; Staats, 1961; Staddon, 1967). Schick (1971) acknowledged the side effects of reinforcement when he stated that reinforcement strengthens all responses that are common (on any dimension) to the reinforced response, therefore reinforcement results in a class of responses that have a common property, that is

not necessarily function. Mechner (1994) discusses concepts which require the recognition of response form such as the Parameter Shift, which cannot rely on the use of function to define the response class. Mechner's (1994) 'Parameter Shift' could not be studied without focus on the change of the topography of responses due to manipulation of the contingencies.

Schick (1971) pointed out that Skinner (1953) contradicted his prior concept of the operant class when he discussed response extinction and transfer of reinforcement and, although he acknowledged this problem, he did not attempt to adapt his concept of the operant to fit such circumstances as extinction. Interestingly in spite of this, Skinner pointed out the importance of topographical variations when he described the behavioural principles of shaping (Catania & Harnad, 1988). Therefore, Skinner's (1938) concept of the operant would suggest topography is relevant during shaping yet irrelevant during experimental analysis of responding. When exploring the topic of the response class, it appears as though there is a need to critique the definition of the operant, as researchers have found that a functional response class cannot be used appropriately in all circumstances of behaviour analysis.

In applied settings, it is typical to use observation systems when analysing behaviour. These require operational definitions which incorporate the description of both functional and topographical properties of the response, in order for each instance of the designated problematic or required response to be recorded accurately (Hudson, 1998; Ollendick, 1998). Operational definitions are used to define each instance of the target response, that is, they define the operant class. Some operational definitions may include only topographical properties of responses, but due to the nature of behavioural observation systems, both

antecedents and consequences that occur before and after the responses are acknowledged during a functional assessment and therefore are included in the description of the response, thus putting focus on both topographical and functional properties in an applied analysis (Ollendick, 1998; Paclawskyj, Kurtz & O'connor, 2004).

The importance of considering topography becomes clear when applying behaviour analytic principles such as reinforcement to manipulate human behaviour. By following Skinner's account of an operant class, we are suggesting that response topography has no significance, so long as the function of the behaviour is the same. Does this mean we could provide reinforcement to a child who picks up a crayon from the floor and places it on the table (the target response), regardless of whether the child uses his hand, toes or mouth to do so? In another case, should a parent give attention to their child regardless of whether the child screams at their mother, or speaks politely? Skinner's (1938) argument would suggest that reinforcement should be provided irrespective of response form. His view on the insignificance of topography becomes clear when he states that a lever press may be performed by any means so long as the lever is pressed (Skinner, 1938). Historically, applied behaviour analysis has focused on the social aspects of behaviour. That is, the society of the individual (those people who surround them) dictate the form of those responses that are acceptable and of those which require change (Baer & Risley, 1987; Baer, Wolf & Risley, 1968). One would assume it would not be socially appropriate for a child to put a crayon on the table using his mouth, or for a child to scream at his mother, and a child should certainly not be given a reinforcer when it does so.

Day and Horner (1989) discussed the difficulties that arise in terms of defining a response class when applying behaviour analysis to everyday tasks, such as opening a door. These authors point out the large number of different situations (i.e., different door handles) that require a different response topography in order for a response to be successful, that is, in order for the door to be opened correctly. In this case, an experimenter may label the response class as ‘opening the door’, however within this class would be a large number of very different response topographies that in the past may have caused a door to open, but for each unique instance of door opening, only a smaller portion of response units within this class would be successful (Day & Horner, 1989). Response classes have often been defined as each response being able to substitute for another and still result in the same effect, i.e., they are functionally similar (Harding, Wacker, Berg, Barretto et al., 2001; Salzinger, 1967; Sidman, 1994; Skinner, 1938). In the case of ‘opening the door’, responses within this class are not functionally similar, and one unit is not able to substitute for another. Therefore, this collection of responses would not adhere to Skinner’s description of a functional operant (Skinner, 1938). Yet in a separate presentation of the stimulus (a different door type), a different portion of responses within this same collection of responses would be successful, suggesting that all of the members within this class are susceptible to reinforcement (because they are valid attempts at door opening) at any given presentation of a door. Therefore, according to Millenson and Leslie (1979), this collection of responses performed under these stimuli could be deemed an operant class. Millenson and Leslie (1979) stated that “the only formal requirement of an operant is that it be a class of behaviours that is susceptible, as a class, to reinforcement” (p. 77). These authors discussed

response classes in terms of limits, and variants. That is, they pointed out that each response performed in the presence of a stimulus will vary from other responses performed under the same conditions. Thus they suggested a response is more accurately labelled a response variant and consequently, instead of specifying an exact topography or consequence, these authors described limits, within which response variants will be reinforced.

When considering the applied setting, the use of topographical and functional properties to define response classes appears to be essential (Day & Horner, 1989; Paclawskyj, Kurtz, & O'Connor, 2004). After examining the literature it is suggested that Skinner's (1938; 1953) concept of the functional response class cannot be used to define all applied behaviours accurately, and that, components within the concept appear to be incompatible with an important property of behaviour, that is, continuity.

Several authors have described cases where the topography of a response appeared to be an important element of an applied behaviour analysis (Day & Horner, 1989; Ollendick, 1998; Paclawskyj, Kurtz & O'Connor, 2004). However, Staddon (1967) pointed out the difficulties that arise when trying to define a response based on topography due to the infinite number of variations of response forms, even for the most basic responses. Staddon (1967) describes an example where a response such as drawing a triangle, can be performed in a vast number of ways, showing that it is difficult to determine a response class based on topography. The literature on the operant class appears to suggest that both topographical and functional response classes have their limitations. In both cases these faults apply to the continuity of behaviour. That is, the topography of responses is often too variable (due to the continuous nature of responding) to be

described accurately (Staddon, 1967), while focusing on the function of responses alone leads to a very rigid response class that ignores the element of continuity (Catania, 1973).

Catania (1973) analysed the concept of the operant and proposed an innovative outlook on response classes. Although Catania (1973) acknowledged the distinction between operant and respondent behaviours when he discussed Skinner's (1938) historical account of reflexes, he pointed out that when the concept of the operant emerged and attempts to distinguish between operant and respondent behaviour were made, the way in which behaviour was described also changed. That is, reflexes (respondent behaviours) emerged and were defined as relations between antecedents and responses, while operant behaviours became defined in regards to either the topography of responses, or resulting consequences (Catania, 1973; Delprato & Midgley, 1992). That is, descriptions of operant behaviours were no longer based on a relation between the properties of responses (topography or consequence), meaning that two of the most significant aspects of behaviour (response form and function) were not necessarily the focus of an analysis, more so, the focus narrowed to one or the other. Catania (1973) pointed out the difficulties that arise when operant classes are defined in terms of the topographical or functional properties of responses alone and proposed that a response class should be perceived as a continuous distribution, containing responses that vary in both function and topography.

Catania (1973) suggests that by looking at a response class in terms of a continuous distribution we can avoid focusing on only a part of the response class. He concludes that all of the responses along a distribution (in terms of a dimension, e.g., force, duration, location, etc.) should be included within the

response class and thus should be considered during the analysis, even if they do not meet the criteria for reinforcement. That is, by acknowledging both the topography and the function of responses (so long as the response occurs on any part of the current distribution), responses are not excluded from an analysis based on any arbitrary criterion. An important point here is that there is variation between responses within a response class, i.e., a response at one end of the distribution would most likely vary in topography from a response at another point on the distribution. Consequently, it is unlikely that all the responses within the distribution would have the same effect, and therefore may not all result in reinforcement. Catania's (1973) concept not only allows for a detailed analysis and description of behaviour, it also allows for calculation of the correlations between responses and their effects, proportions of correct and incorrect responses, as well as providing an account of the manipulation of the array of responses due to the application of a contingency. The ability to determine these statistics is particularly important in applied settings. For example, when teaching new skills a child must meet a 'mastery criteria' (e.g., at least 80% correct across three consecutive sessions) in order to proceed to the next skill (Center for Autism and other Related Disorders, 2010). When considering again the target response of picking up a crayon and placing it on the table, all responses that are emitted when presented with these stimuli should be recorded in order to determine whether a child has mastered the task. Simply recording the frequency of 'crayon placed on table' (regardless of how the child places it there) is not enough for an effective analysis.

Catania (1973) suggests that an essential property of a response class is that the correlations of responses and their effects can be manipulated. As

presentations of stimuli in relation to certain responses accumulate, the correlations between successful responses and the reinforcing stimuli will increase, while the correlations between non-successful responses and other stimuli will decrease. This results in changes in the relations over time, which, according to Catania (1973), defines the operant. Catania (1973) stated that manipulating the properties of responses within a response class is achievable by altering the criterion for reinforcement

Other authors have also pointed out the significance of variation within a response class when discussing reinforcement in terms of selection (Novak & Pelaez, 2004; Staddon, 1983). It has been stated that each unit within a class is not identical, and it is this important property (variance) that allows an operant to adjust to new contingencies. That is, without variation, a response class could be limited to fulfilling only one contingency, and selection could not occur (Donahoe, Burgos, & Palmer, 1993; Glenn, Ellis, & Greenspoon, 1992). Donahoe and his colleagues (1993) stated that more complex behaviours appear to arise from gradual adaptation and manipulation of simple units of behaviour. In experimental analysis such manipulations are intentional. However, this process also arises outside of the laboratory in naturally occurring learning environments and allows organisms to adapt their behaviours in order to receive reinforcement more frequently within their environment (Catania & Harnad, 1988). Without the availability of the initial variation in responding, the process of selection would not occur (Catania & Harnad, 1988; Donahoe et al., 1993; Glenn et al., 1992; Staddon, 1983). Therefore, it seems essential for an operant class to include responses that hold a similar property, but still vary in topography and function.

That is, an appropriately defined response class should resemble a continuous distribution of responses (Catania, 1973).

When discussing operant behaviour, Skinner (1953) also described the continuous distribution of responses observed when reinforcing a particular response. He explained that when reinforcing the lifting of the pigeons head to a specific height, the result is a rapid change in frequency of head lifts to this specific point, as well as a change in the frequency of head lifts to other heights surrounding the target height, and in particular, head lifts to points higher than previously reached. Using Skinner's (1953) example again, a new distribution of responses (head lifts) to heights around the target is observed, this suggests that these responses have been manipulated due to the new contingency. These, therefore could be allocated to a response class, despite their different functions (reinforcement or not reinforcement). This idea is discussed further in Skinner's 'Operant Behaviour' where he states that reinforcement within a contingency stimulates a new array (in terms of the current manipulated dimension, e.g., force or location) of responses (Skinner, 1969). However, when Skinner (1938) defines a response class, he appears to discount the continuity of behaviour and classifies responses dependent on one property - response outcome (reinforcement), and excludes all other responses, despite the fact that these other responses may be similar across various dimensions to those within the functional response class.

Some authors have defined the response class using a concept similar to Catania's (1973) during their research by including both criterion and non-criterion responses within their analysis (Galbicka & Platt, 1989; Mechner, 1994; Scott, 1982; Scott & Platt, 1985). In these studies the authors investigated the change in response patterns over time when gradual or sudden manipulations of

the contingency occurred. That is, rather than looking only at the target responses and making inferences about these data alone, these authors recorded all relevant responses that occurred during sessions (which Catania (1973) suggests is more appropriate). As a result they were able to draw conclusions about the rate of change of response proportions, patterns of response shifts, response distributions, and were able to calculate correlations based on response-reinforcer relations (Galbicka & Platt, 1989; Mechner, 1994; Scott, 1982; Scott & Platt, 1985).

Mechner (1994) points out that most studies only analyse steady-state behaviours, and rarely take note of the rate of change from one steady-state behaviour to another. In order to make inferences about the rate of acquisition of a response, it is important for all responses to be recorded, that is, the use of Catania's (1973) continuous distribution of responses within the operant class would be most effective. Skinner (1953), using the example of head lifts in the pigeon, suggested observing all heights of head lifts to describe the effect of reinforcement more accurately. Here Skinner (1953) appears to agree with Mechner (1994), Catania (1973) and others (Galbicka, & Platt, 1989; Scott, 1982; Scott & Platt, 1985) who pointed out the importance of recording all responses along the distribution (in terms of a specific dimension) in order to see more clearly the changes of responses taking place. These authors support Catania's (1973) statements, by acknowledging the importance of including the entire response class (both successful and non-successful responses) within the analysis, therefore recognising the continuity of behaviour and incorporating this property within the response class.

In his discussion, Catania (1973) provides several figures predicting the degree of variation before a contingency is in place, the frequency of both

criterion and non-criterion responses after reinforcement of the specific criteria begins, the shape of the response distribution, and the change in the frequency of different topographies after a contingency has been applied. Catania's (1973) ideas can be seen in Figure 1, which shows three response distributions. The distribution labelled 'A' shows the initial response variation (in terms of a response force) before a reinforcement contingency is in effect. After reinforcement is provided for responses falling between limits 'X' and 'Y' the distributions change, these are shown as the distribution labelled 'B' and 'C'.

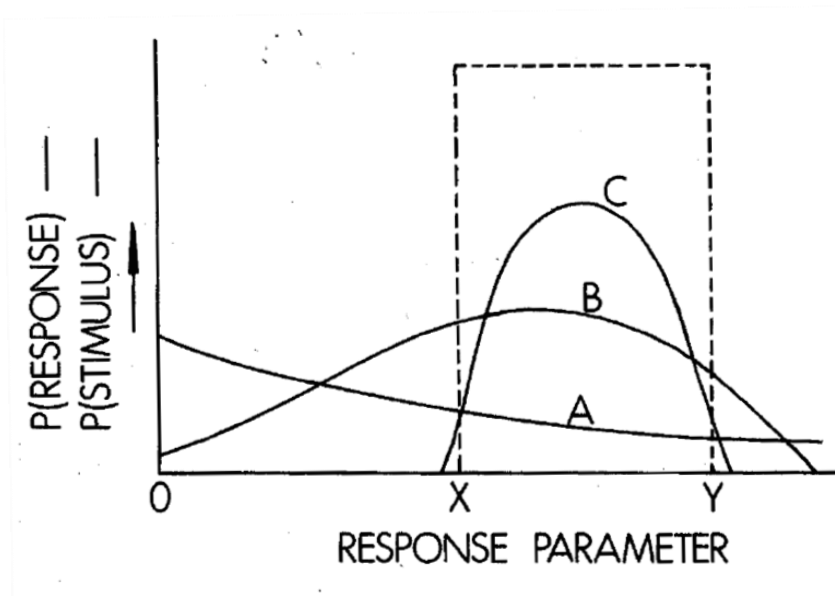


Figure 1. Catania's (1973) hypothetical figure of the response distributions during different states of a reinforcement contingency.

Although Catania's (1973) figures support his discussion, they are simply hypothetical. As far as the literature goes, it appears as though there are limited empirical data to support Catania's concept. There appears to be, however, several theoretical discussions described previously which support his concept of the

operant, suggesting Catania's hypothetical data would be an accurate account of these response patterns if an empirical analysis was performed.

In this area of experimental behaviour analysis, there are many aspects of response acquisition that are not yet understood (Stokes & Balsam, 1991). According to the basic behavioural principles of shaping, reinforcement and extinction, responses that do not meet the criteria for reinforcement should not be observed after responding stabilizes (Novak & Pelaez, 2004; Schwartz, 1982; Weiten, 2004). In one example, Novak and Pelaez (2004) describe the shaping procedure used to teach a child to pick up a pencil. These authors explain that after the child masters the first approximation to the target, the teacher will provide reinforcement only when the child emits the second approximation to the target, therefore putting the first approximation under extinction. That is, reinforcement of criterion responses inevitably results in extinction of the non-target responses (Reynolds, 1968; Novak & Pelaez, 2004). With these two processes occurring simultaneously within an experiment (reinforcement and extinction) one would expect to see a dramatic difference in the proportion of the two forms of responses (successful and non-successful), with this difference increasing as trials proceed. Many researchers have found that extinction can result in nearly complete elimination of the selected responses if the extinction procedure is prolonged (Millenson & Leslie, 1979; Reynolds, 1968). Therefore, after a sufficient number of trials where reinforcement is provided for target responses and withheld for non-target responses, it seems appropriate to assume that all responses occurring during the later trials would be of the topography and function of the criterion response only. However, Catania (1973) predicts otherwise.

Some authors have given theoretical accounts describing the complex effects of reinforcement. That is, although reinforcement follows only correct responses, its effects are not as simple as increasing the frequency of just one response topography (Catania, 1971; Catania & Harnad, 1988; Dews, 1966; Escobar & Bruner, 2007; Galbicka, 1988; Reynolds, 1968; Salzinger, 1967; Schick, 1971; Skinner, 1938; 1953; Stokes & Balsam, 1991). Salzinger (1967) utilises the concept of generalisation to explain this effect. An organism generalises between two responses that have a shared property but have a different function (one results in reinforcement and the other does not), i.e., the shared property is not related to the reinforcing event, but is the cause of the generalisation between the responses. Similarly, Skinner (1938; 1953) discussed concepts such as response generalisation, transfer and response induction, where reinforcement of an element of a response strengthens all responses that hold that same element therefore many responses can be indirectly reinforced. Furthermore, because these responses that occur outside the limits of reinforcement are indirectly reinforced, the range of responses occurring around the target response widens resulting in a further increase of incorrect responses (Galbicka, 1988).

Catania (1971) also discussed the effects of reinforcement in terms of its ability to strengthen not only the reinforced response, but also the responses that precede the reinforced response. These ideas support Catania's (1973) suggestion that a contingency may result in a continuous distribution of responses, even though reinforcement is typically associated with stereotypic responding (Antonitis, 1951; Doughty & Lattal, 2001; Reynolds, 1964; Schwartz, 1982).

The problem with the concept of response classes in behaviour analysis lies with the type of data collected and the amount of data excluded because an experimenter sets 'hard and fast' criteria and only records responses of this previously defined operant class in which the topography of responses is often ignored (Stokes & Balsam, 1991). Interestingly, many authors discuss the importance of knowing an organism's history of behaviour and reinforcement, in order to make accurate inferences about the control over responding (Mechner, 1994; Schick, 1971), yet responses which according to Catania (1973) should be included in the analysis are continuously excluded. Furthermore, most authors acknowledge the presence and necessity of response variation in terms of selection and adaptation (Catania & Harnad, 1988; Donahoe, Burgos, & Palmer, 1993; Escobar & Bruner, 2007; Glenn et al., 1992; Novak & Pelaez, 2004; Staddon, 1983). While only a few authors recognize that when there is variation within a response class, it is unlikely that all of the responses within the class would meet the criteria for reinforcement (Catania, 1973; Johnston, Pennypacker, & Deitz, 1981; Schick, 1971).

Eckerman, Heinz, Stern and Kowlowitz (1980) carried out a study that recorded all responses made along an illuminated line of keys. These authors examined the shift in response distribution extensively, but their analysis and discussion focused on the size of the shaping step, and didn't touch on topic of response classes. The response distributions found in this study suggest that Catania's (1973) hypothetical figures may be an accurate description of the change of response distributions. That is, Eckerman and Colleagues (1980) plotted the distributions of real responses and these resembled a normal curve. Their figures showed that the highest frequency of responding occurred around the

active key with response frequencies decreasing on either side of the active key. These results suggest that Catania's (1973) hypothetical figures could be an accurate representation of responding.

Oliver (2009) designed an experiment where hens were autoshaped to peck a screen surrounded by an infra-red device. The results from this study found that response locations came to be distributed around the active region, with responses occurring most frequently within the active region. This study acknowledged the current problems with the concept of the operant, but was unable to make any theoretical conclusions around the significance of Catania's concept, except to say that where an experimenter is expecting variation among responses, considering Catania's concept of the operant would be appropriate. These studies have provided some empirical evidence to support Catania's (1973) concept, but have not answered theoretical questions around response acquisition demonstrated by changes in proportions of correct and incorrect responses, the shape of distributions throughout the application and modification of contingencies, and most of all, have not stimulated discussions based on a new approach towards the concept of the response class in order to incorporate the continuity of behaviour.

There is a need to examine principles such as reinforcement and shaping with a focus on response continuity, in order to gain a more thorough understanding of response acquisition and the effects of reinforcement on response distributions. The current study hypothesised that Catania's (1973) predictions would be confirmed. That is, responses would be made in both active and inactive regions after several sessions, therefore contradicting the typical

views on the effects of reinforcement on response variation. Experiment 1 tested this hypothesis by the use of a large screen, surrounded by an infra-red device that detected the location of responses. The screen was divided into four quadrants, each of which became an active region during consecutive conditions.

Reinforcement was provided for responses made on the active regions, and the proportion of correct and incorrect responses was examined. Given the support for Catania's (1973) concept of the operant evident in the literature, Catania's (1973) interpretations of a response class were used throughout this experiment in order to determine whether providing reinforcement for responses made within the active region resulted in a continuous distribution of responses varying in both topography and function. This study explored the concept of the operant while making sure to avoid the use of arbitrarily defined 'hard and fast' units, thus maintaining an emphasis on the continuity of behaviour.

Experiment One

Experiment 1 was designed to determine whether or not manipulating the reinforcement criteria would cause response locations to move to within the area where reinforcers were provided following responses.

Method

Subjects.

The subjects were 6 Brown Shaver Hens, each aged approximately one year at the beginning of this study. All hens had no previous experimental history. The hens were housed in individual cages within the laboratory, and had free access to water when in the home cages. The hens were weighed daily and were maintained at a body weight of approximately 80% of their free-feeding weight for the duration of this experiment to prevent laying during the study. During the session wheat was delivered as reinforcement. After experimental sessions commercial laying pellets were provided after the experimental session if required to maintain the hens' body weight. The subjects received grit and vitamins weekly during normal feeding hours. Light within the housing area operated on an automatic 12:12 hour light/dark cycle. These subjects were used for the entire study.

Apparatus.

The experimental chamber was made from plywood with dimensions 620 x 580 x 410 mm. A 310 x 235 mm LCD computer screen was inserted into the right hand side wall of the chamber, it was set back into the wall 48 mm. Surrounding the LCD computer screen was an infra-red touch panel. Underneath the LCD computer screen (100 mm above the floor) and in the centre of the right

hand wall, a hole measuring 100 x 124 mm allowed the magazine on the outside of the chamber to be accessed internally when the magazine was raised. A plastic mat covered with rubber grid was placed over the floor of the chamber. The interior walls were painted white. A Dell Optiplex GX240 computer and USB interface were used to arrange all experimental events and record the hens' responses. The location of responses was recorded using the infra-red device that surrounded the LCD computer screen. This apparatus was used for the entire study.

Procedure.

Part 1: Magazine Training and Hand Shaping Procedures.

Each of the Brown Shaver hens was placed alone in the experimental chamber for one 30 min session in order to allow the hens to habituate to the chamber, during this time the magazine and the LCD computer screen were turned off. During magazine training the magazine was turned on, while the computer screen remained off. Magazine training used a VI 60 s schedule in which the magazine was raised for 3 s after every minute (on average) throughout the 30 min session, therefore providing each hen with approximately 30 opportunities to feed from the magazine. Magazine training was considered complete when the hens fed from the magazine at each presentation of wheat during the session.

Following magazine training, a hand shaping procedure was used to train the hens to peck the LCD computer screen. During this procedure the magazine and the LCD computer screen were turned on. The LCD computer screen was coloured white throughout the 40-min session, when the magazine was raised the screen became black in order to signal the reinforcer. A response on any part of

the white screen resulted in the magazine being raised for 3 s, i.e., a CRF reinforcement schedule. This training procedure was considered complete when each hen received 40 reinforcements before the session time of 2400 s elapsed.

Part 2: Experimental procedure.

Experimental sessions were either in effect for 2400 s or a session would terminate once a hen had received 50 reinforcers for Condition 1, or 40 reinforcers in all following conditions. Hens responded for reinforcement within the experimental session seven days a week. In each session the contingency required the hens to respond either 1 or 5 times (dependent on the condition) on the active area of the screen in order to gain a reinforcer. The entire area of the screen was coloured white, and thus the quadrants were not visually discriminable from each other. The computer software was used to change which quadrant of the screen would produce reinforcement when responses occurred within it.

All hens participated in the five conditions. In one case, where a hens was not able to complete a condition (e.g., it did not gain 40 reinforcers by the final session of the condition), the hen's pecking was re-shaped prior to the following condition using the hand shaping procedure described previously.

Condition 1.

In Condition 1 all four quadrants were active regions, therefore a response on any of the four regions was considered a correct response. The hens responded on a CRF schedule and received reinforcement from the magazine for 3 s after each correct response. This condition was carried out over five sessions with 50 reinforcers available in each session. The active area for this condition is shown in Figure 2 as the outer line.

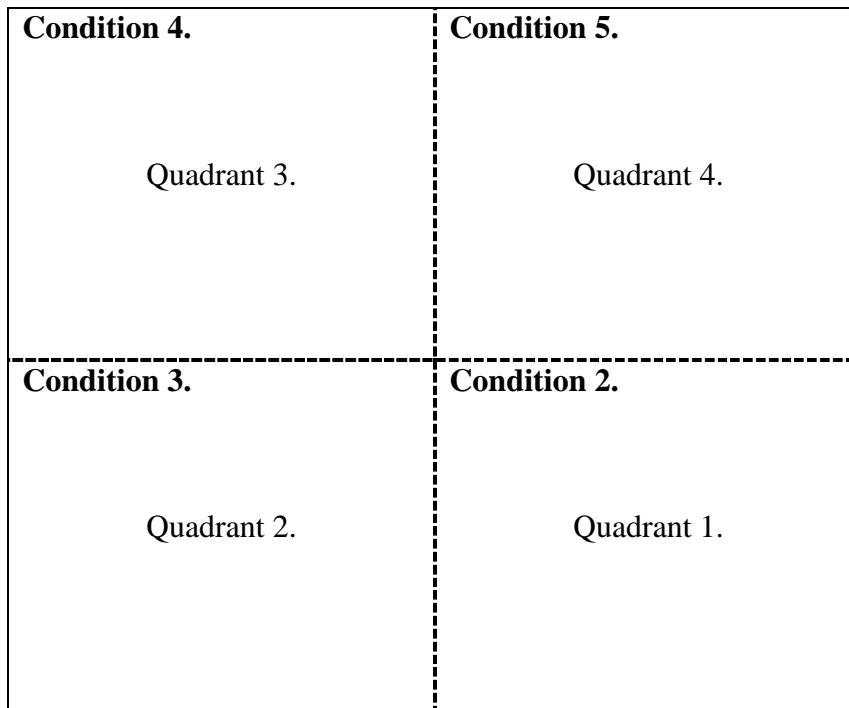


Figure 2. The active quadrants of the screen for Conditions 2 through 5, no divisions were visible on the screen. The whole screen was active for Condition 1.

Condition 2-5.

In each of Conditions 2 through 5, only one quadrant of the screen was active per session, i.e., only responses on the active quadrant could result in reinforcement. Quadrant 1 was active for Condition 2, Quadrant 2 was active for Condition 3 and so on. The quadrants and condition numbers are shown in Figure 2. The FR required that hens made five responses within the active region, reinforcement followed the fifth correct response. Forty reinforcers were available in each of the five sessions.

Results

Figure 3 shows the response locations for all hens during Condition 1. All hens showed only minimal response location variation by the final session of the condition.

Figures 4 through 9 show the cumulative records of the number of responses occurring on each of the four quadrants during the five conditions for Hens 9.1 - 9.6. For Condition 1, the change in frequency of total responses from 50 down to zero shows the end of the previous session and the beginning of the next. For Conditions 2 through 5 the peak in each graph at 200 responses on the active quadrant shows the changeover from one session to the next.

Figures 4 through 9 show that five hens successfully gained the maximum number of reinforcements available within a session by the final session of each condition. The first session of each condition showed the widest response distribution (i.e., response coordinates were spread across more than one quadrant) across the four quadrants, with the exception of Condition 1 for Hens 9.1, 9.2 and 9.6. The width of response distribution can also be seen in Figure 10, which shows the proportion of correct responses during each session for all hens. That is, wide response distributions result in lower proportions of correct responses, therefore, the narrowing response distribution is shown in Figure 10 by the increase in the proportion of correct responses. These figures show that four Hens (9.1 - 9.4) reached proportions of higher than 0.6 by the final session of a condition. While Hen 9.5 gained proportions above 0.6 in Conditions 2 and 3, and proportions below 0.5 in Conditions 5 and 6. Similarly, Hen 9.6 gained proportions of less than 0.6 in Conditions 1, 2 and 3. Figure 10 shows that all hens made at least one incorrect response (shown by a proportion of correct responses

that is less than 1) in each session during Conditions 2 through 5, with the exception of Hen 9.4 during a session in Condition 2 where the proportion of correct responses was 1 (100% accuracy).

During several of the conditions, the hens continued to show response variation (in terms of location) through all sessions. Hen 9.1 continued to respond on two quadrants throughout the second condition and four sections throughout the third condition. Hen 9.5 continued to respond on two of the quadrants during Conditions 4 and 5. These results can be seen in Figures 4 through 9. Figure 11 shows the number of correct and incorrect responses for each hen during Conditions 2 through 4. These figures show that four of the six hens (9.1 – 9.4) made more correct than incorrect responses during the last session of Conditions 2 through 5. Hens 9.5 and 9.6 made more incorrect responses during two of the five conditions.

Figure 12 shows the total number of correct and incorrect responses made for each hen during Conditions 2 through 5. This figure shows that four hens (9.1 – 9.4) made a larger number of correct responses than incorrect responses during Experiment 1, while Hens 9.5 and 9.6 made a larger number of incorrect responses. Figure 13 shows the total number of correct and incorrect response made during the first session of Conditions 2 through 5. During the first sessions, all hens made a larger number of incorrect responses during Experiment 1.

During Experiment 1 it was found that Hen 9.5 was performing non-target behaviours at a high rate, and was able to be reinforced for these behaviours because of their topography (feet on the screen, jumping with feathers out, and rubbing head along the screen).

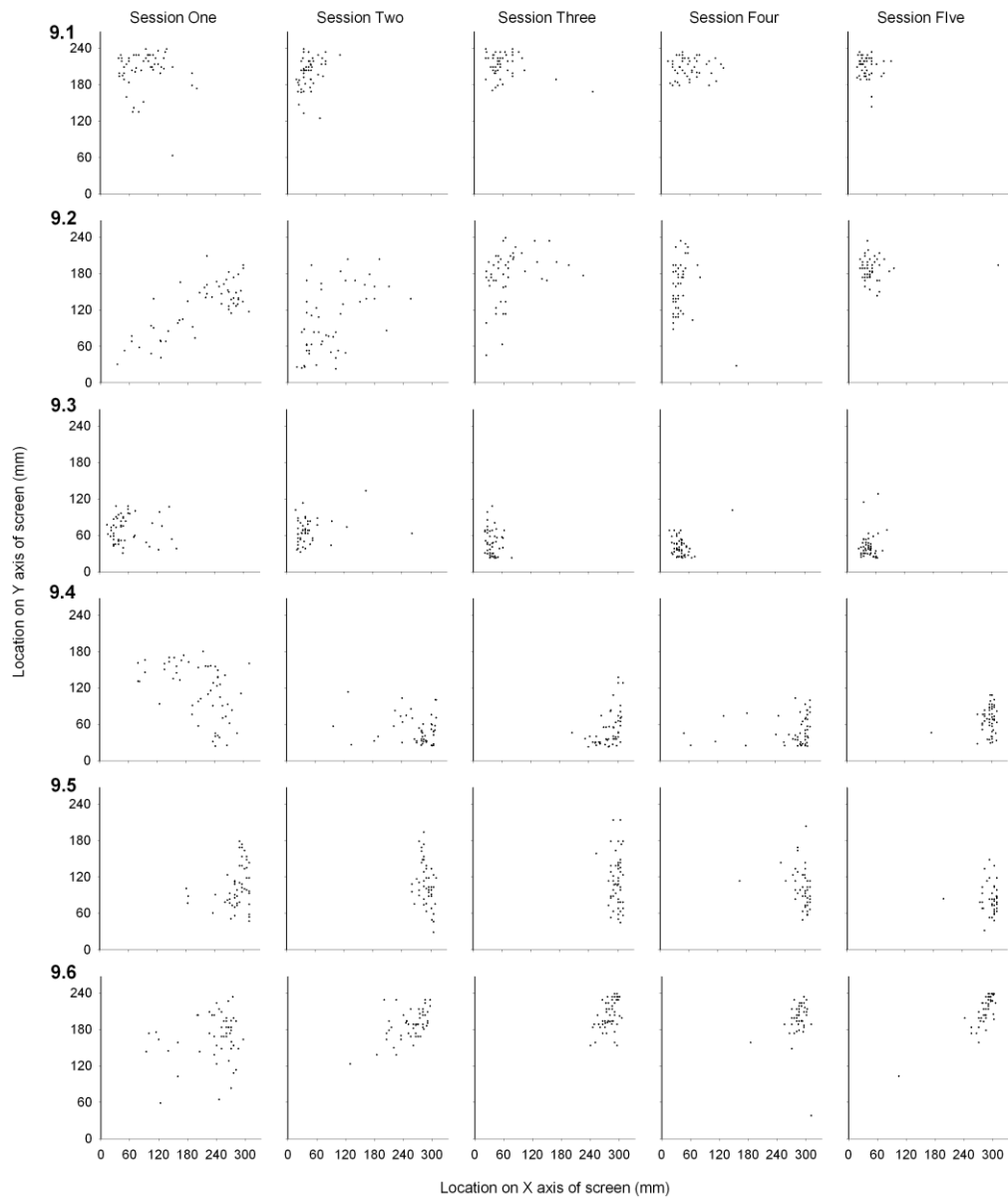


Figure 3. The location of pecks for each session of Condition 1 for all hens.

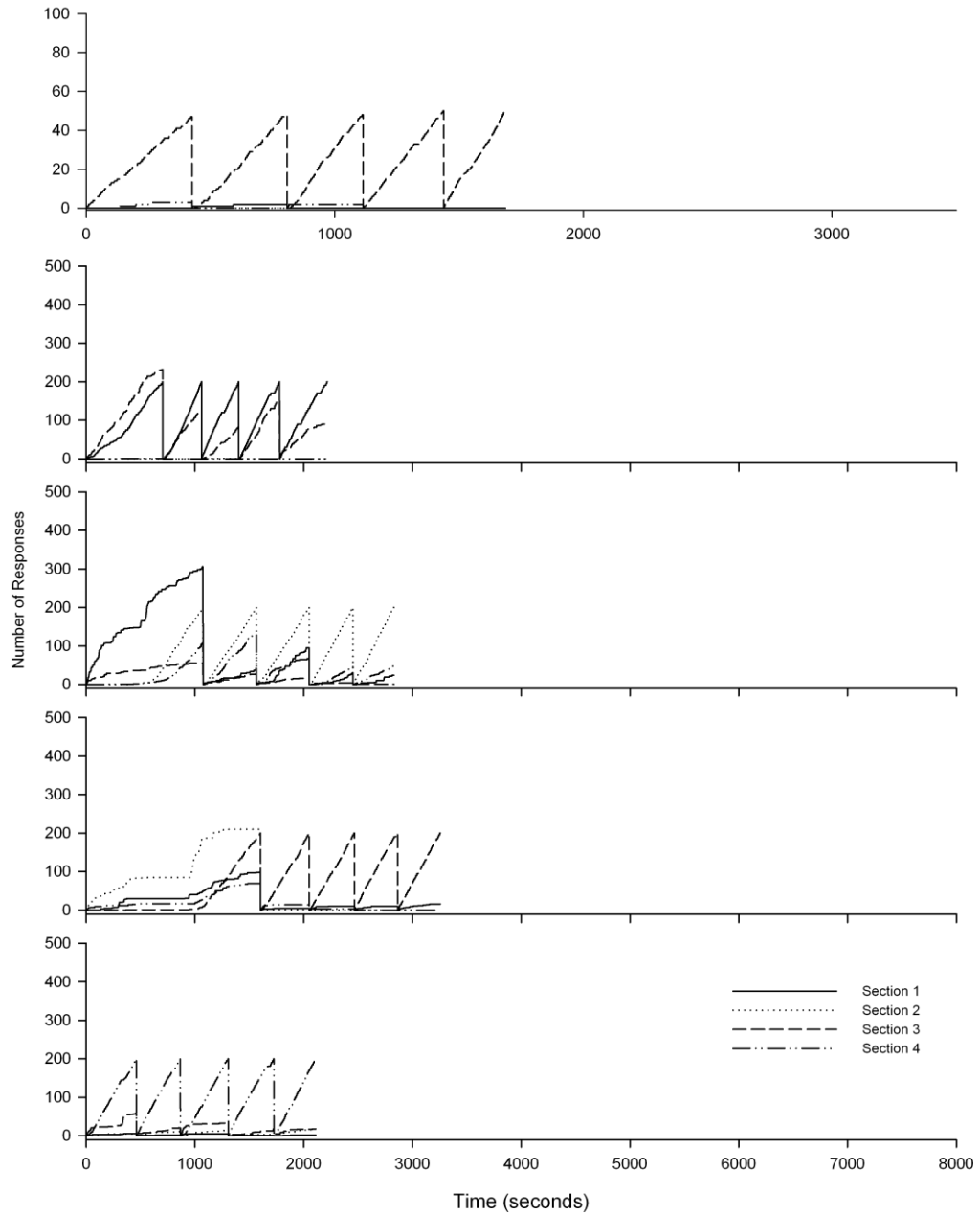


Figure 4. Response rates on each region for Condition 1 through 5 (from top to bottom), Experiment 1 for Hen 9.1

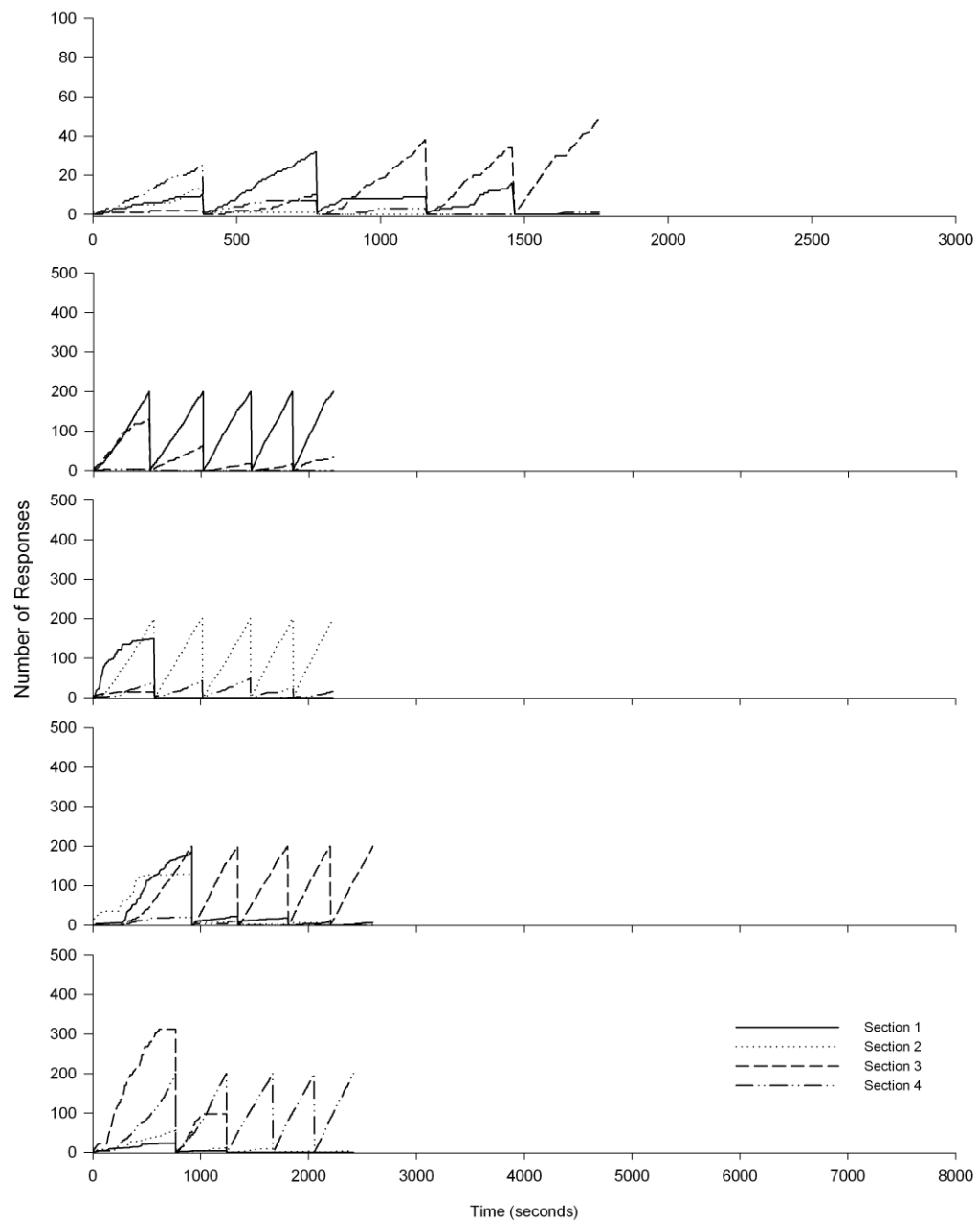


Figure 5. Response rates on each region for Condition 1 through 5 (from top to bottom), Experiment 1 for Hen 9.2

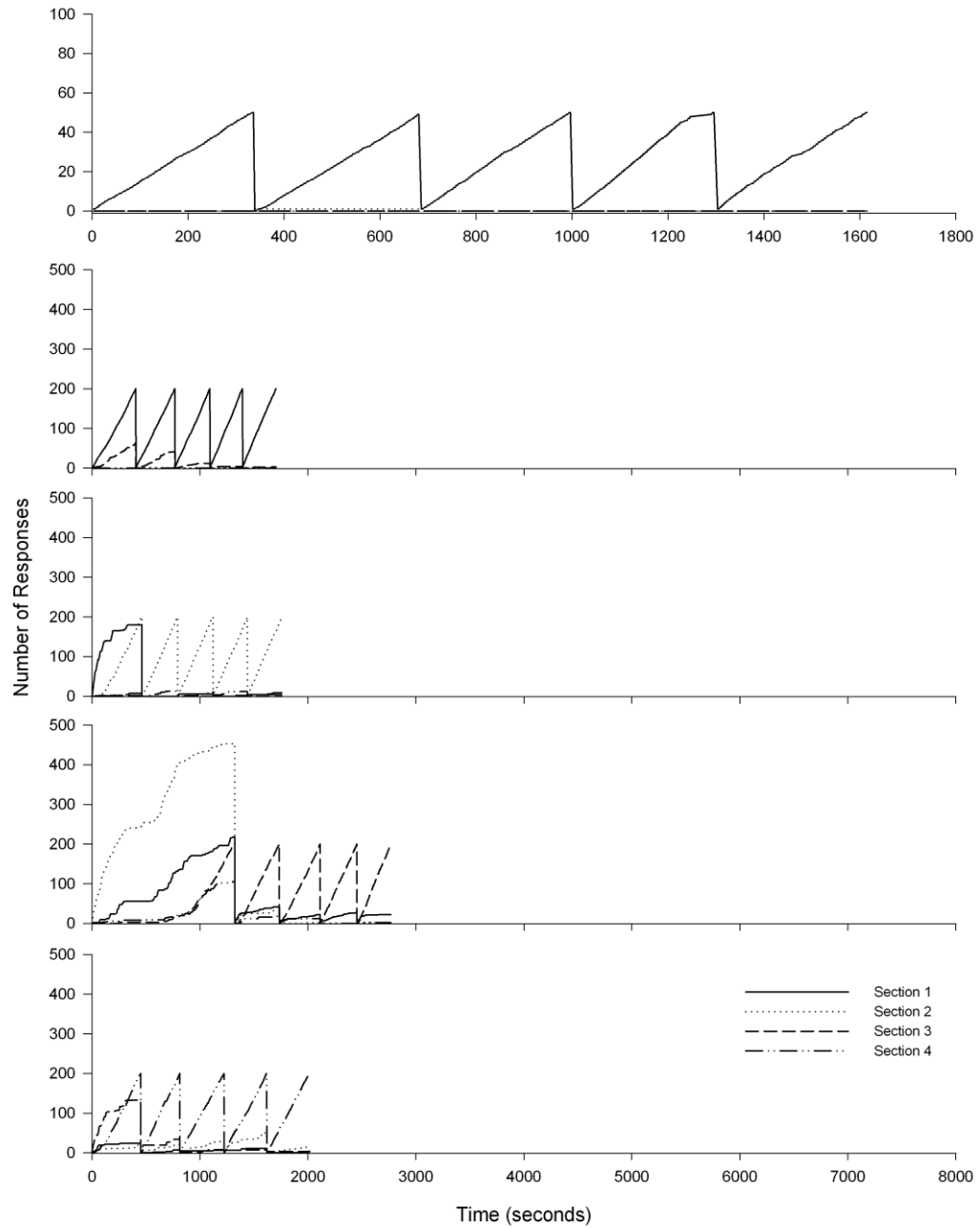


Figure 6. Response rates on each region for Condition 1 through 5 (from top to bottom), Experiment 1 for Hen 9.3.

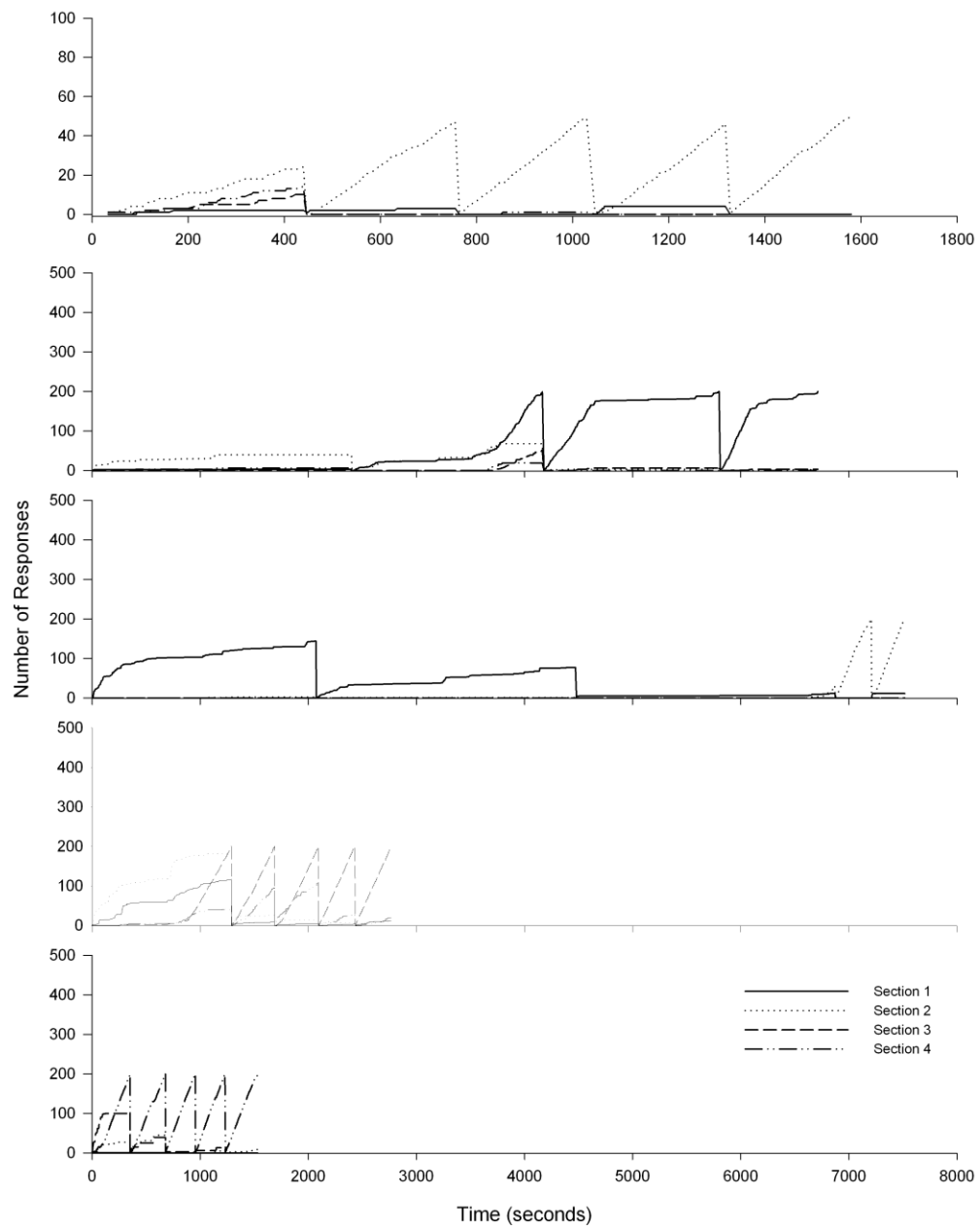


Figure 7. Response rates on each region for Condition 1 through 5 (from top to bottom), Experiment 1 for Hen 9.4.

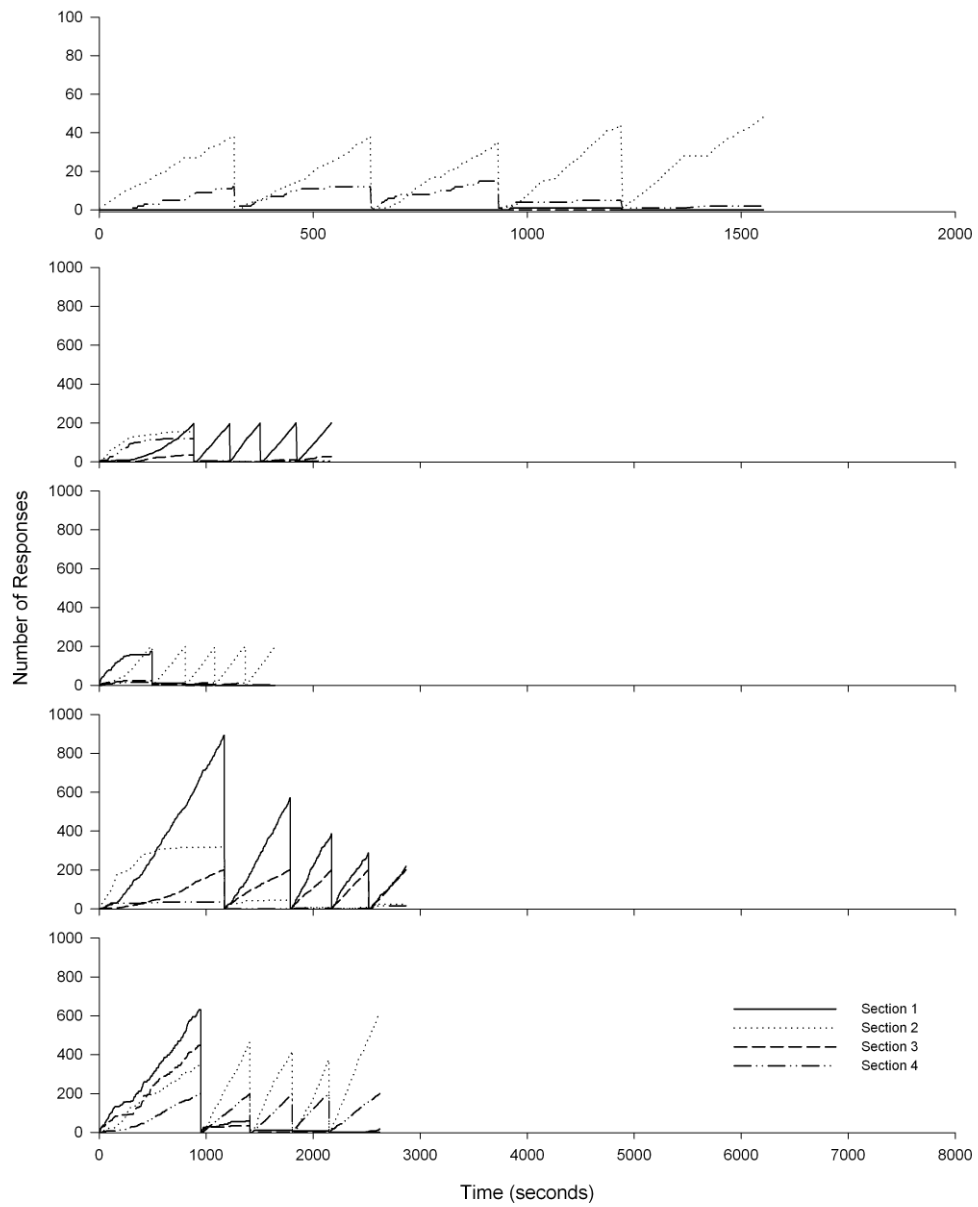


Figure 8. Response rates on each region for Conditions 1 through 5 (from top to bottom), Experiment 1 for Hen 9.5.

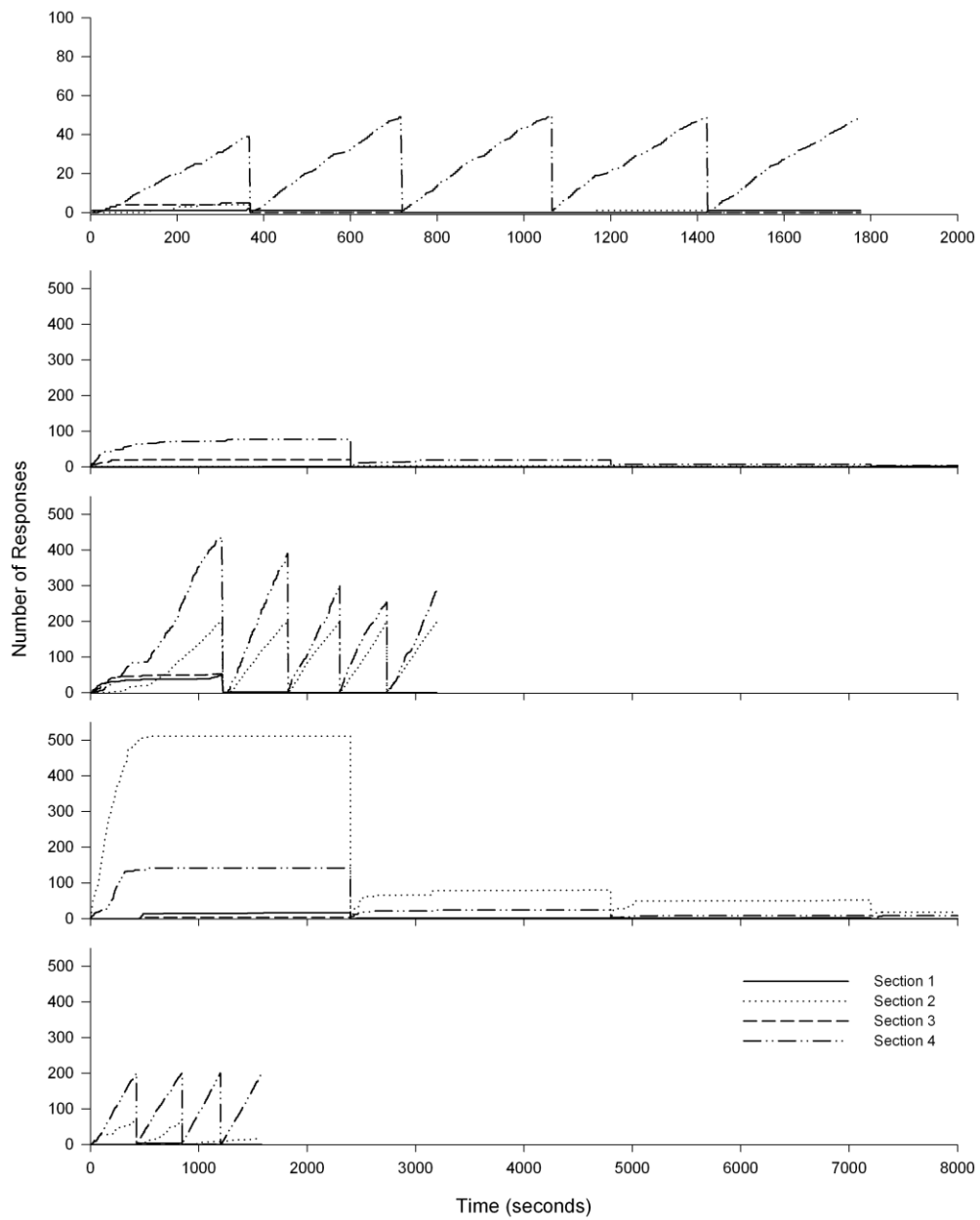


Figure 9. Response rates on each region for Conditions 1 through 5 (from top to bottom), Experiment 1 for Hen 9.6. Conditions 2 and 4 extended to 12000 seconds, but are not shown fully here as this pattern (minimal responding) seen here is similar throughout the conditions and so adds no value to the discussion.

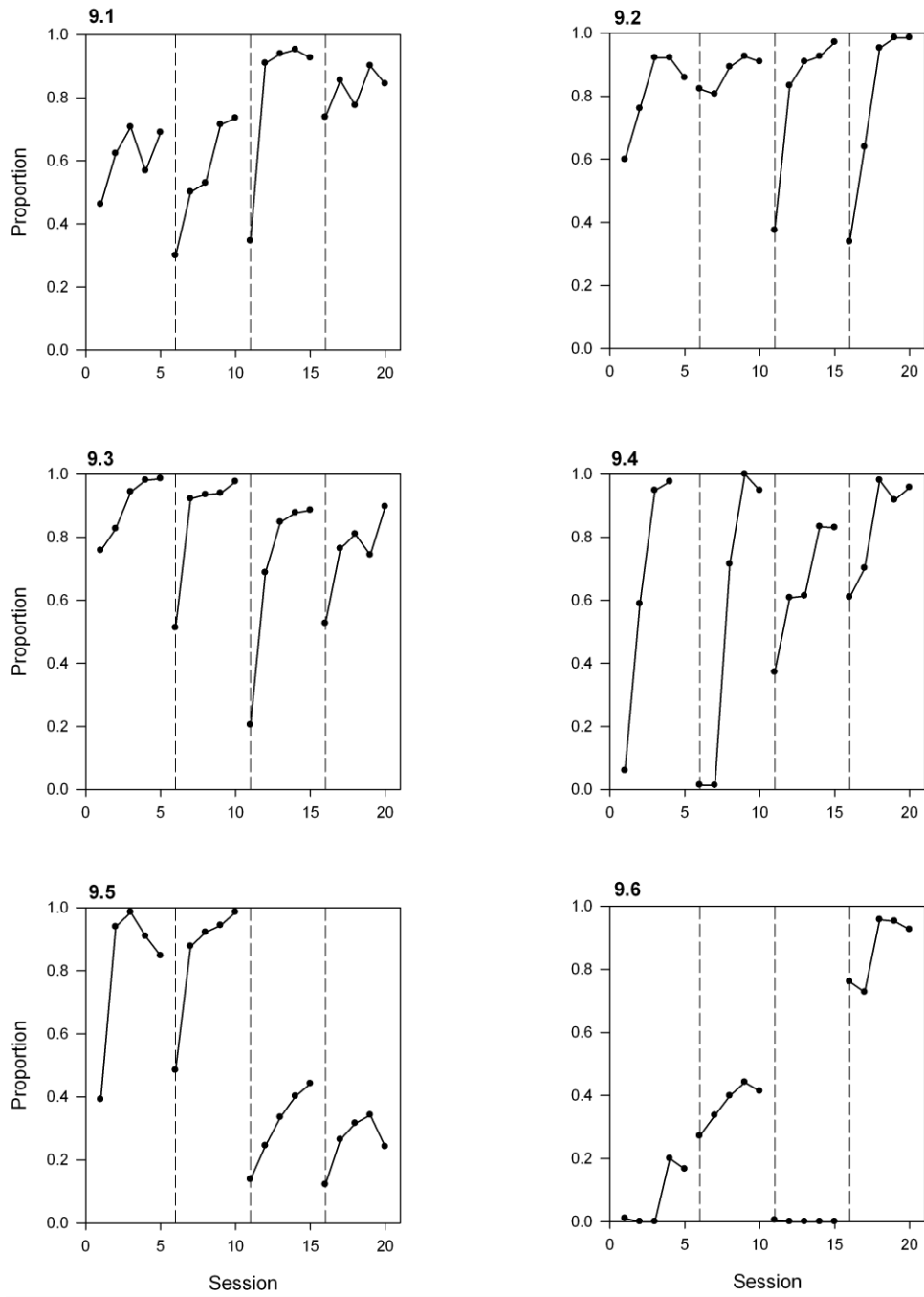


Figure 10. The proportion of correct responses for each hen across all sessions of Conditions 2 through 5 for Experiment 1.

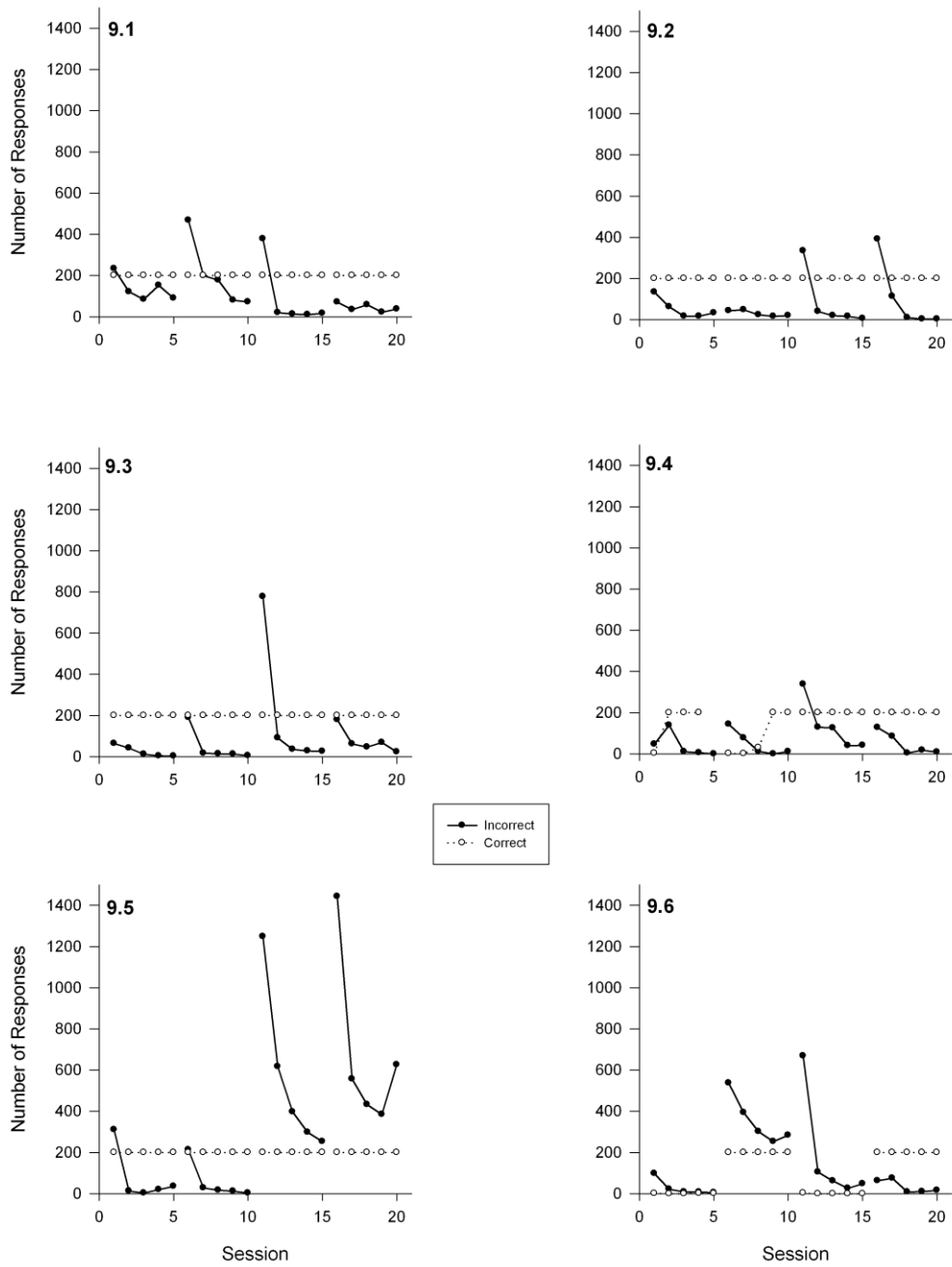


Figure 11. The number of correct responses vs. incorrect responses for each hen across all sessions of Conditions 2 through 5.

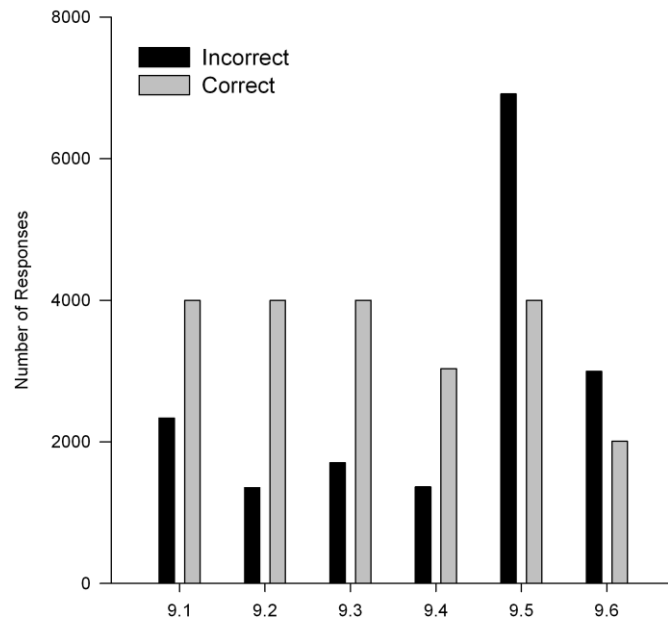


Figure 12. The total number of correct and incorrect responses for each hen for all sessions of Conditions 2 through 5 for Experiment 1.

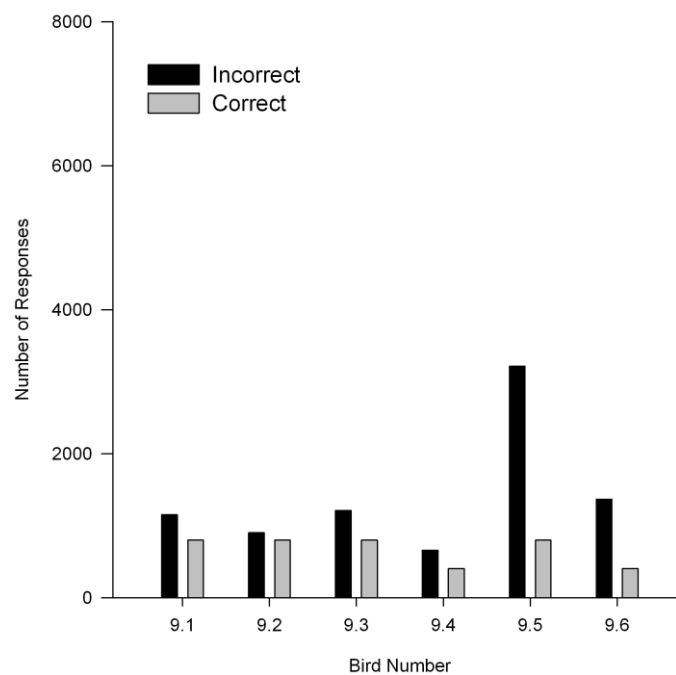


Figure 13. The total number of correct and incorrect response made during the first sessions of Conditions 2 through 5 for each hen during Experiment 1.

Discussion

Experiment 1 was designed to determine whether the hen's responding would conform to the limits set by the contingency, that is, would responding begin to occur in only the active quadrant after five consecutive sessions. The results show that the distribution of responses made on the screen can be manipulated and controlled by applying a reinforcement contingency. Furthermore, the distribution of responding can be rapidly shifted to a specific quadrant of the screen without the use of visual cues.

Hens made both correct (within the active quadrant) and incorrect (outside of the active quadrant) responses when the reinforcement contingency was in place. These unsuccessful responses reduced across successive sessions of each condition. Therefore suggesting the topography of the incorrect responses was conforming to the desired topography. That is, the total number of incorrect responses decreased, while the response rate of correct responses increased. A number of unsuccessful responses persisted through a total of 200 available reinforcers for responses that met the reinforcement criteria and a total of 1000 possible correct responses during each condition. These results support Catania's (1973) concept of the operant in that the previously determined response class (all responses manipulated by the contingency) defined using Catania's (1973) concept was able to be controlled by applying a contingency. Furthermore, this response class contained responses varying in both function, and topography. These three features; manipulation, variation of a dimension, e.g., location, and variation in function and topography, appeared in Catania's (1973) key descriptors of an appropriately defined response class during his discussion on operants (Catania, 1973).

In general, the results showed that all hens emitted responses that were not made within the active quadrant across all sessions of Conditions 2 through 5, confirming Catania's (1973) assumptions that responses within a class would not always have the same function and topography. By using Catania's (1973) concept of a response class this experiment was able to show the large number of responses that would have been ignored, had the criteria for data collection focused on either topography or function alone. That is, in the first session of each condition, all hens performed more incorrect responses than correct responses. If these incorrect responses had been excluded because the response class was defined by the consequence of the response, more than half of the organism's behaviour would have been ignored. This is important particularly because four of the six hens also reached the maximum number of correct responses within the first session. Therefore, had only the responses that met the criteria been recorded, data analysis would have suggested that the hens had mastered this task, which they had, but in effect they emitted far more incorrect responses than correct responses in spite of mastering this task.

Suggestions from other authors stating that variation within a response class is essential for selection of behaviour to occur (Glenn et al., 1992; Donahoe et al., 1993) are also supported by the results of this experiment. That is, hens that performed responses on all four quadrants during the first session (e.g., Hens 9.1 - 9.3, and 9.5) of a condition reached the maximum number of correct responses across a condition faster than those hens who only responded on one or two of the quadrants (Hens 9.4, and 9.6). That is, when the responses within the response class were more variable, the new topography was shaped more successfully. This

can be seen by the total time taken to complete a condition shown in Figures 4 through 9.

The current experiment confirms Catania's (1973) hypothesis that there will be some incorrect responses that persist even though they do not meet reinforcement criteria.

Experiment 2

Experiment 2 was designed to partially replicate the procedure of the Eckerman et al. (1980) study, while applying Catania's (1973) concept of the operant in order to determine whether his concept is able to adequately organise responses, resulting in a practical and comprehensive response class. That is, both correct and incorrect responses were recorded.

Method

Subjects.

As in Experiment 1.

Apparatus.

As in Experiment 1.

Procedure.

Part 1: Training Procedure.

The hens were hand shaped to peck at the left side of the screen (the position of the first active region) to prevent extinction of pecking that might have occurred due to the large proportion of the screen that was ineffective. After two consecutive sessions where the maximum number of reinforcers were gained the hens moved on to Condition 1.

Part 2: Experimental Procedure

Conditions 1 through 11.

The LCD screen was split into ten, 30 mm wide x 341 mm high regions. During each condition only one of the regions was active. Delivery of

reinforcement required five responses on the active region (FR 5 schedule). As with Experiment 1 the entire screen remained white, no signals or visual cues were used to show a change in the contingency. During Condition 1, the left most region (Region 1) was active, while remaining regions were inactive. Regions 2 through 4 were active during Conditions 2 through 4 respectively. These conditions took twelve sessions, with a total of 480 available reinforcements. After graphed comparisons between the 8th and 12th sessions showed no change in responding, the length of each condition was shortened to eight sessions, with a total of 320 reinforcements. Condition 5 had a larger step moving the active region from Region 4 to 6, as did Condition 6 which moved from Region 6 to Region 8. Condition 7 consisted of a smaller step to Region 9. This was done so that Conditions 3 through 7 could be replicated. That is, Condition 8 replicated Condition 6, Condition 9 replicated Condition 5 and so on. The active regions for each condition are shown in Figure 14.

Condition 12.

The LCD screen was divided into ten nominal keys as before, and the active region (Region 6) was illuminated red. The hens were required to respond on an FR 5 schedule on the red region, sessions ended after each hen gained 40 reinforcements, or after 2400 s elapsed. Hens 9.1 and 9.3 did not gain any reinforcers during the first three sessions and so the location of their pecks were hand shaped to the red region. Data was recorded from the session following the hand shaping session.

Region 6 was chosen as the active region because the results from Conditions 5 and 9 (conditions where Region 6 was the active region) showed that

all hens made the smallest increase in the proportion of correct responses throughout the condition when compared to all other conditions.

Region Number	1	2	3	4	5	6	7	8	9	10	
Condition Number	1	2	3	4		5		6	7		
			11	10		9		8			
						12					

Figure 14. The active regions for Conditions 1 through 12. The shaded area was not included within the 10 regions, as each of the 10 regions were 30mm and the length of the screen 310mm meant there was a small area (10mm) that was not a part of any region. The shaded area remained white throughout the experiment.

Results

These results show that a large number of incorrect responses persisted throughout each condition for all hens. Figure 15 shows the proportion of correct responses during each session for all conditions. Sessions where hens received five or fewer reinforcers, or laid an egg in the experimental chamber, were removed from this figure. There was a noticeable decrease in the proportion of correct responses for Experiment 2, when compared with proportions in Figure 10 from Experiment 1 for all hens. As seen in Figure 15, the accuracy of responding was high during Condition 1 as the hens were hand shaped to peck in Region 1 (the active region), therefore the results from Condition 1 in Experiment 2 will not be reported but are represented in Figures 33 and 34 in Appendix A. Conditions 2 through 4 showed similar patterns of responding for all hens. Figure 15 shows that in most cases the first session of these conditions had the lowest proportion, which then increased gradually, yet not steadily throughout the following sessions. This is true for most conditions, however during Conditions 3, 5, 7 and 11 several hens responded in such a way that the number of correct and incorrect responses varied to a high degree, and no obvious increase in the proportion of correct responses could be seen. In several of these cases, the starting proportion of correct responses was already higher than the first session of conditions where the proportion of correct responses increased, e.g., Hens 9.1 and 9.2 in Condition 7 had no increase in the proportion of correct responses, yet the proportion of correct responses for these two hens was above 0.5, showing high accuracy in comparison to other conditions. The gradual decline of incorrect responses during each condition is shown in Figure 16, this figure shows the total number of incorrect responses compared with the total number of correct responses for each

session of Experiment 2, the two data lines moving closer together illustrates an increase of the proportion of correct responses. This figure clearly shows the high number of incorrect responses made during the first session, followed by a highly visible decrease in the frequency of incorrect responses.

Figure 17 shows the change in the response distribution across regions between the first session of each condition for Hen 9.6. When a hen did not receive 40 reinforcers during the first session, the data from the second session was plotted. These graphs show that the distribution centres over the previously active region during the first session and shifts towards the active region during the eighth session, with a slight left skew for Conditions 1 through 3. Condition 4 shows that by Session 8, the skew is not visible and the distribution appears to become a normal distribution around the active region. Although Conditions 5 and 6 required a larger step from the previously active region to the current active region, the response patterns appear to have similar properties as Conditions 2 through 4. However, as seen in Figure 17 a noticeable shift in the distribution was visible for Condition 6 when the 8th region was active. All hens show a right (as opposed to a left) skew in the eighth session of this condition, that is responding had moved past the active region (Region 8), and the hen made a higher number of responses on the following region (Region 9). Conditions 8 and 9 were replications of Conditions 6 and 5 respectively, and showed relatively similar distributions of responses on the eighth sessions for this hen. The first session of Conditions 8 and 5 and Conditions 9 and 6 showed response distributions with opposite skews, i.e., the conditions moving towards the right of the screen showed a left skew, while the conditions moving towards the left of the screen showed a right skew. Condition 8 was the first of the reversal conditions, and showed very

little change in distribution from the first session to the eighth session. In general the response patterns shown in Figure 17 are an accurate representation of the response patterns for the remaining hens, Figures 45 to 49 represent Hens 9.1 – 9.5 and can be found in Appendix A.

In general the hens' response location was well controlled, by the last session of a condition, the hens performed more pecks on the active region than any other single region, but still performed a higher number of pecks on the incorrect regions combined than on the active region alone, that is the total number of incorrect responses was higher than the total number of correct responses. In most cases the frequency of responses made on the inactive regions decreased, while the responding on the active region, and the two adjacent regions progressed at a high rate, this pattern can be observed in Figures 18 through 20 which show the number of responses made on each region for Conditions 4, 7 and 10. All hens continued to respond on at least one other region (other than the active region) at a high rate throughout all conditions, this is shown in Figures 21 through 23 which show the response rates in the form of cumulative frequency plots for Conditions 4, 7, and 10. Figures 35 through 44 represent the remaining conditions (aside from Condition 3, 6 and 12), the histograms show similar response distributions, and the cumulative frequency plots show similar response rates, these can be found in Appendix A.

An exception to this response pattern can be seen in Figure 24 and 25 which represent Condition 3. During this condition, all hens pecked on the previously active region more than the current active region during the eighth session of this condition, meaning that the distribution of responses did not shift towards the active region (Region 3) during this condition. This effect is also

demonstrated in Figure 17, where the two response distributions for Session 1 and Session 8 are very similar.

Condition 6, 7 and 11 resulted in a different response pattern. Figures 26 and 27 represent Condition 6 and show that all hens made more responses on the region to the right of the active region on the eighth session. This can be seen in Figure 26 where the hens made a higher number of pecks on Region 9 creating a right skewed response distribution. Figure 27 illustrates this pattern by showing a gradual increase in response rate for Region 9 across sessions, with a lower response rate for all other regions. The active region (Region 8) shows an increase in response rate, but to a lesser degree than Region 9. This is shown by the shortening of session times and the increased slope of the cumulative lines. Figures 19 and 22 represent Condition 7, while Figures 43 and 44 representing Condition 11 are shown Appendix A.

The proportion of correct responses appeared to be higher during Condition 7 for all hens shown in Figure 15. This condition required pecks on the ninth region and therefore the contingency required a smaller step from the previous condition to the current condition. Five of the six hens reached proportions of over 0.5. Although the active region for this condition was close to the edge of the screen, Figure 17 suggests that few pecks were made to the right of the screen (and therefore most responses broke the infra-red beams) because the distribution of responses drops to near zero before the edge of the 10th region. Whereas in Conditions 1 and 2, the hens appeared to be responding to the left of the screen and some responses may not have been recorded as they would not have broken the infra-red beam. Therefore the proportion of correct responses appeared higher. This can be seen in Figure 17 where the frequency of pecks does

not decrease to a low rate before the left edge of Region 1. This pattern is also shown in Figure 19, these histograms representing Condition 7 show that by the final session the distribution is narrow when compared to the eighth session of other conditions. Three of the six hens responded on only three regions during Session 8 of Condition 7, while in other conditions hens tended to respond on at least five regions. Figure 22 shows the cumulative graphs for Condition 7, and although the hens performed more responses on the active region (Region 9), all hens still responded on Region 8 at a high steady rate for all eight sessions.

Condition 12, (the only condition where the active region was visible) showed similar patterns to Condition 7, where responding showed a narrower distribution, but still resembled a normal distribution that centred over the active region. The response distributions can be seen in Figure 28, these graphs show the number of responses made on each region during eight of the nineteen sessions of this condition. As with the other conditions, the hens made the maximum number of correct responses on the active region, and also made responses on regions other than the active region. This can also be seen in Figure 15. The proportion of correct responses was higher in Condition 12 than previous conditions, for all but one hen (9.5), yet the proportion of correct responses fluctuated after an initial rapid increase in the proportion of correct responses. One hen reached proportions of 0.7 during seven of the nineteen sessions, but fluctuated between 0.7 and 0.5 throughout the Condition. The remaining hens fluctuated around a proportion of 0.6 correct responses with the exception of Hens 9.5 and 9.6. By the final sessions of Condition 12, these hens (9.5 and 9.6) performed similarly to the previous conditions gaining proportions of below 0.5 correct responses. Figure 30 shows the change in response distributions from the first to the nineteenth session. Four

of the six hens showed a large increase in the frequency of responding around the previously active region (region 3), but by the last session, showed a narrow, normal distribution over the active region. All hens made responses on either side of the active region in the final session. Figure 29 shows the cumulative plots for all hens during Condition 12. These plots show similar changes in response rates as previous conditions. That is, hens responded on the active region at a high, steady rate, but continued to respond on the adjacent regions at a low (Hens 9.3 and 9.4) or moderate (all other hens), steady rate.

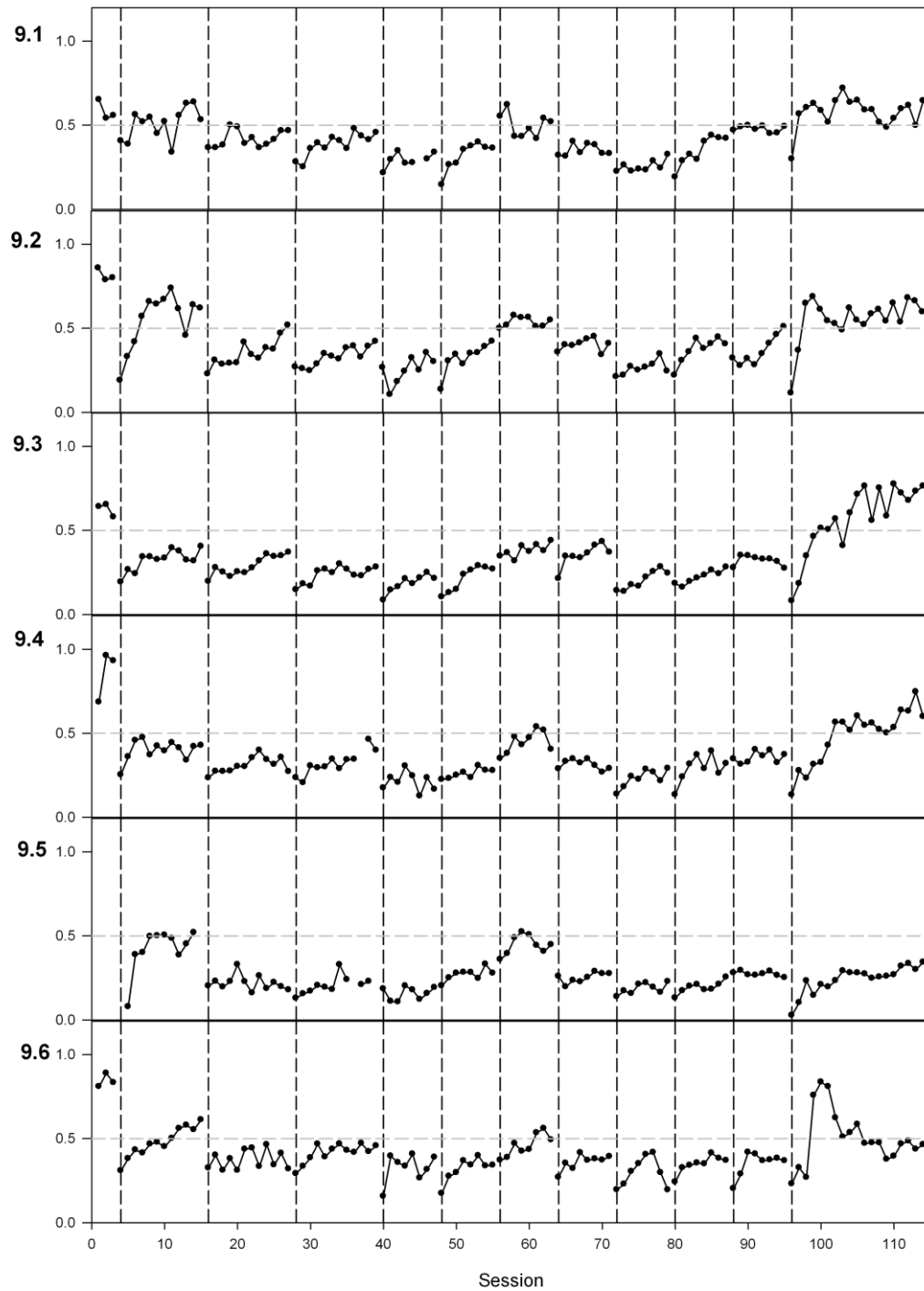


Figure 15. The proportion of correct responses for each hen across all sessions of Experiment 2. The black dashed line shows the end of the previous conditions and the beginning of the next.

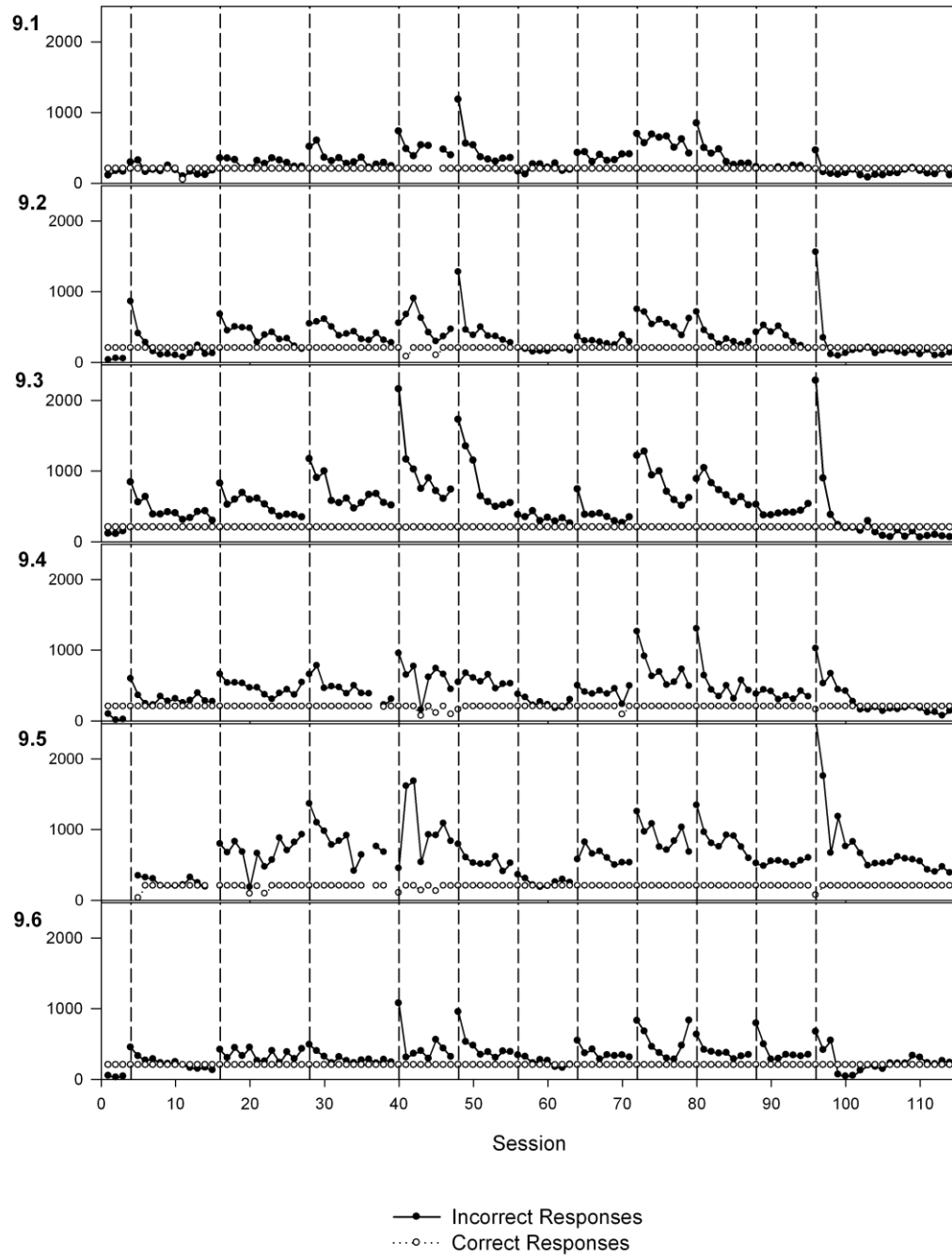


Figure 16. Total number of correct and incorrect responses for each hen across all sessions of Experiment 2. The black dashed line shows the end of the previous conditions and the beginning of the next.

Hen 9.6

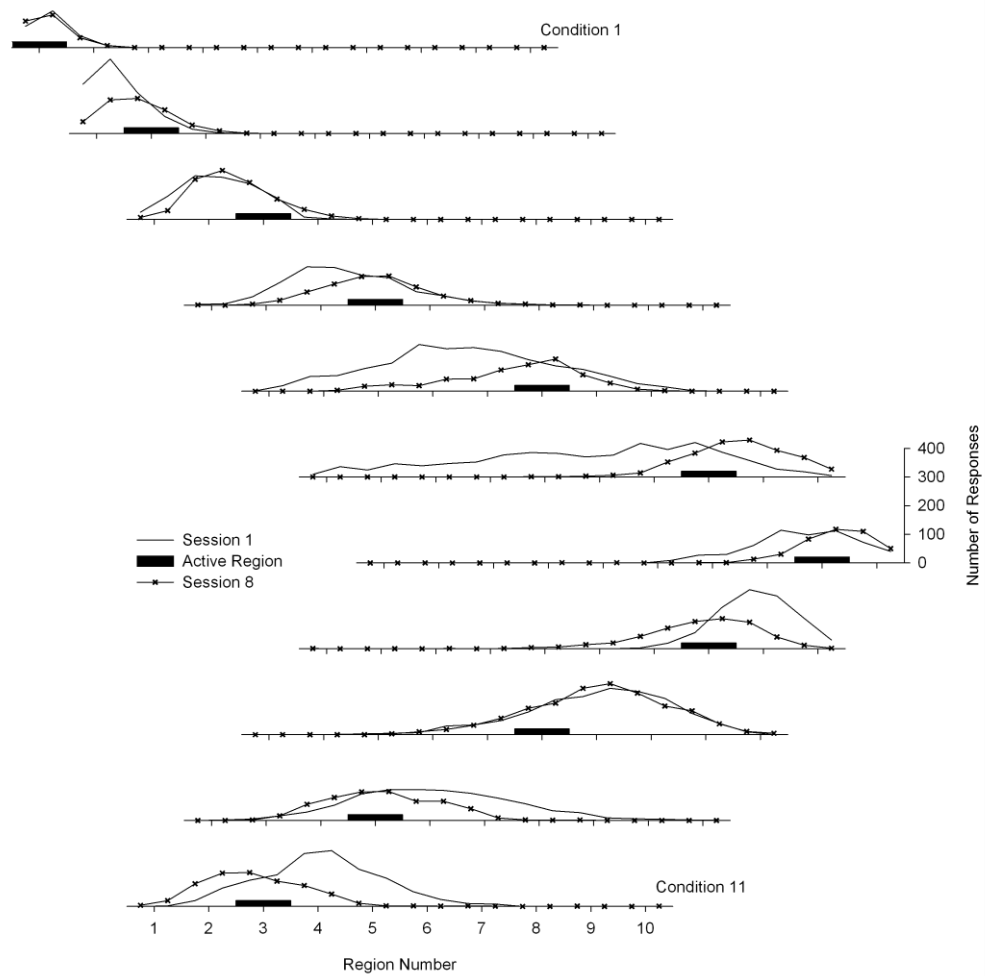


Figure 17. The distribution of responses in the 1st and 8th Session of all conditions for Hen 9.6.

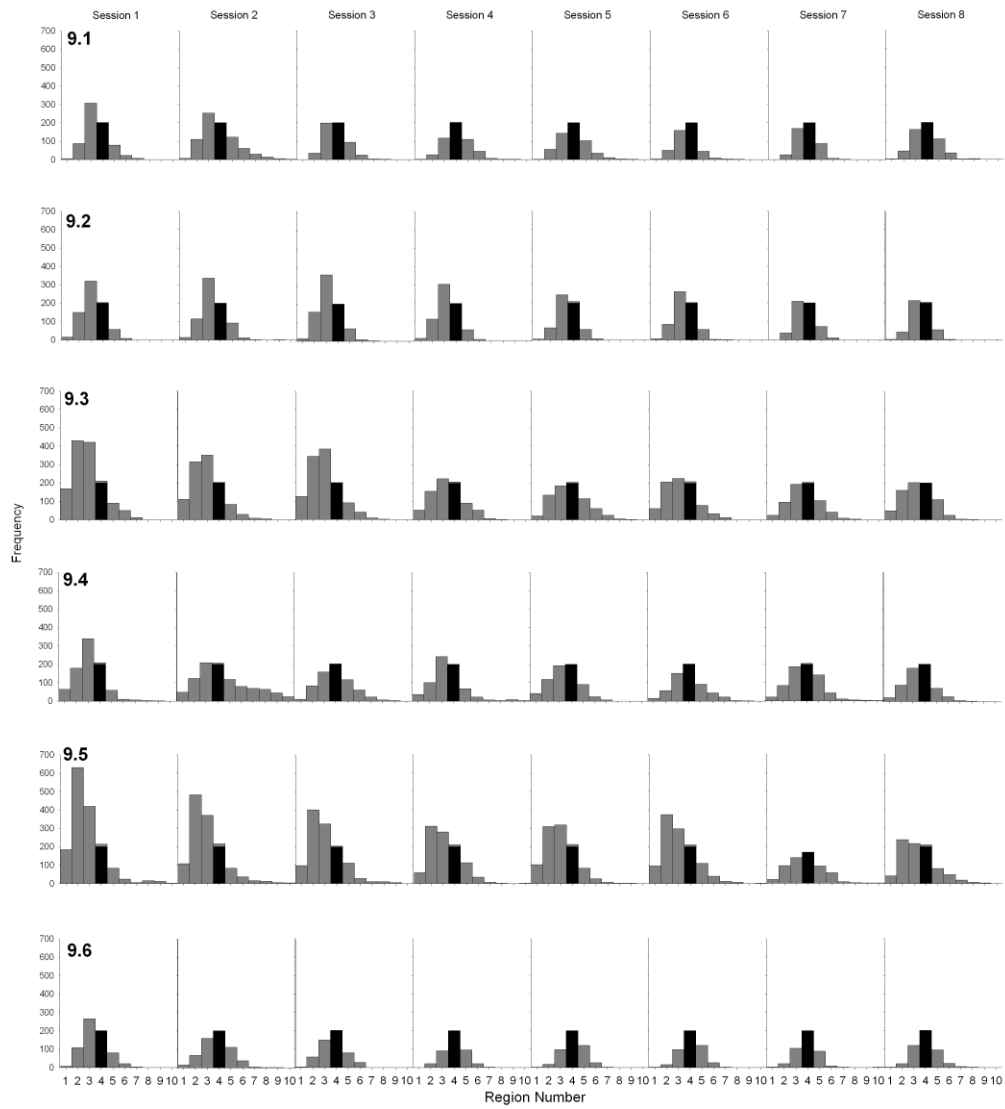


Figure 18. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 4 of Experiment 2. During this condition, Region 4 was the active region.

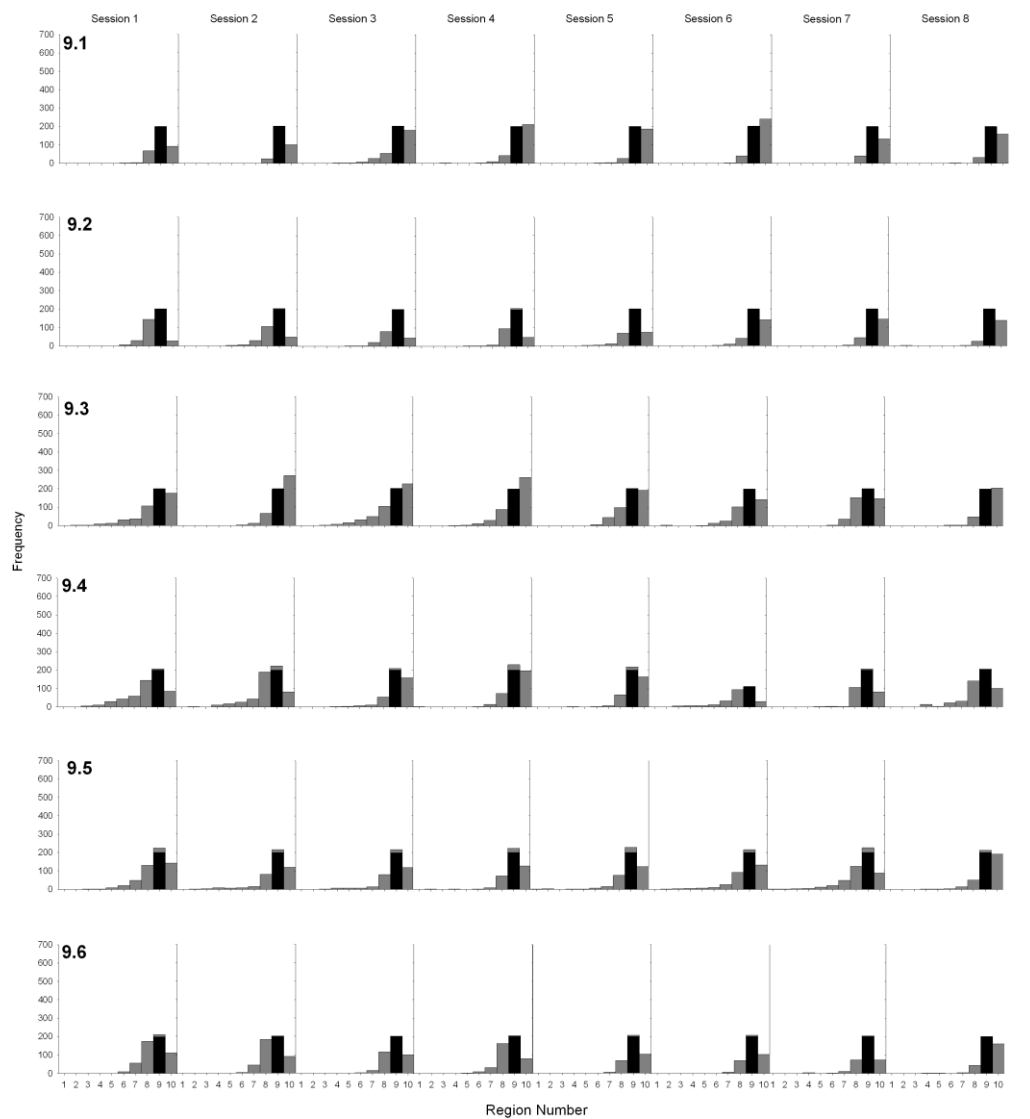


Figure 19. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 7 of Experiment 2. During this condition, Region 9 was the active region.

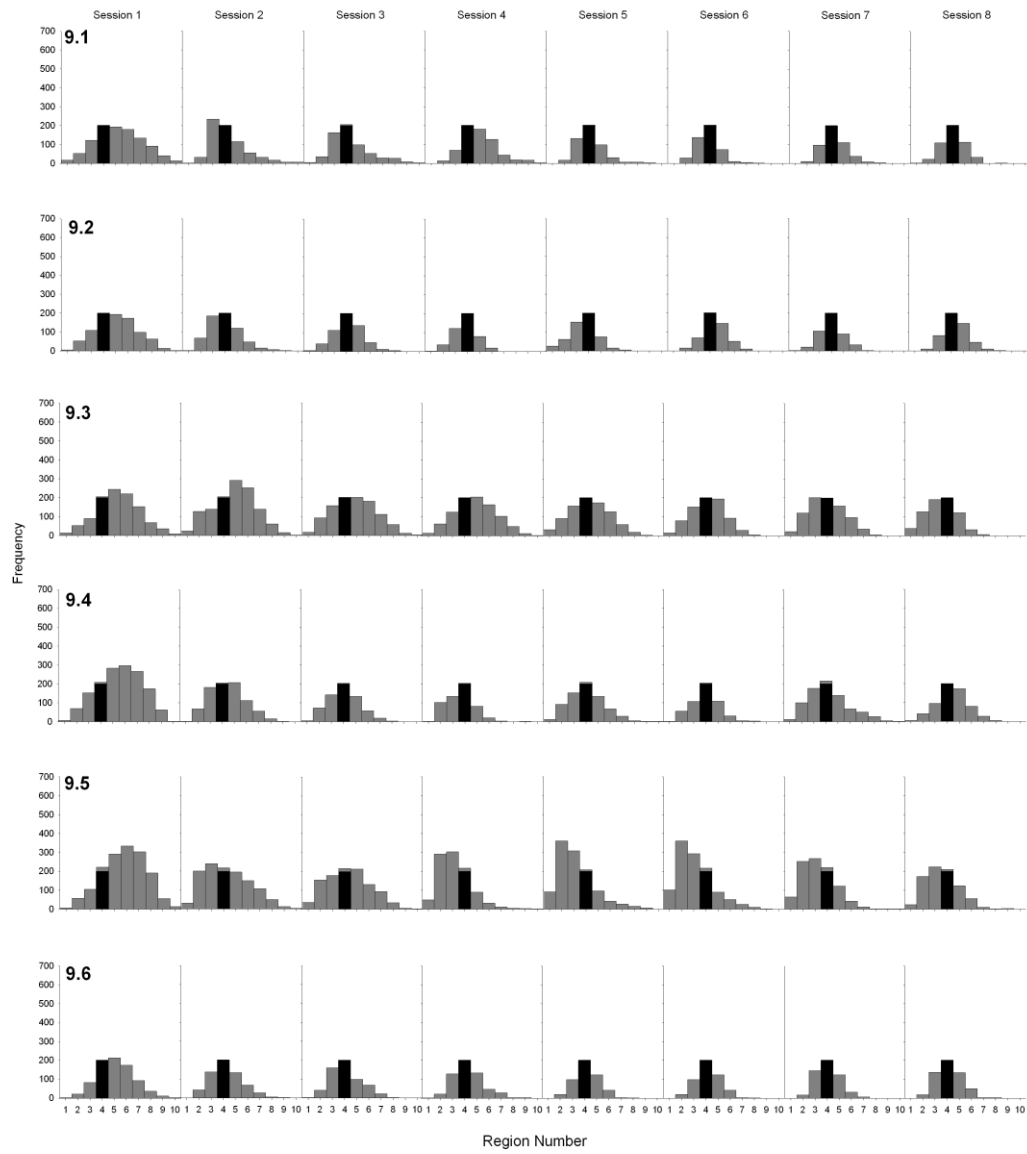


Figure 20. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 10 of Experiment 2. During this condition, Region 4 was the active region.

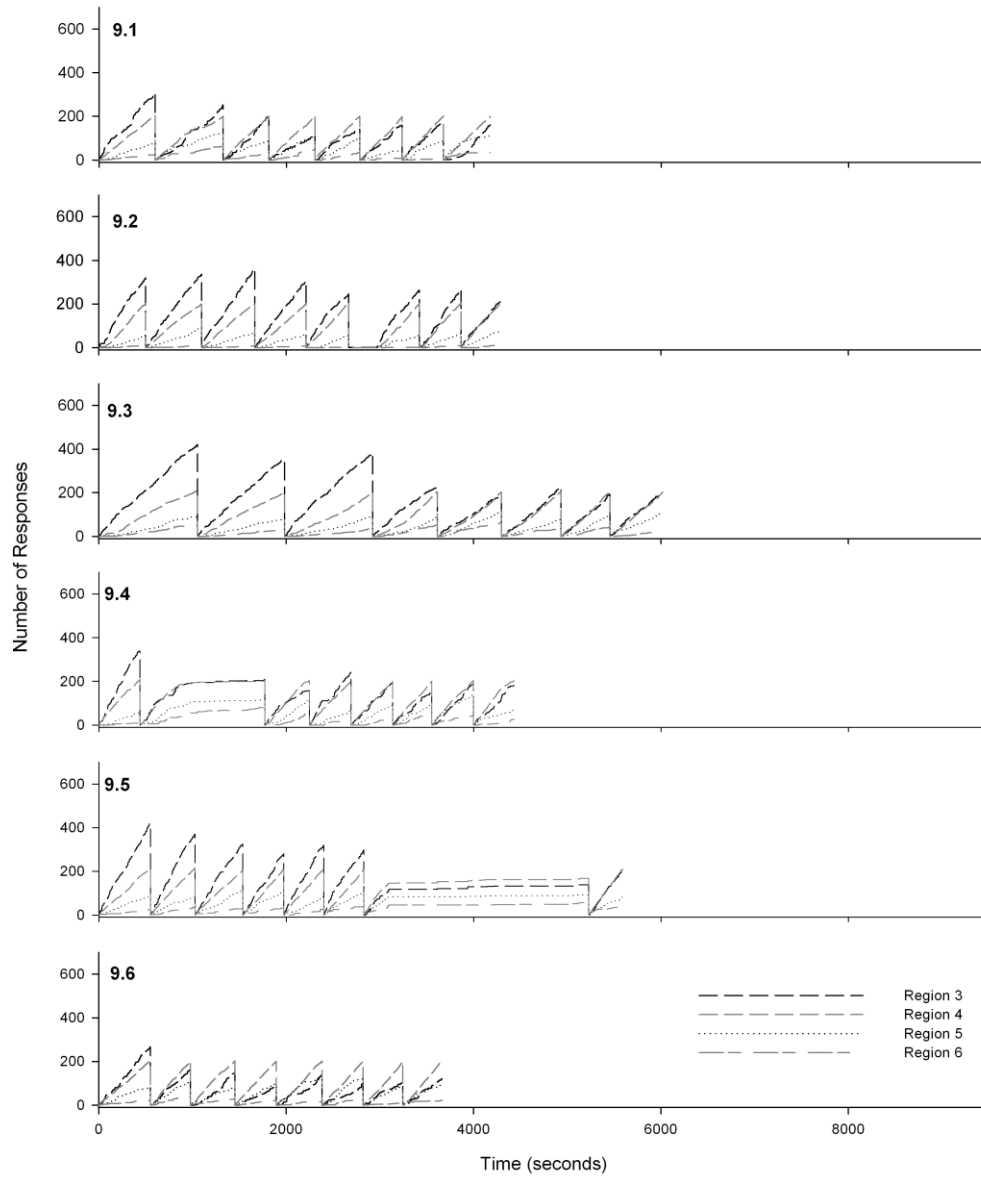


Figure 21. The response rate on the active region (4), the previously active region (3) and the next region to be active (6) for all hens during Condition 4 of Experiment 2.

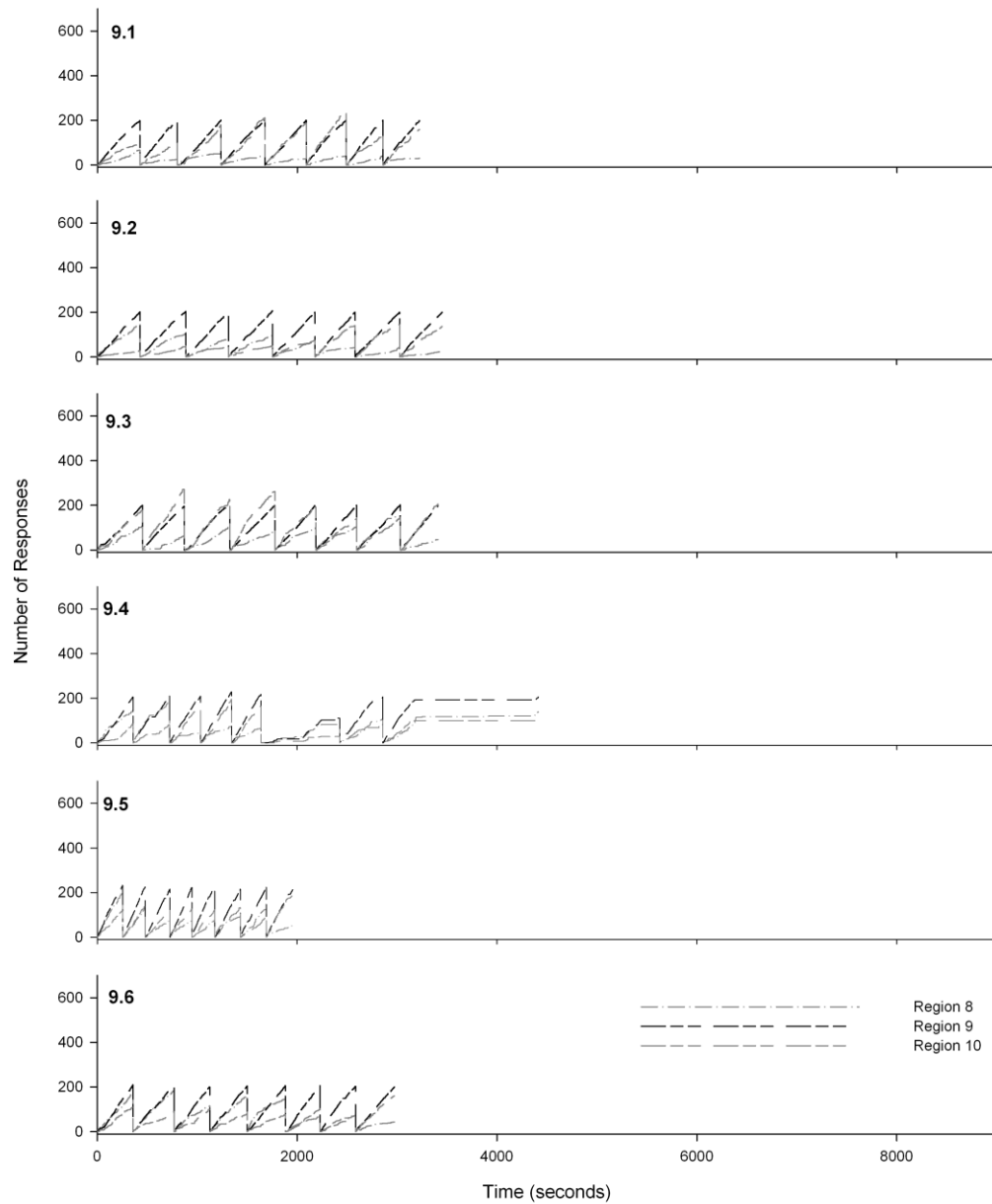


Figure 22. The response rate on the active region (9), the previously active region (8) and the adjacent region (10) for all hens during Condition 7 of Experiment 2.

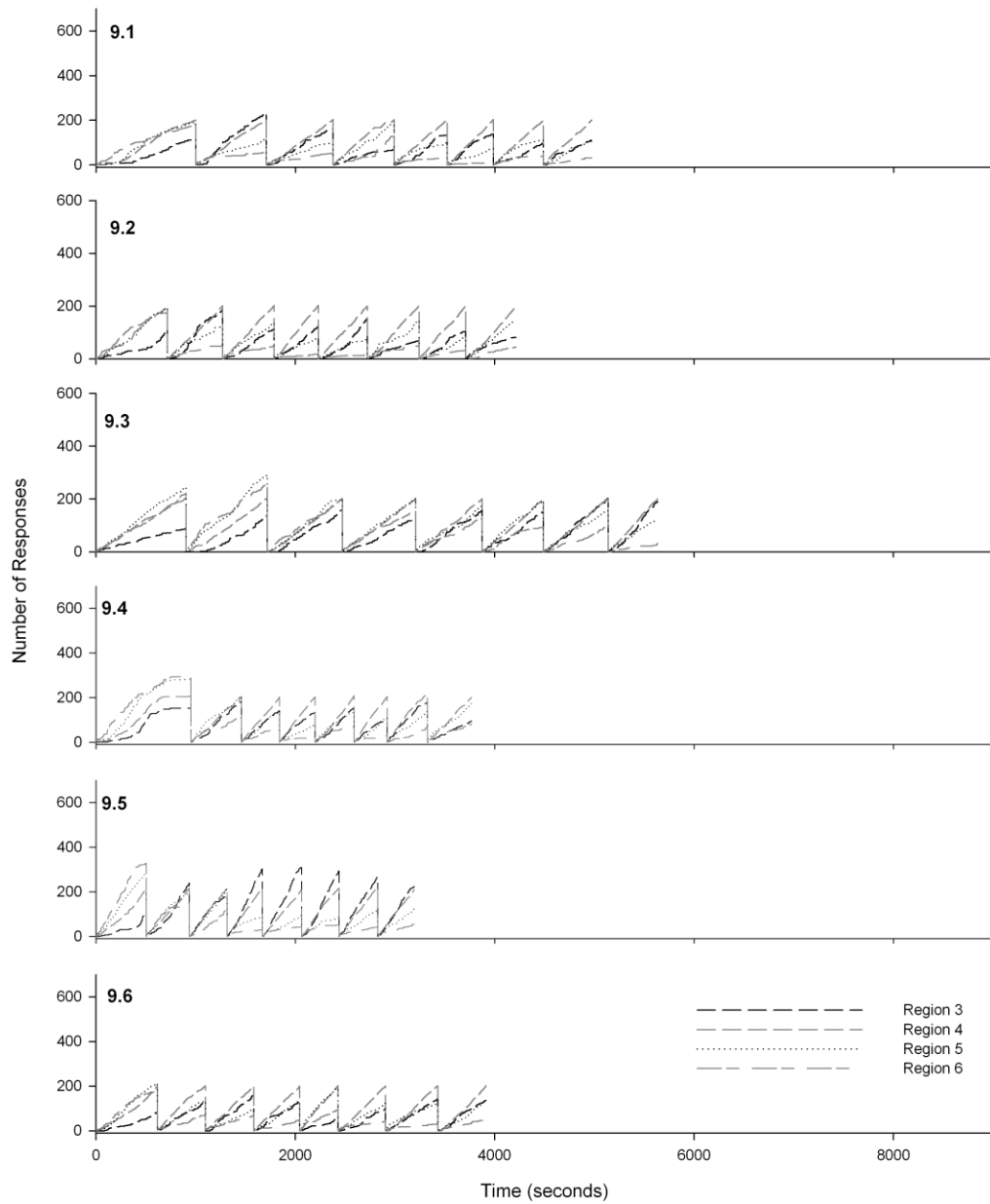


Figure 23. The response rate on the active region (4), the previously active region (6) and the next region to be active (3) for all hens during Condition 10 of Experiment 2

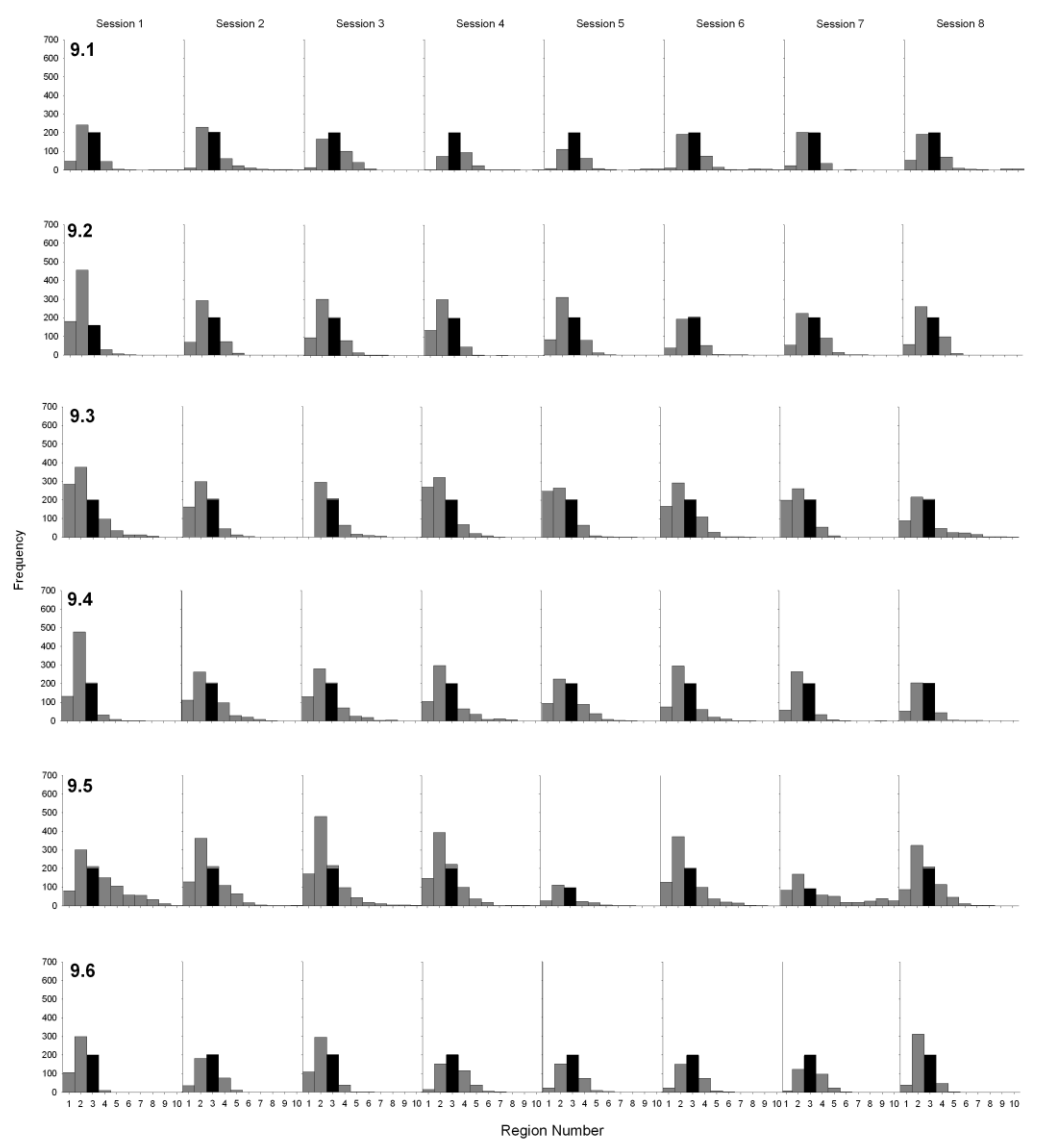


Figure 24. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 3 of Experiment 2. During this condition, region 3 was the active region.

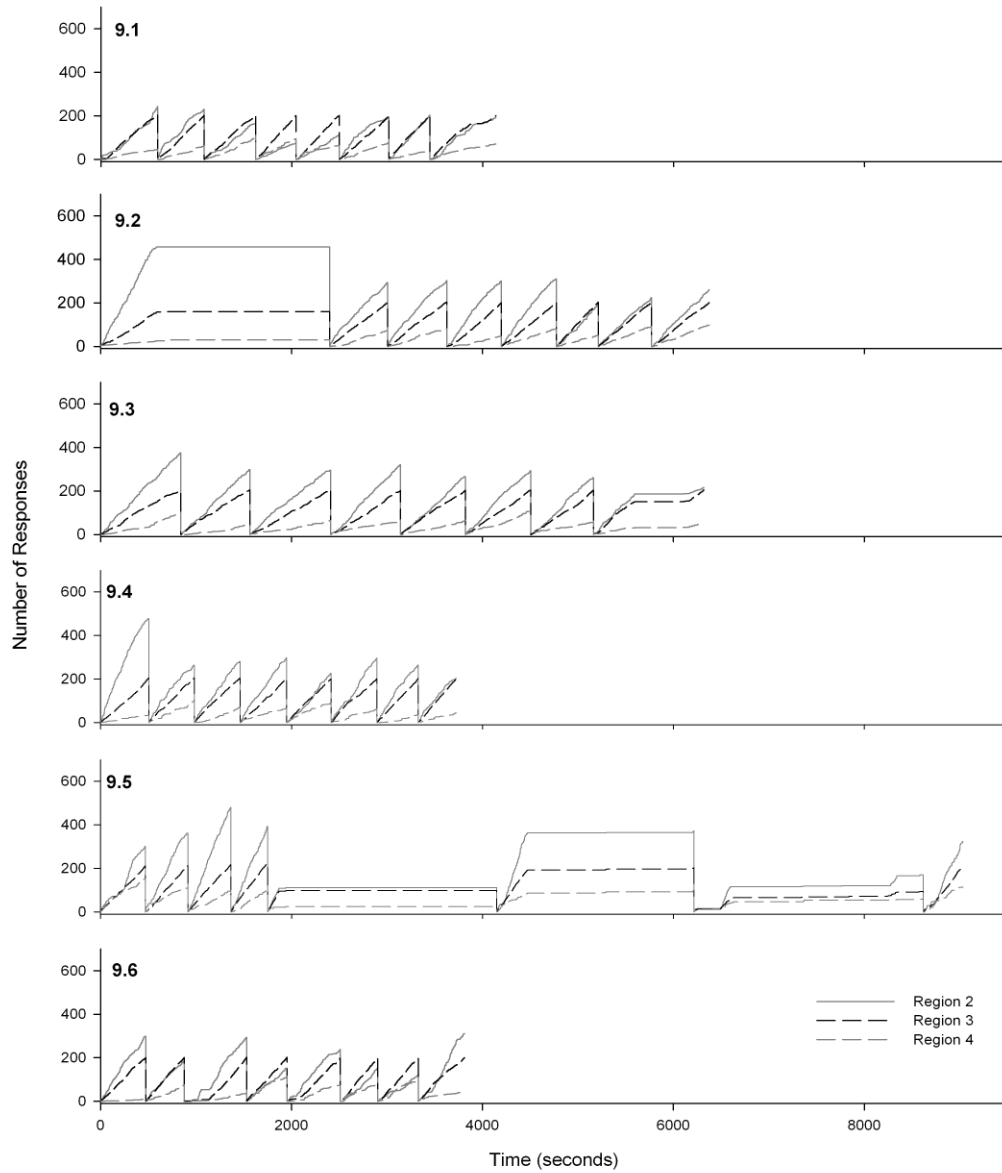


Figure 25. The response rate on the active region (3), the previously active region (2) and the next to be active region (4) for all hens during Condition 3 of Experiment 2.

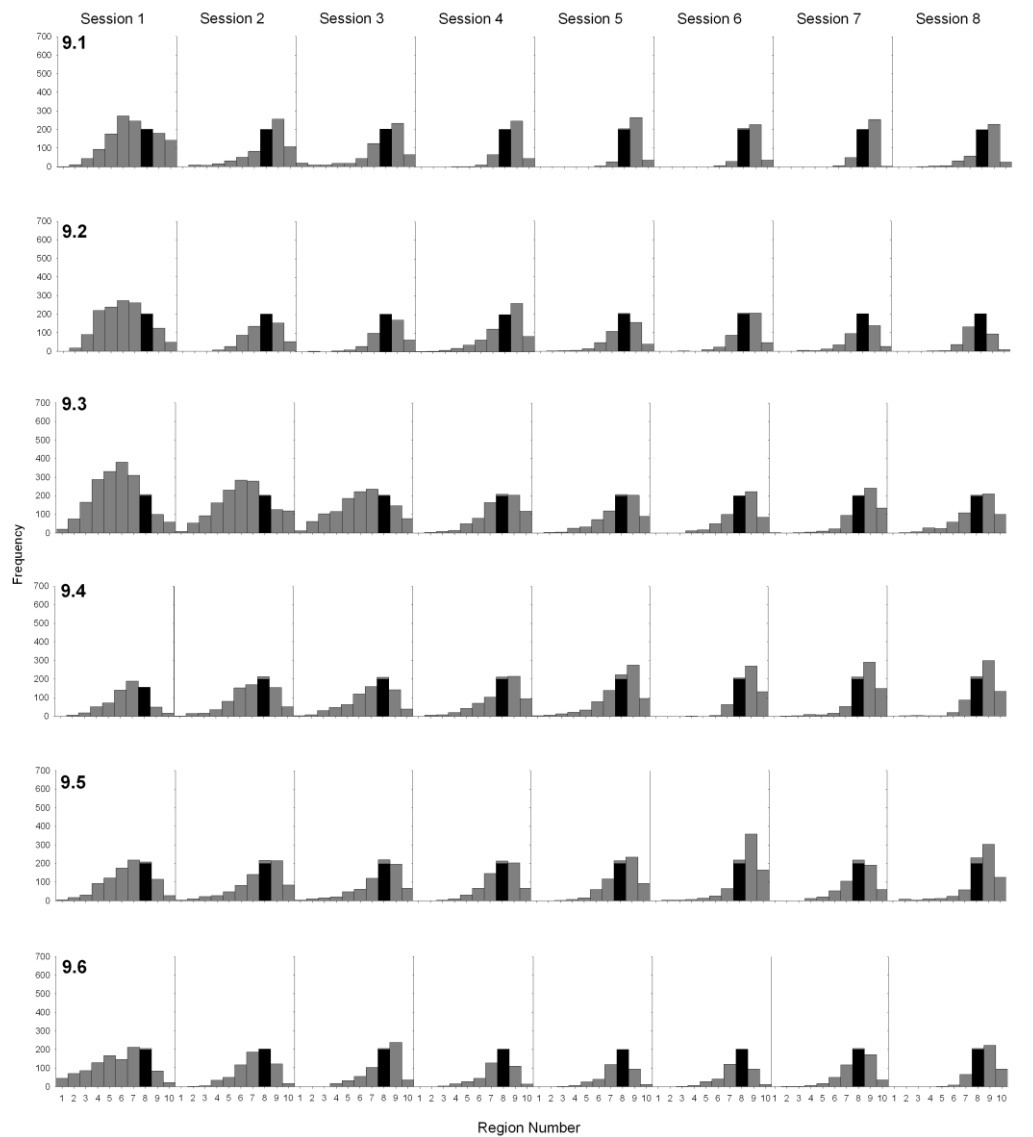


Figure 26. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 6 of Experiment 2. During this condition, region 8 was the active region.

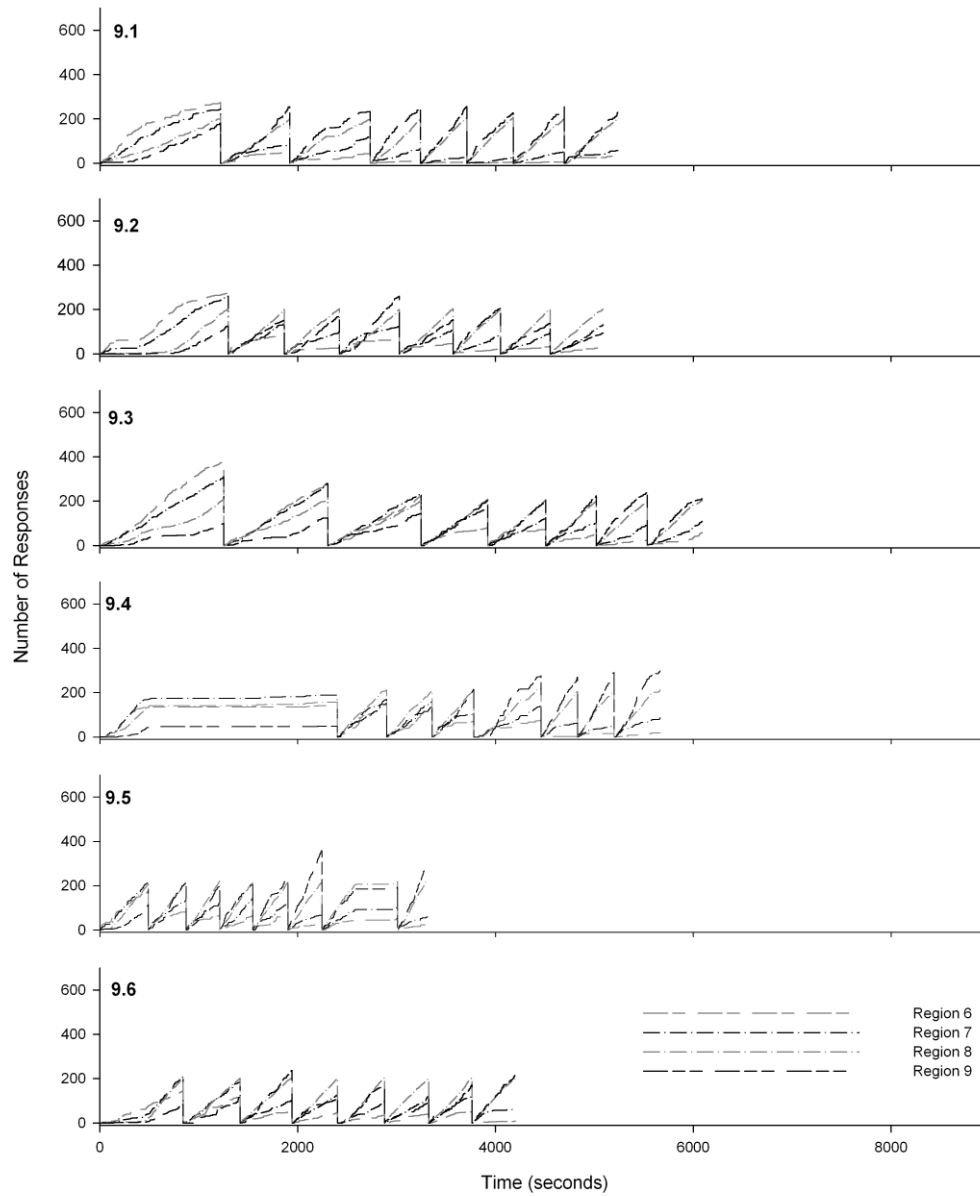


Figure 27. The response rate on the active region (8), the previously reinforced region (6) and the next region to be active (9) for all hens during Condition 6 of Experiment 2.

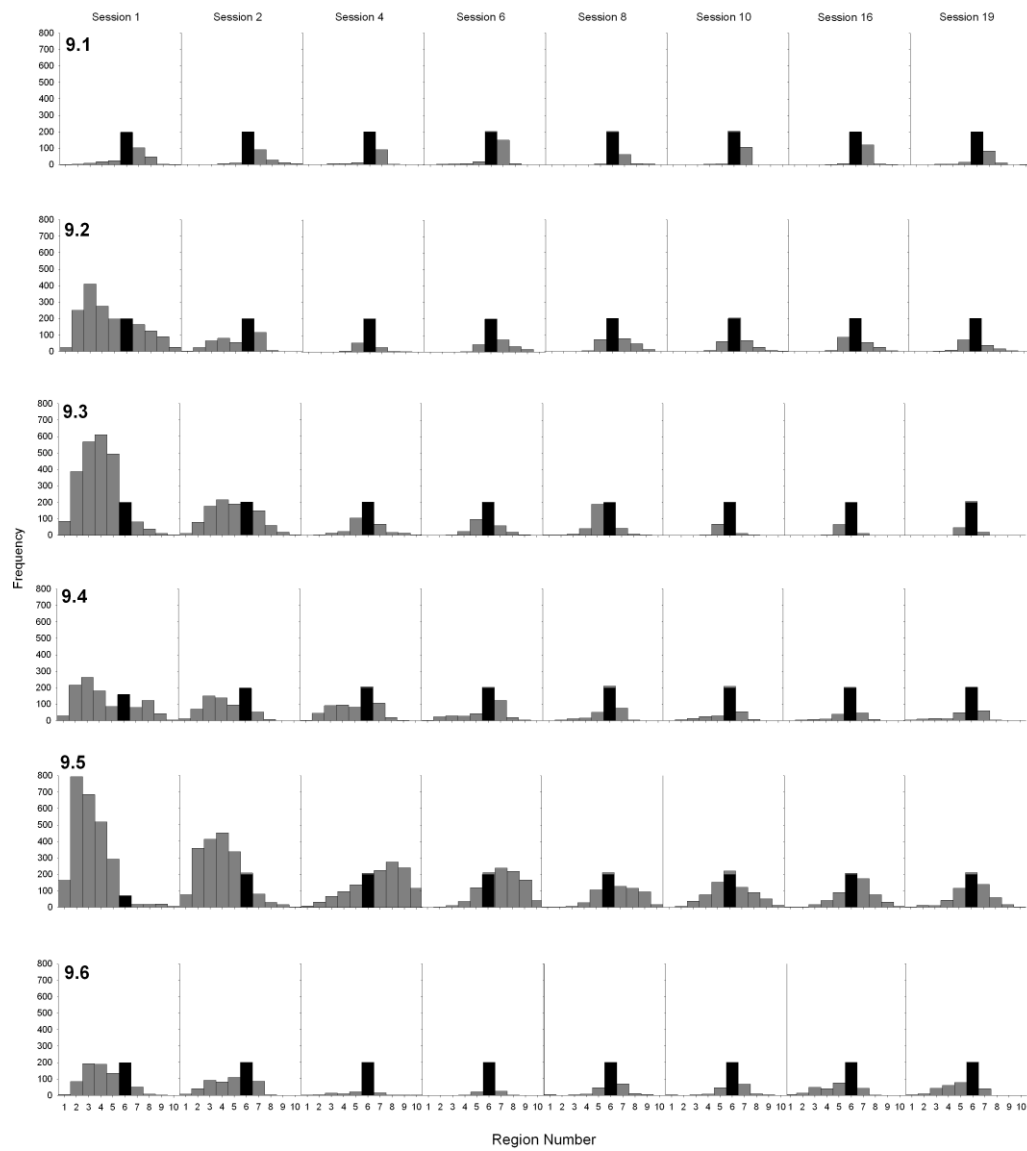


Figure 28. The frequency of pecks on each of the ten regions for eight of the nineteen sessions of Condition 12 of Experiment 2. During this condition, Region 6 was the active region, and was coloured red.

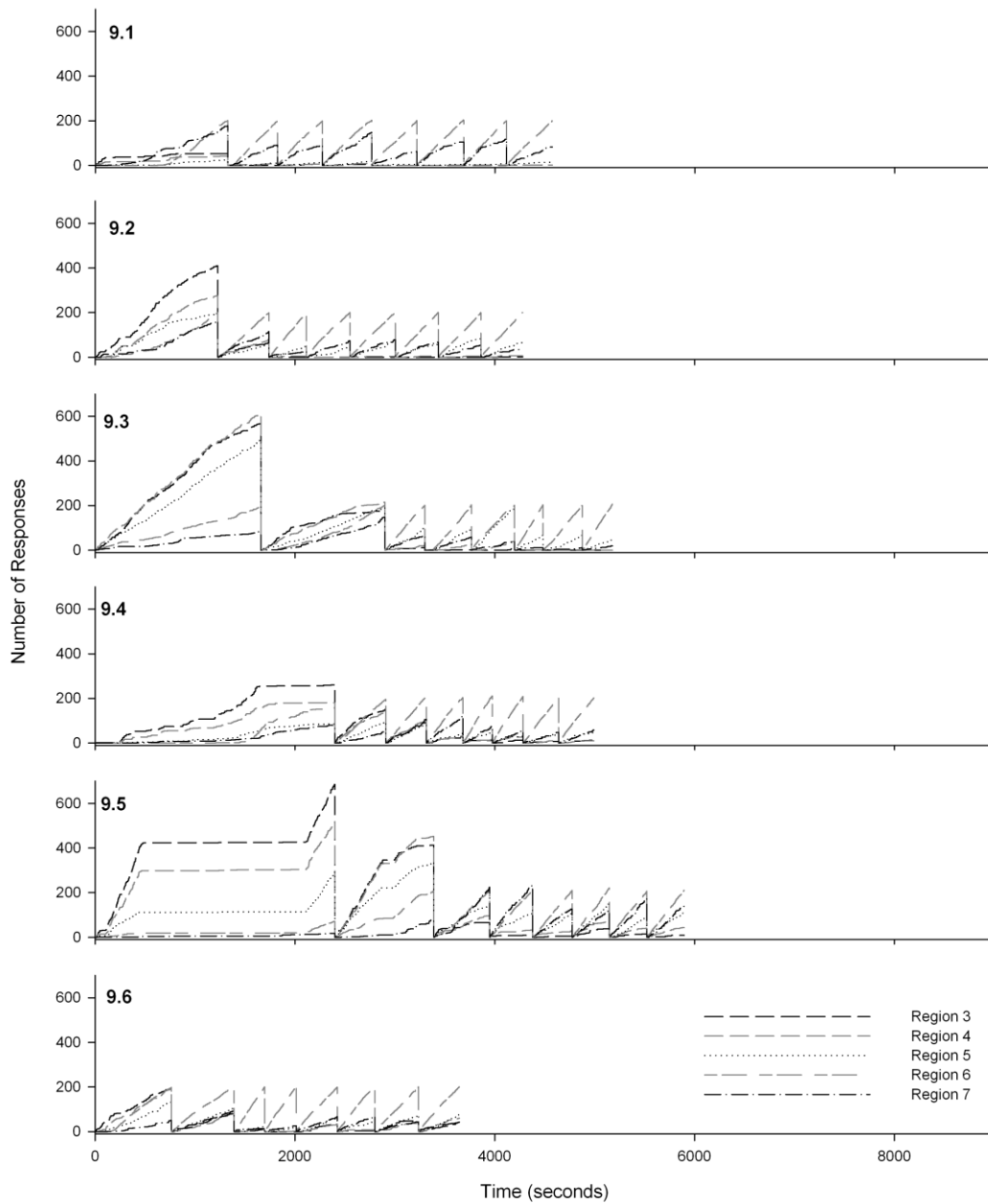


Figure 29. The response rate on the active region (6), the previously active region (3) and the adjacent region (7) for all hens during Condition 12 of Experiment 2. During this condition the active region was coloured red.

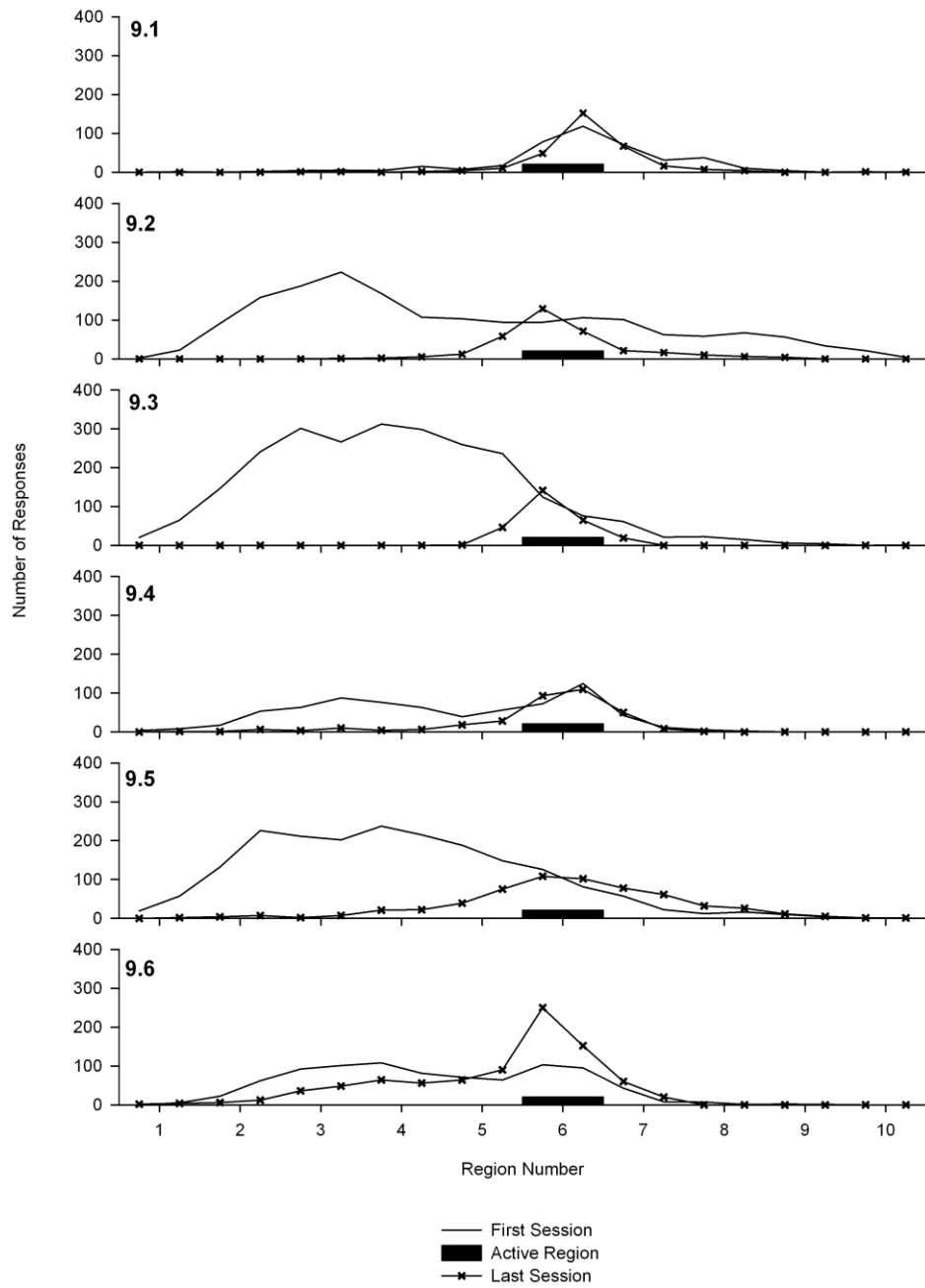


Figure 30. The distribution of responses from the first session to the last session for all hens during Condition 12 of Experiment 2.

Discussion

The aim of Experiment 2 was to determine whether Catania's (1973) hypothetical data (shown in Figure 1) could be replicated. This was done by partially replicating the procedure of Eckerman et al.'s (1980) study, by attempting to move hens' behaviour across different locations (active regions) on a screen. The findings suggested that changing the criteria for reinforcement (in this case changing the location of the active region on the screen) resulted in a shift of the distribution of all responses towards the target region. That is, not only did responses become more frequent in the active region, responses became more frequent in the surrounding regions, while responses furthest from the active region decreased in frequency. Therefore creating a normal distribution (in terms of response location), with the highest percentage of responses occurring around the active region, with fewer responses being made further away from the active regions.

These data support Catania's (1973) concept of the operant, as he proposed that the location of responses would occur along a continuous distribution, with responses occurring most frequently within the active region and decreasing in frequency on either side of this region. While the current study examined response distributions in terms of response location, Catania's (1973) discussion focused on the force of responses. One might assume that response distributions such as these may occur with any dimension, e.g., height, duration, or intensity) so long as all responses that occur along the selected dimension are recorded. The similarities between the distribution of response locations found in this experiment and a normal curve are shown in Figure 31 where the response distribution for Hen 9.6 during Condition 4 is plotted alongside a normal curve.

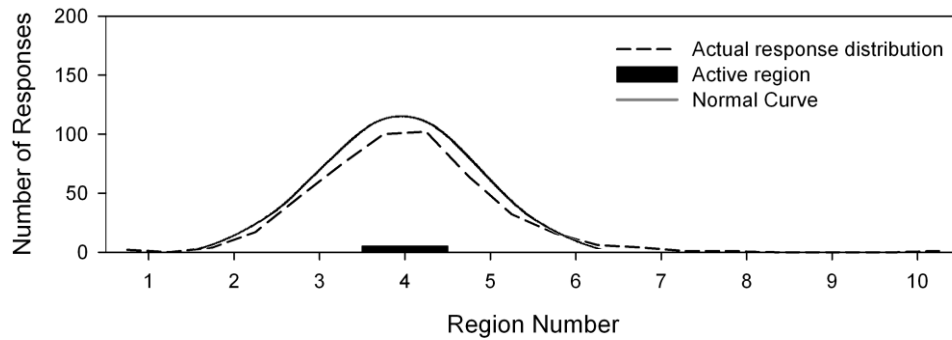


Figure 31. A normal curve plotted against the response distribution for Hen 9.6, Condition 4 of Experiment 2.

Although the number of incorrect responses decreased throughout each condition, the results showed that incorrect responses persisted through all conditions. The response distributions found appear to be very similar to those collected by Eckerman and his colleagues (1980) with the exception of Condition 12 where the active region was visible. In general, during this study, the proportion of correct responses emitted was less than 0.5 in the final session. Therefore, although the hens' responding was manipulated, in that the distribution shifted towards the location set by reinforcement, in most cases, these hens emitted more incorrect than correct responses during each conditions. Eckerman et al.'s (1980) results showed that pigeons also performed more incorrect than correct responses, with his pigeons making between 30% and 50% correct responses during the final shaping step.

One may be tempted to argue that response distributions would narrow further if conditions had been longer, i.e., more than eight sessions. When looking at the trends shown in the data from the current study, there appears to be no

indication that the distributions would narrow, in fact the proportion of correct responses seen in Figure 15 responding does not systematically trend towards a reduction of incorrect responses.

Catania (1971) discussed the role of responses preceding the reinforced response as a means of explaining the apparent high response rate of seemingly non-reinforced responses. Catania (1971) carried out three experiments, all of which led to the same conclusion. That is, reinforcement of a response, results in an increase in the frequency of responses that occurred prior to the target response.


Catania's (1971) views are supported by research in the area of delay to reinforcement which suggests responses can be strengthened even when reinforcement is delayed (Pubols, 1958; Skinner, 1938; 1953). That is, responses made early on in the sequence may have a longer delay to reinforcement, but can still be strengthened to a degree. This is depicted in Table 1 where the arrow representing the degree of reinforcement of responses decreases from the point of reinforcement to the beginning of the trial.

In the current study the hens were worked on an FR 5 schedule, meaning that five correct responses resulted in reinforcement. Hens most often made more than five responses prior to reinforcement as they often made responses on inactive regions during each trial. Therefore, each response that occurred between the previous reinforcement and the current reinforcement may have been strengthened to some degree, according to Catania's (1971) discussion. Table 1 shows five response sequences taken from a session of Condition 4 for Hen 9.6, and demonstrates that although reinforcement would follow the fifth response on

Region 4, it may subsequently reinforce responses made on the other regions as responses on these regions occurred within the sequence that was eventually reinforced.

Table 1. Sequence of responses made on regions for Hen 9.6 Condition 4 when Region 4 was the active region. Reinforcement followed the fifth response (shown in bold) on the active region.

Trial	Sequence of responses on regions
36 th	2 4 4 4 4 3 3 4
37 th	3 3 4 3 3 3 4 5 4 5 5 4 4
38 th	3 4 4 5 4 6 5 5 4 4
39 th	5 4 3 3 3 3 4 2 4 3 3 3 4 3 4
40 th	5 4 3 3 3 3 4 2 4 3 3 4 3 4


 Decreasing strengthening effect of reinforcer

Skinner's (1938; 1953) principles such as induction and generalisation also provide a theoretical account for the persistent occurrence of incorrect responses, this may be more valid than the explanation provided by Catania (1971). Skinner (1953) describes the continuity of behaviour, stating that responses have an infinite number of properties, and, therefore, can have common properties with responses that are topographically or functionally different. That is, a correct response, in this case a peck on Region 4, may have common properties with a peck on Region 5. Therefore, when reinforcement is provided

for a peck on Region 4, all responses that have a common property with this response are indirectly reinforced. In the current experiment, responses on different regions could have many common properties such as; responding on a white screen, responding with a certain force or rate, or responding on the screen while simultaneously emitting behaviours with other topographical properties that were not recorded during this experiment (i.e., different body postures). If a reinforced response holds any of these common properties with any non-reinforced response, Skinner (1938; 1953) suggests that induction could occur resulting in a strengthening of incorrect responses.

Infact, the data we see must be explained by a commonality on the current dimension, i.e., response location. This is because Catania's (1971) explanation of diminishing reinforcement for responses prior to the reinforced response would produce equal numbers of responses across all other inactive regions if the responding was randomly allocated across those regions. This is not the case in the current study, strongly suggesting a bias in responding towards the active regions prior to the impact of reinforcement suggested by Catania (1971). Catania's (1971) explanation cannot account for the data from the current study, without considering the commonality of response topography.

Although these non-reinforced responses are strengthened in some way, they are not strengthened to the same degree as the response directly preceding reinforcement (Catania, 1971; Schick, 1971). Therefore responses made on the active region will be strengthened to a higher degree than all other responses, this is supported by the empirical analysis from the current study. After examining the results from the current study, one could make the argument that the degree of

commonality (on any dimension) between responses, is likely the cause of the persistent responses made on the inactive regions.

Most studies will confirm that a continuous reinforcement schedule (CRF) or FR 1 schedule results in very stereotypic levels of responding (Antonitis, 1951; Doughty & Lattal, 2001; Mazur, 1994; Reynolds, 1964; Schwartz, 1982). The literature and research around schedule-induced variability or stereotypy with other schedules has led to a diverse range of ideas. Although there are no clear answers about the relationship between some schedules and response stereotypy, several authors have shown that Fixed Ratio (FR) schedules result in stereotypic levels of behavioural variability. Boren and Colleagues (1978) carried out a study that found FR 5 schedules resulted in 98% of responses being made on the active lever. While another study comparing the effects of FR and Variable Ratio schedules on behavioural variability concluded that lower FR schedules resulted in response repetition (Tatham, Wanchisen & Hineline, 1993). These results suggest that the large amount of variation of response locations found in this study is not necessarily induced by the reinforcement schedule, therefore supporting the use of an FR 5 in the current study.

Herrick (1964) discussed the possible effects of previous reinforcement history when successively shaping operant behaviour. His study examined the distribution of lever placements to successive positions and found that, like the current study, the location of lever placements formed a normal curve distribution pattern that centred around the reinforced zone. That is, both correct and incorrect responses were made in the final session of each condition. Herrick (1964) acknowledged that by reinforcing successive approximations to the final lever position, all responses made within the reinforced zone during any session prior to

the final condition (the target lever position) received reinforcement, and therefore responses that became ineffective during the final condition could have been resistant to extinction because of their previous reinforcement history (Herrick 1964). However, due to the finding that responses on regions such as Regions 1 and 7, 8, 9 and 10, were extinguished when reinforcement was provided for Region 4, the current study also provides evidence to suggest that the hens previous reinforcement history was unlikely to have impacted the responding of these hens in the way described by Herrick (1964).

The number of incorrect responses that persisted throughout each condition of this experiment stimulates a discussion about shaping, reinforcement and extinction. The literature states that shaping is a procedure that results in the change of behaviour from one form to another by presenting reinforcement after responses which meet the successive approximations of the target response (Eckerman, et al. 1980; Novak & Pelaez, 2004; Weiten, 2004; Millenson & Leslie, 1979; Cooper et al., 1987). The current study and the distribution of the location of responses found during these experiments, confirm that shaping of response form has occurred. That is, responses made on one location shifted towards another location when reinforcement was presented following the fifth response made in the new location. Reinforcement however, is usually associated with stereotypic behaviour. Many studies have shown that when reinforcement is presented after a particular response form, all responses begin to hold the property that was reinforced, that is the variation of behaviour is reduced (Antonitis, 1951; Doughty & Lattal, 2001; Millenson & Leslie, 1979). On the other hand, extinction has been associated with an initial increase in response variability (Antonitis, 1951) by a decrease in response frequency (Millenson & Leslie, 1979; Cooper et

al., 1987). These principles would suggest that during shaping, reinforced responses (the target responses) would increase in frequency, while the non-target responses should decrease to a very low level as these responses are not receiving reinforcement and are therefore controlled by an extinction schedule.

Interestingly, the current study found that even though these two schedules (reinforcement and extinction) were simultaneously reinforcing correct responses and causing extinction of incorrect responses, the distribution of responses rarely narrowed to the expected stereotypic level. That is, a moderate level of variation remained throughout each condition.

The results from Experiment 2 showed that the location of responding resembled a normal curve centred over the criterion region for all hens in all but three conditions. For these remaining conditions, all hens responded in a way that had previously been described by Mechner (1994) as the 'Parameter Shift'. Mechner (1994) proposed that reinforcement does not cause strengthening of the most recent response, rather it strengthens the direction of change (in terms of a particular dimension) of the most recent response. In the current study, Mechner's (1994) concept would explain the response patterns seen in Condition 6, 7 and 11 where hens emitted more responses on the region following the criterion region. That is, during these conditions it would appear that responding was being shaped in terms of the direction of change of reinforced responses, rather than the actual location they occurred. Mechner's (1994) concept could also account for the apparent resistance to adapt to the new contingency seen in Condition 8, where the criterion region was relocated to the left of the previously active region, that is, the contingency required that the hens shifted the location of their pecks in the opposite direction than the previous seven conditions in order to receive

reinforcement. The change in distribution between the first and eighth session of this condition showed almost no shift towards the active region. This pattern observed could suggest that reinforcement had been reinforcing the direction of change, rather than the location of the response preceding reinforcement.

The change of step sized between conditions could also account for this pattern observed in Conditions 6, 7 and 11. Both Conditions 6 and 11 involved a smaller step size than the previous condition. For example, Condition 6 required that the hens move the location of their responses to the right by 30mm, whereas Condition 5 (the previous condition) required a shift of 60mm. Although this change in step size could account for the distribution of responses 'moving ahead' of the active region, this finding still supports Mechner's (1994) concept. That is, it appears as though the hens shifted the distribution of their pecks along the screen in the same distance as previously reinforced during Condition 5 resulting in the distribution of responses being centred on the region to the right of the active region, suggesting that reinforcement strengthened both the distance and the direction of responses.

This experiment demonstrates the continuity of behaviour by revealing the continuous distributions that result when a contingency is in place, therefore supporting Catania's (1973) hypothetical data.

General Discussion

As previously pointed out, the results of this study demonstrate the continuity of behaviour by showing the continuous response distributions that emerged when only responses between two limits were reinforced. This suggests that the first aspect of Catania's (1973) concept of the operant (his hypothetical figure of response distributions) is an accurate representation of response patterns when under the control of a reinforcement contingency. A second aspect of Catania's (1973) discussion looked at the division of responses into a class based on the manipulation of the response distributions due to a contingency. This second aspect will be discussed next.

Catania's (1973) suggestion to view a response class as a continuous distribution may give the impression that his concept of the response class does not actually distinguish any individual responses from any other responses, because of the flexibility of his approach. Catania's (1973) method of distinguishing between those members that make up a response class and all other responses is based on the observation of control or manipulation over responding resulting from the application of a reinforcement contingency. Therefore, all responses that were changed on some dimension, i.e., their location moved towards (not necessarily within) the limits set by the reinforcement criteria are members of one response class. Suggesting that responses made continuously on the furthest regions and are not changed, make up a second response class as they were not manipulated by the contingency. Catania (1973) stated that an effective method of assessing the manipulation of responses along the dimension is most easily calculated using correlations.

Catania (1973) discussed the possibility of dividing a larger response class (the whole distribution) into subclasses. Figure 32 shows the application of this idea using the response distribution of Hen 9.6 during Condition 4. This figure demonstrates the possible subclasses within the operant class. One could then calculate the correlations between the two subclasses 'A' and 'B' in order to determine whether the contingency is causing response topographies (and possibly their function) to change in terms of the current dimension.

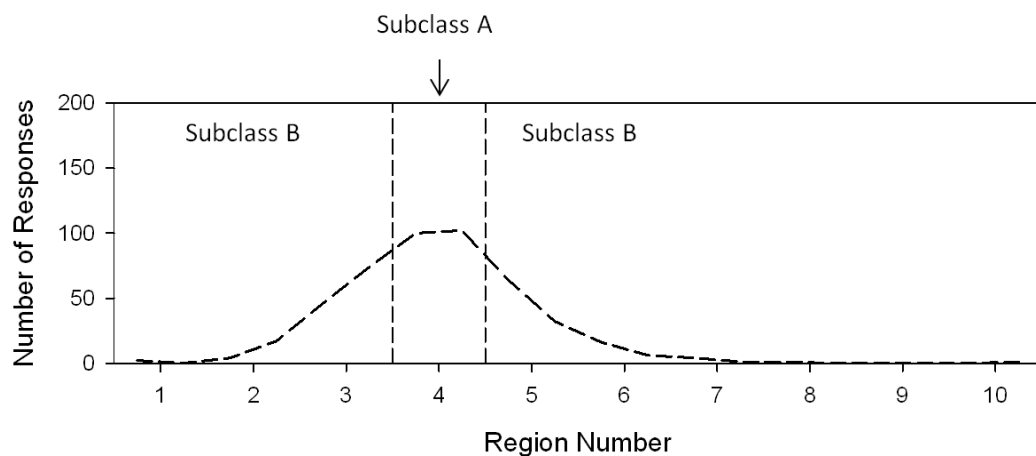


Figure 32. Catania's (1973) subclasses within a larger operant class.

This concept results in a new approach towards the division of responses into a class. That is, previously responses have been collated based on 'hard and fast' criterion, resulting in either a functional class containing only responses made between limits 'X' and 'Y' (e.g., Subclass A) or a topographical class containing responses of only a previously defined form. Catania's (1973) concept of the operant resolves several of the present difficulties of response classes discussed earlier by incorporating the continuity of behaviour. Although Catania's (1973) concept eventually results in the *division* of responses based on function, (e.g., Subclass A vs. Subclass B), his concept does not *exclude* responses based on

this criterion. Instead, Catania (1973) utilises both subclasses in order to analyse data.

This is particularly important when considering Skinner's (1938; 1953) principles such as induction. If we assume that induction takes place during an experiment, we are saying that those responses that are not meeting the specified reinforcement criteria are indirectly reinforced (Skinner, 1938; 1953). These responses that are indirectly reinforced are not functionally equivalent to those responses within a functional response class but are, in a way, being strengthened as if they were. That is, although reinforcement is provided only for those responses within the functional response class, both classes of responses are being strengthened (Schick, 1971). Therefore we cannot define a response class based on function alone. How can one divide these two types of responses into two separate classes when a reinforcement contingency is having similar effects on them?

This study acknowledges that the literature surrounding schedule induced response variability is inconsistent. Therefore, the findings of this study could be supported by the replication of the current method with the application of an FR 1 schedule in order to determine whether or not the large amount of response variability in the current study was induced by the use of an FR 5 schedule. This however, could make the analysis of response distributions difficult as fewer responses would be made within a session resulting in a smaller array of responses.

Another limitation to the results of this study is the inability of the equipment to separate valid pecks on the screen from responses which, due to

their topography result in many responses being made simultaneously on different regions on the screen. Hen 9.5 was found to be emitting responses other than pecks that were being detected and were causing very higher numbers of incorrect responses. Future studies could carry out more shaping sessions, and could ensure that hens had prior experience of receiving reinforcement for pecks on all regions, this may prevent new responses being learnt when extinction was in effect for pecks on the previously reinforced. Interestingly, although the topography of responding for this hen resulted in lower proportions of correct responses, responding was still shaped to the active regions of the screen shown by the response distributions in Figure 49 in Appendix A. Therefore the data for this hen was able to be incorporated within the results of this study.

In order to further support Catania's (1973) hypothetical data, future research could explore response distributions on other dimensions such as force, duration, rate, topography etc. Further research replicating the method of Condition 12 where the active region was visible would also support Catania's (1973) concept.

This study suggests that it is important to consider the continuity of behaviour when analysing behaviour, this would be particularly important for applied behaviour analysis in cases where the effects of reinforcement are to be analysed or where reinforcement schedules are to be applied. That is, the results from the current study support theories that discuss the broader effects of reinforcement (e.g., Skinner's (1938; 1953) induction and Catania's (1971) discussion on the role of preceding response). These theories do not necessarily only apply to experimental analysis, as behaviours in the applied setting will most likely be affected by reinforcement in the same way as observed in the current

study. Referral behaviours, as well as appropriate behaviours will likely have common properties with other, non-target behaviours, suggesting that the application of reinforcement should be carefully considered so as to minimise indirect reinforcement of non-target behaviours. Herrick (1964) discussed resistant to extinction due to previous reinforcement history. This is a significant point when considering the applied setting as problem behaviours have previously been subject to reinforcement schedules as behaviour comes to be a part of one's repertoire through reinforcement (Pipkin & Vollmer, 2009). Therefore in applied settings, the use of shaping, reinforcement and extinction are required to induce change, and would most likely need to overcome the effects of one's previous reinforcement history (Pipkin & Vollmer, 2009).

This study demonstrated the continuity of behaviour by exploring response distributions when a reinforcement contingency is applied. The findings are important to future research as they contradict basic behavioural principles such as reinforcement, shaping, and extinction, and create awareness of the processes (e.g., induction) that emphasise the continuous characteristic of behaviour. This thesis concludes that there is sufficient evidence to stimulate discussions around a different approach to the concept of the operant. That is, when carrying out empirical analysis it may be appropriate to consider Catania's (1973) concept in order to prevent the division of responding into 'hard and fast' units, as Skinner (1953) pointed out; organisms' behaviour will not always conform to such rigid boundaries.

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Appendix A.

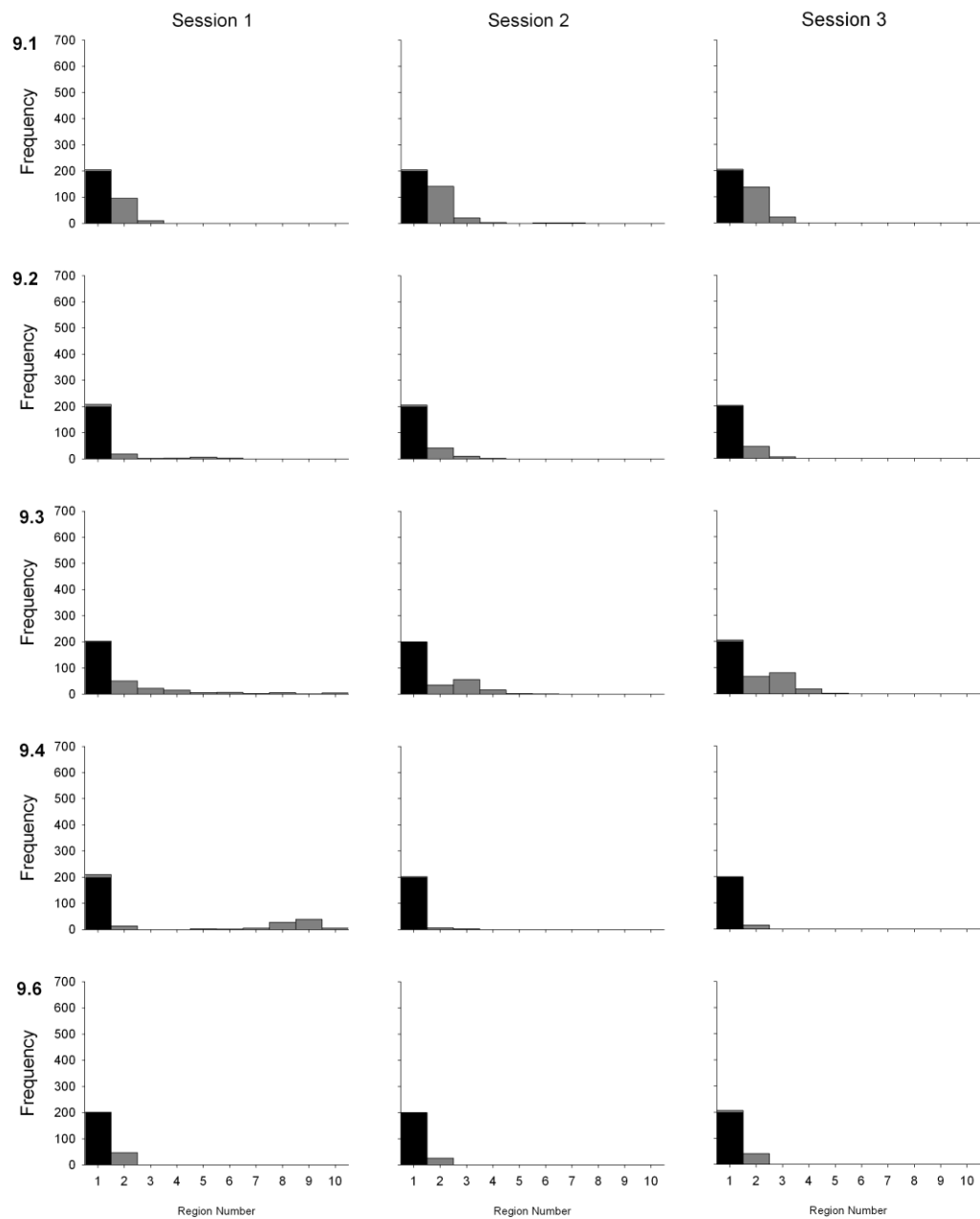


Figure 33. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 1 of Experiment 2. During this condition, Region 1 was the active region.

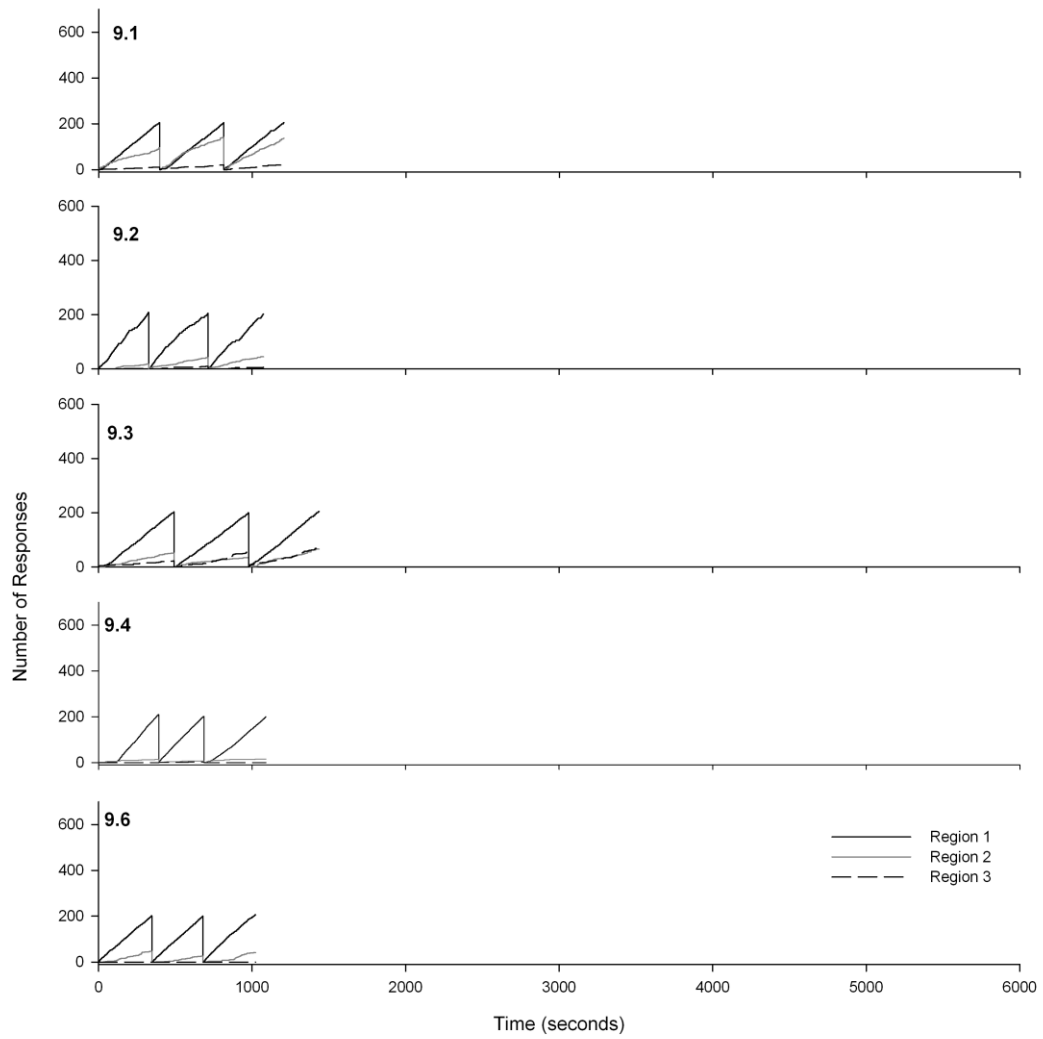


Figure 34. The response rate on the active region (1), the next region to be active (2) and the adjacent region (3) for all hens during Condition 1 of Experiment 2.

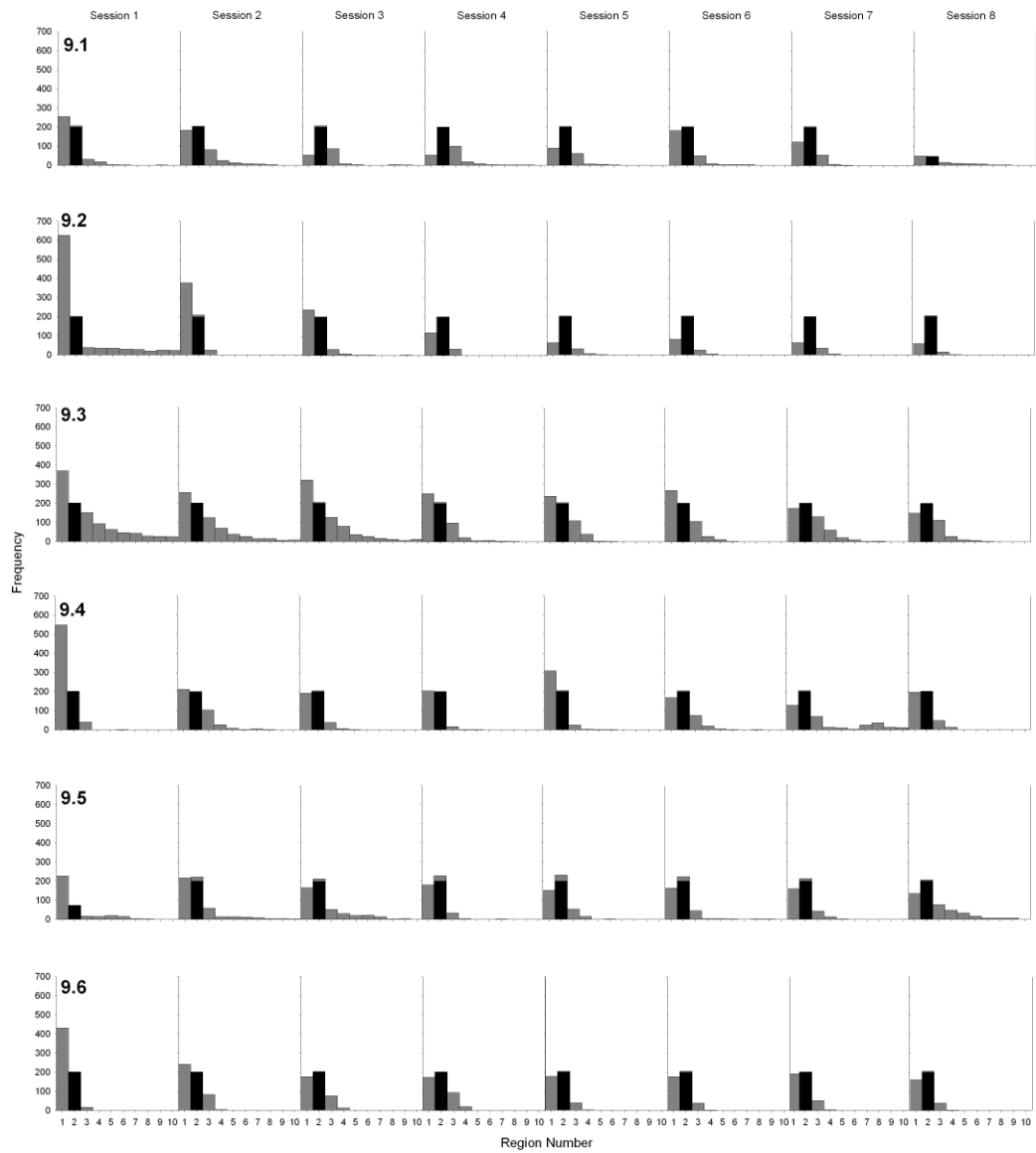


Figure 35. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 2 of Experiment 2. During this condition, Region 2 was the active region.

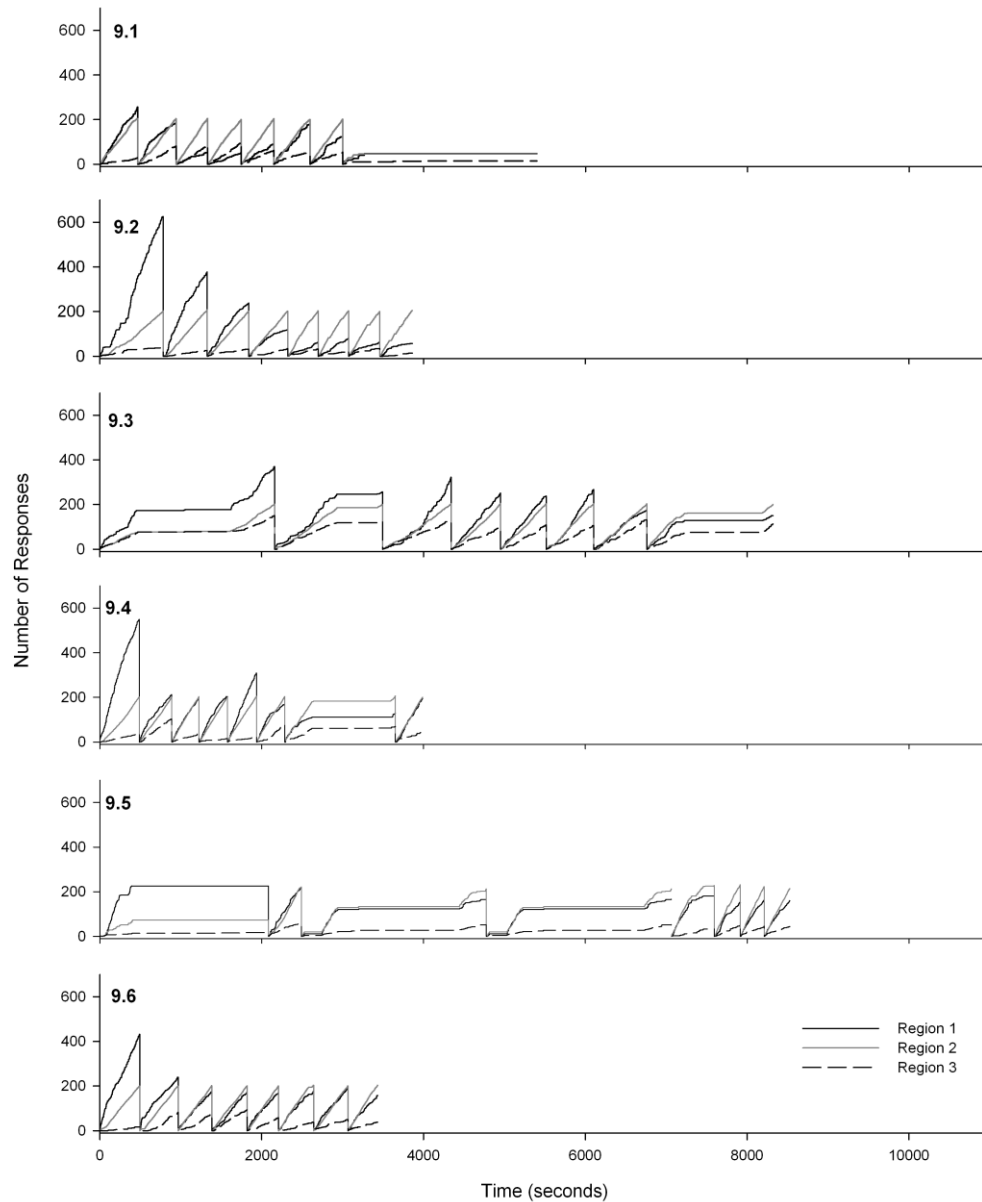


Figure 36. The response rate on the active region (2), the previously active region (1) and the next region to be active (3) for all hens during Condition 2 of Experiment 2.

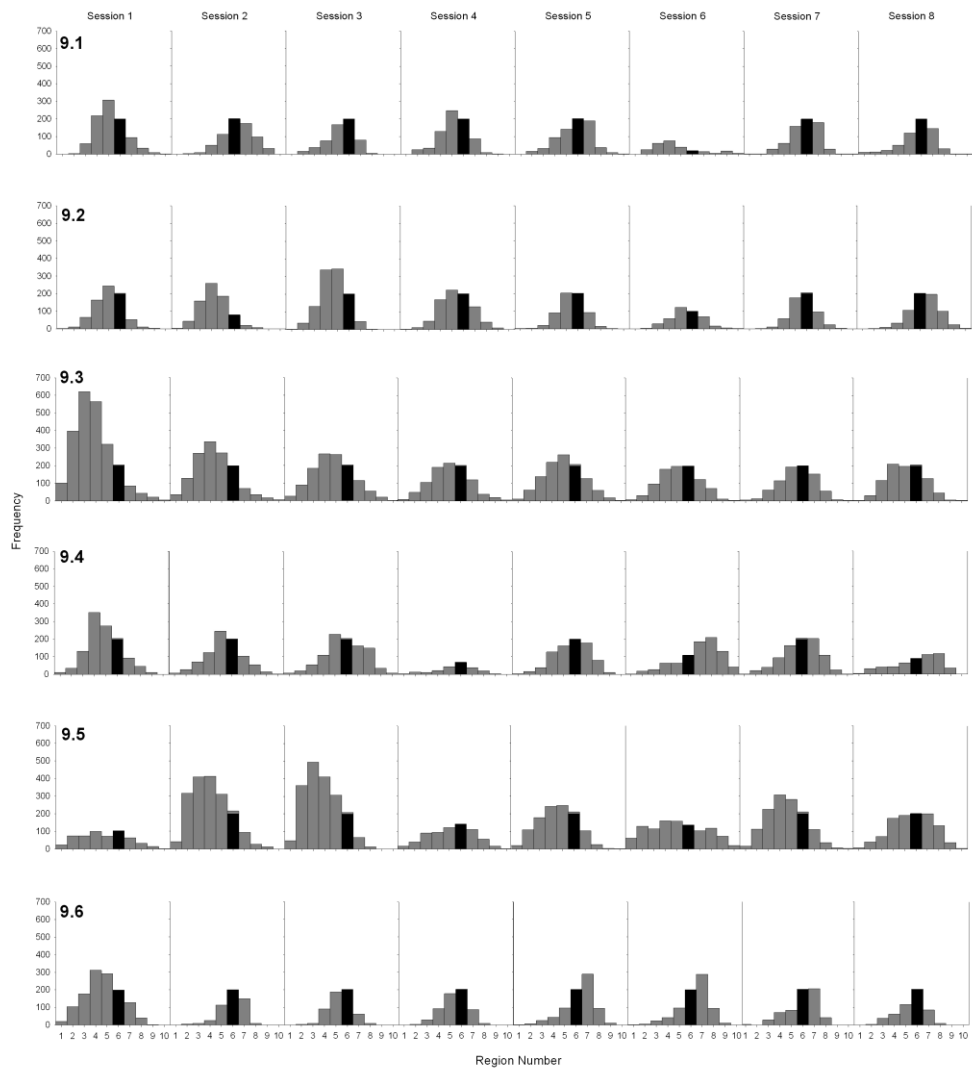


Figure 37. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 5 of Experiment 2. During this condition, Region 6 was the active region.

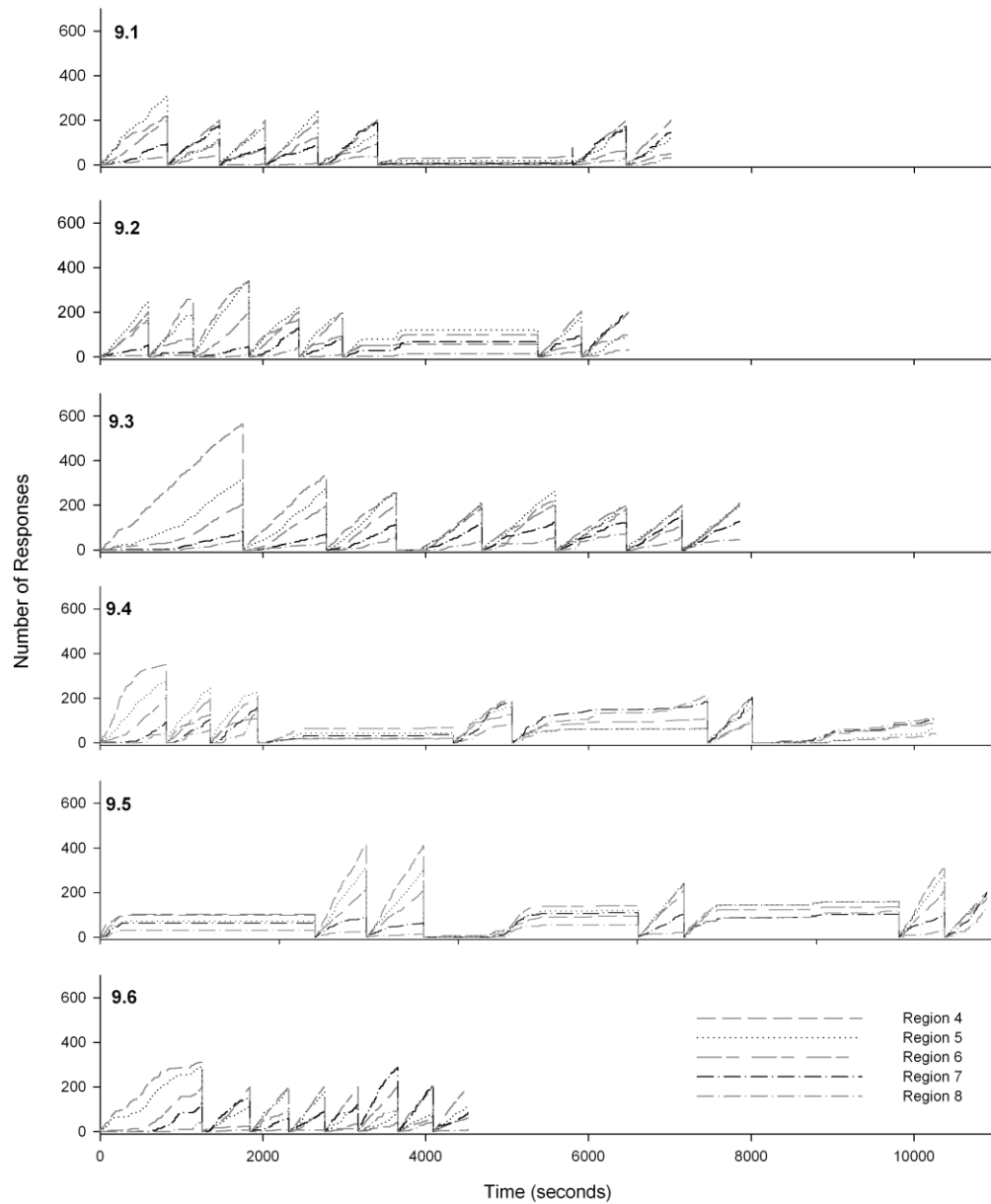


Figure 38. The response rate on the active region (6), the previously active region (4) and the next region to be active (8) for all hens during Condition 5 of Experiment 2.

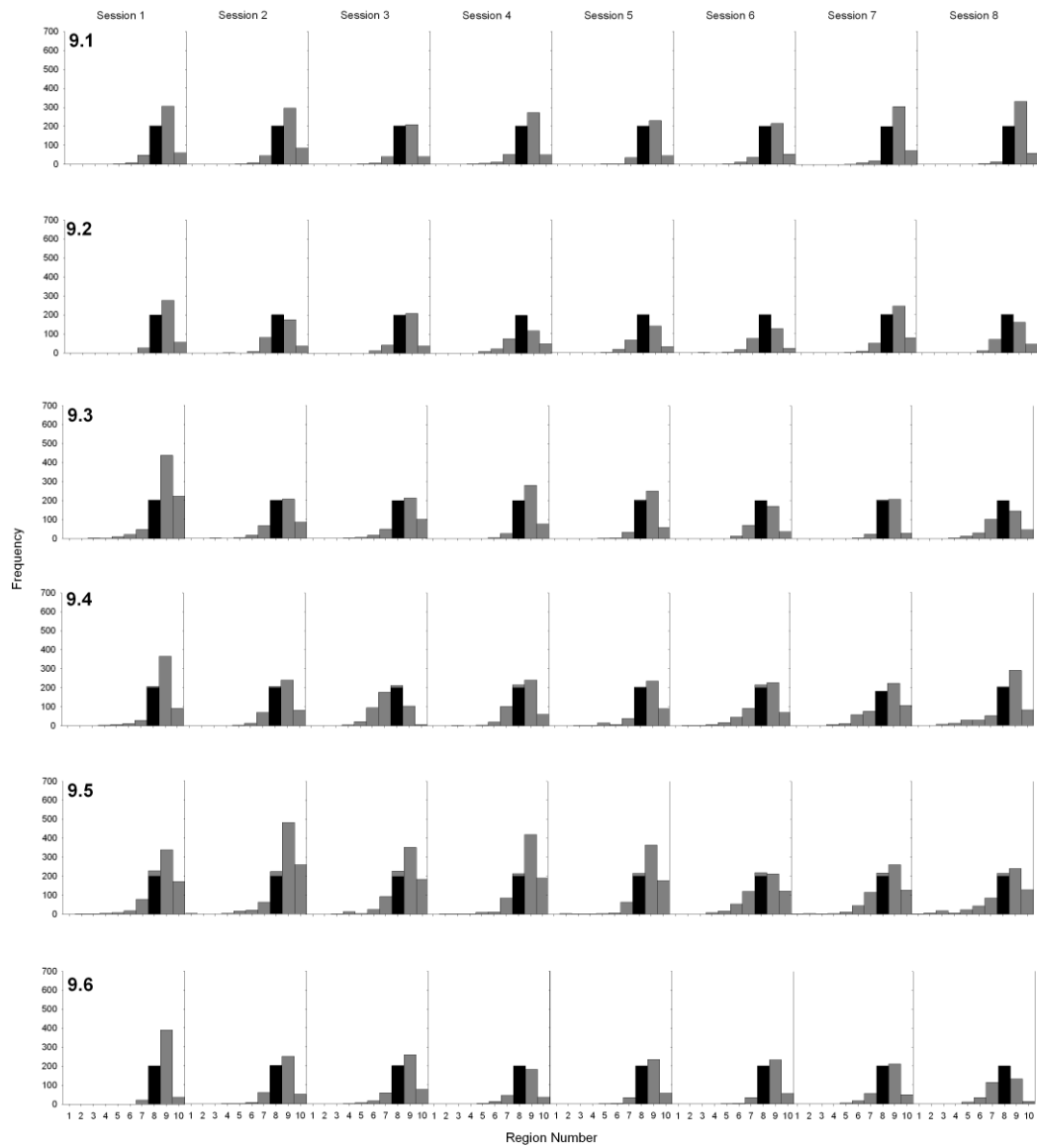


Figure 39. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 8 of Experiment 2. During this condition, Region 8 was the active region.

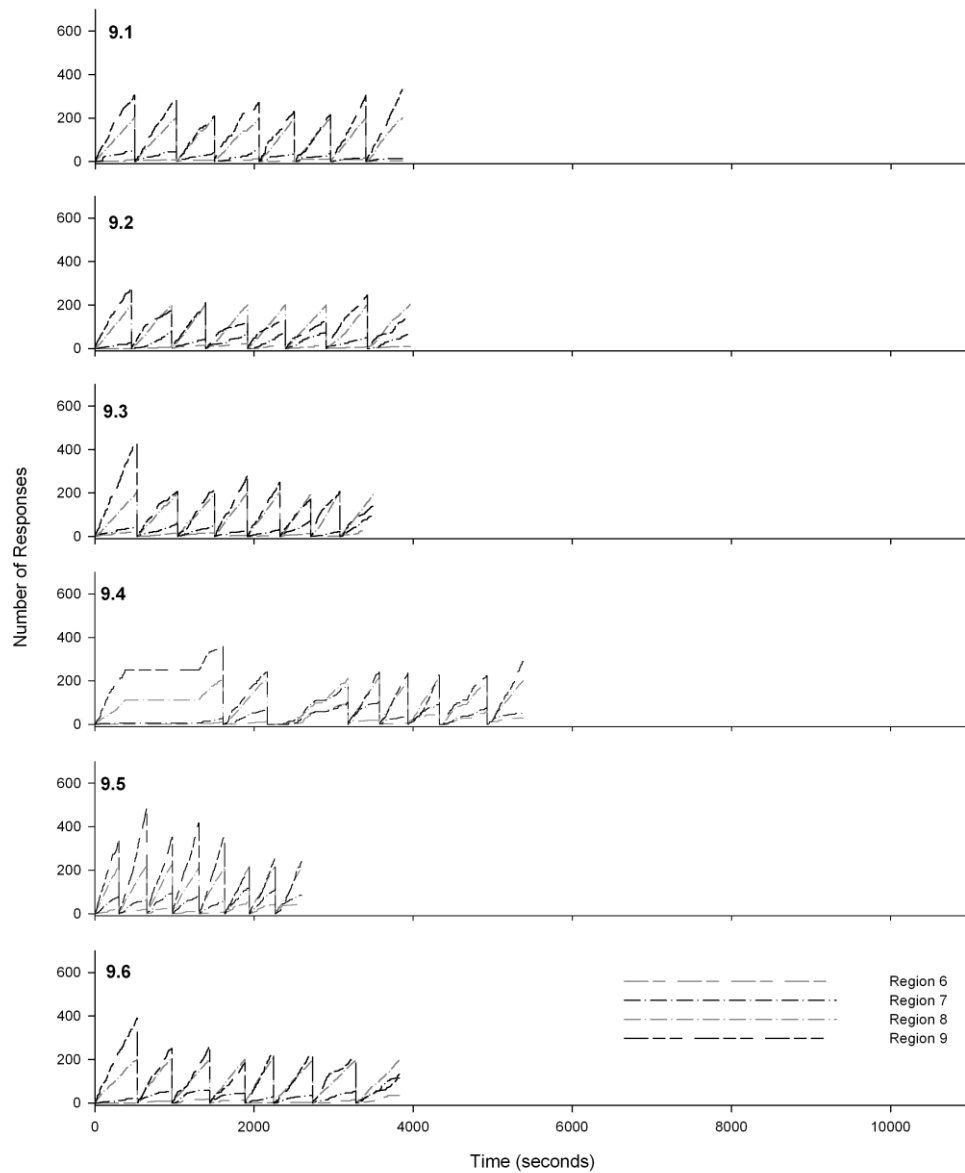


Figure 40. The response rate on the active region (8), the previously active region (9) and the next region to be active (6) for all hens during Condition 8 of Experiment 2.

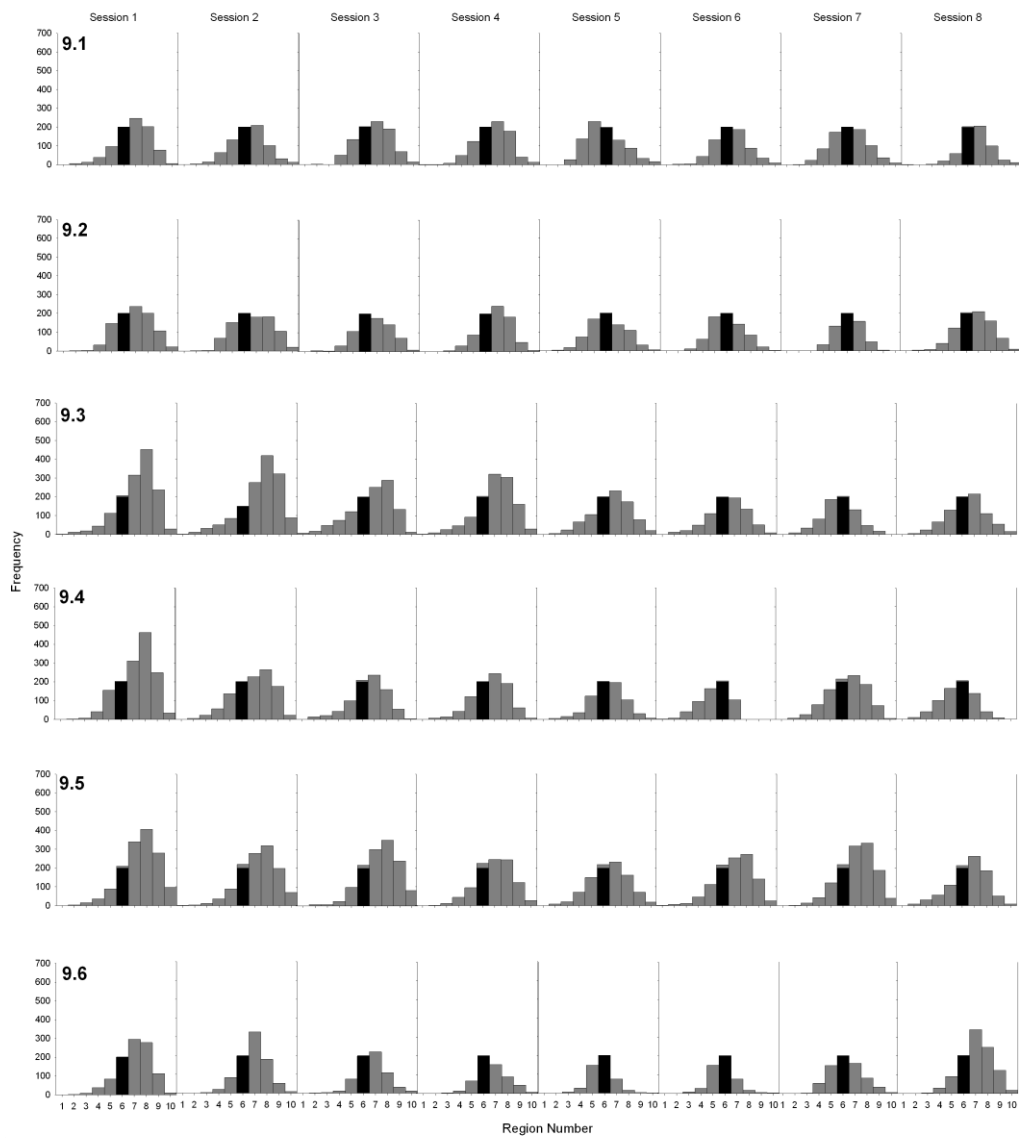


Figure 41. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 9 of Experiment 2. During this condition, Region 6 was the active region.

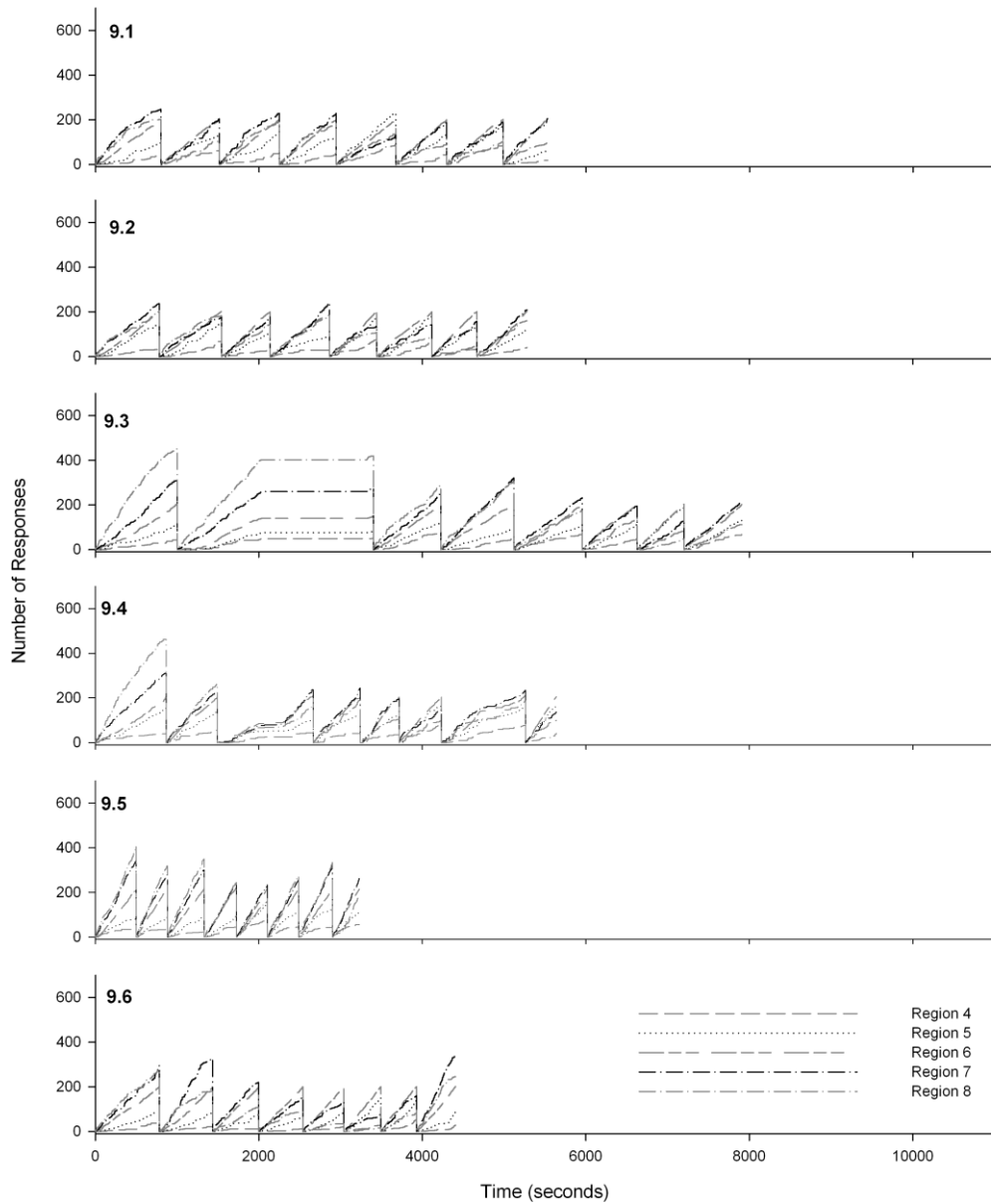


Figure 42. The response rate on the active region (6), the previously active region (8) and the next to be active region (4) for all hens during Condition 9 of Experiment 2.

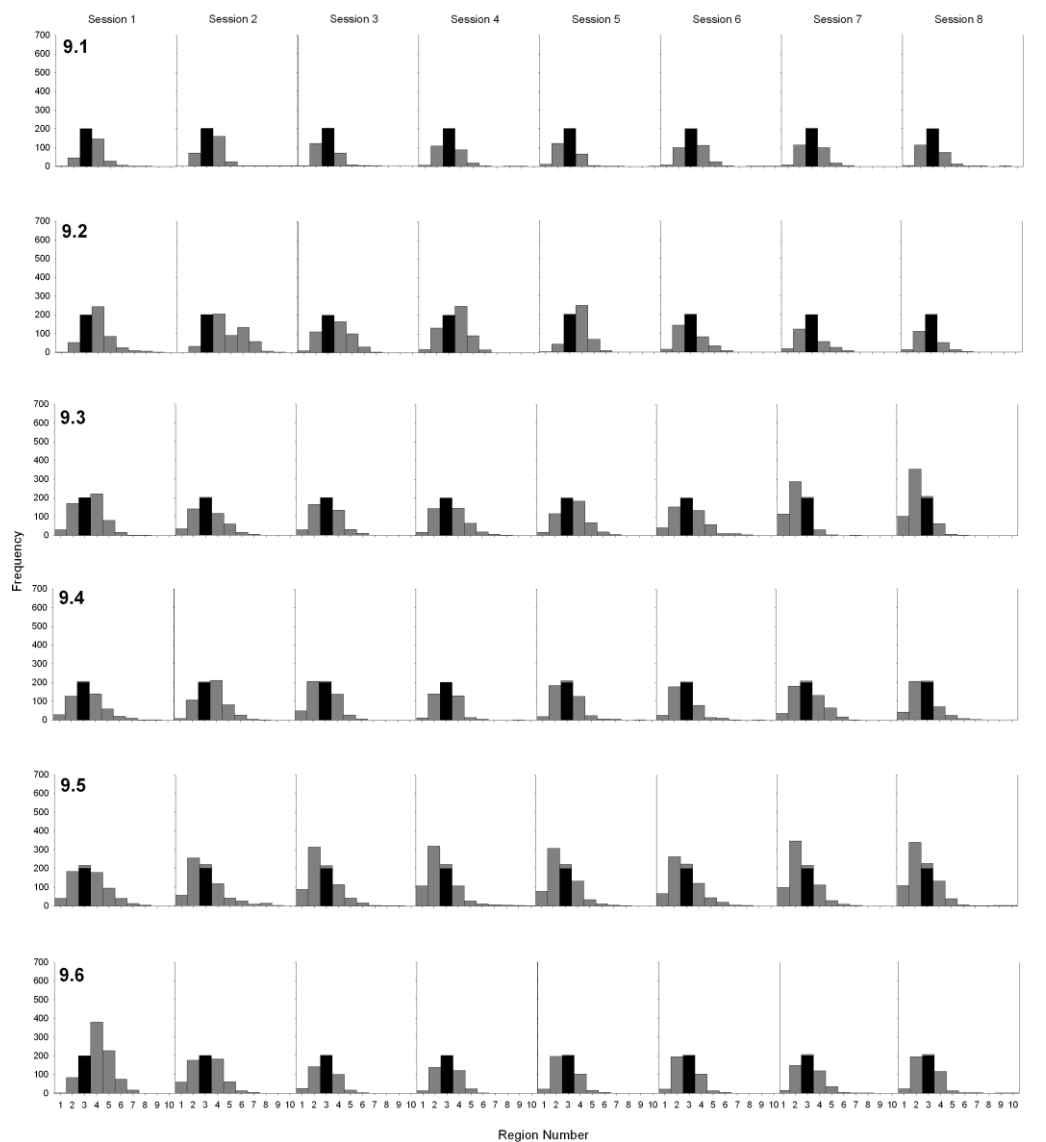


Figure 43. The frequency of pecks on each of the ten regions for Sessions 1 through 8 for all hens during Condition 11 of Experiment 2. During this condition, Region 3 was the active region.

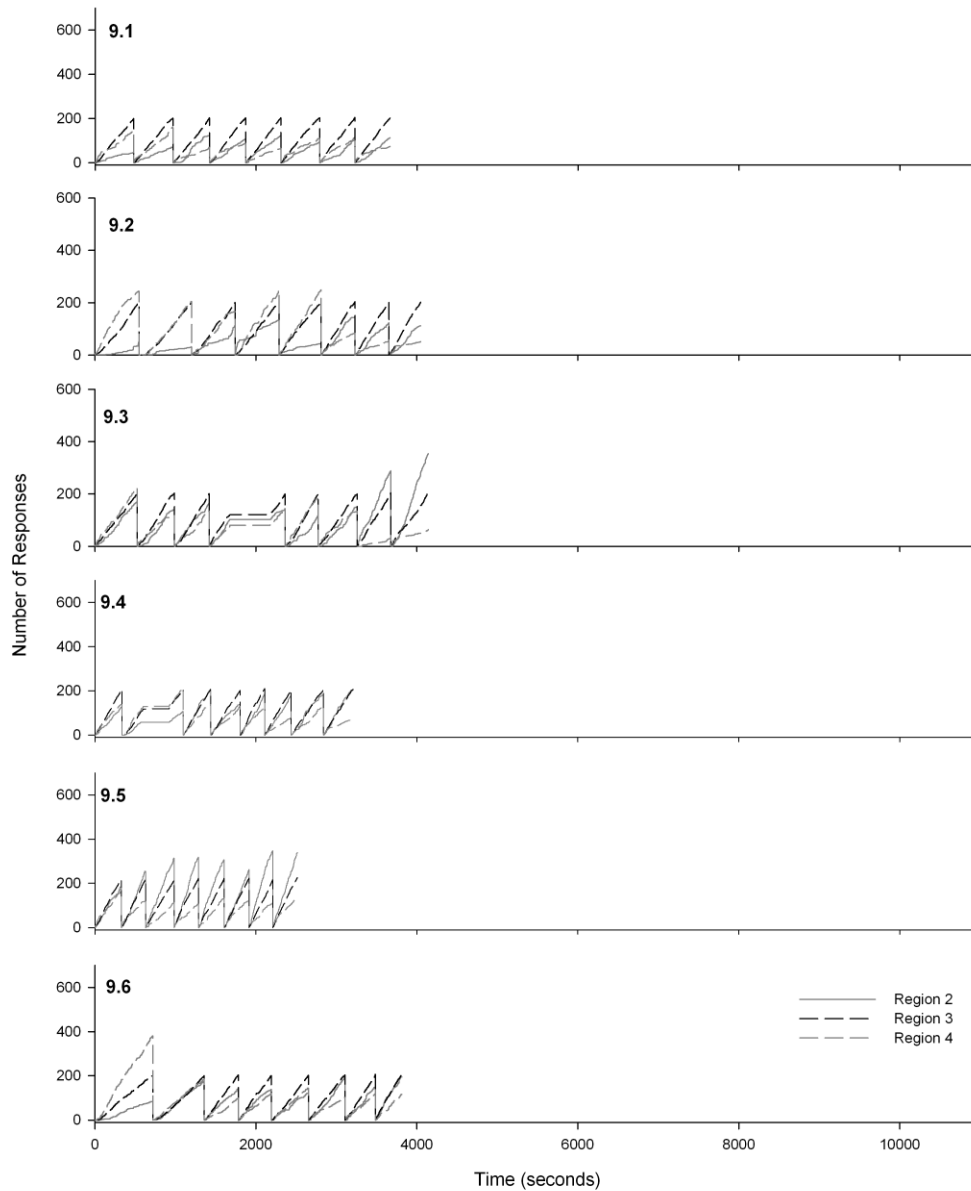


Figure 44. The response rate on the active region (3), the previously reinforced region (4) and the adjacent region (2) for all hens during Condition 11 of Experiment 2.

Hen 9.1

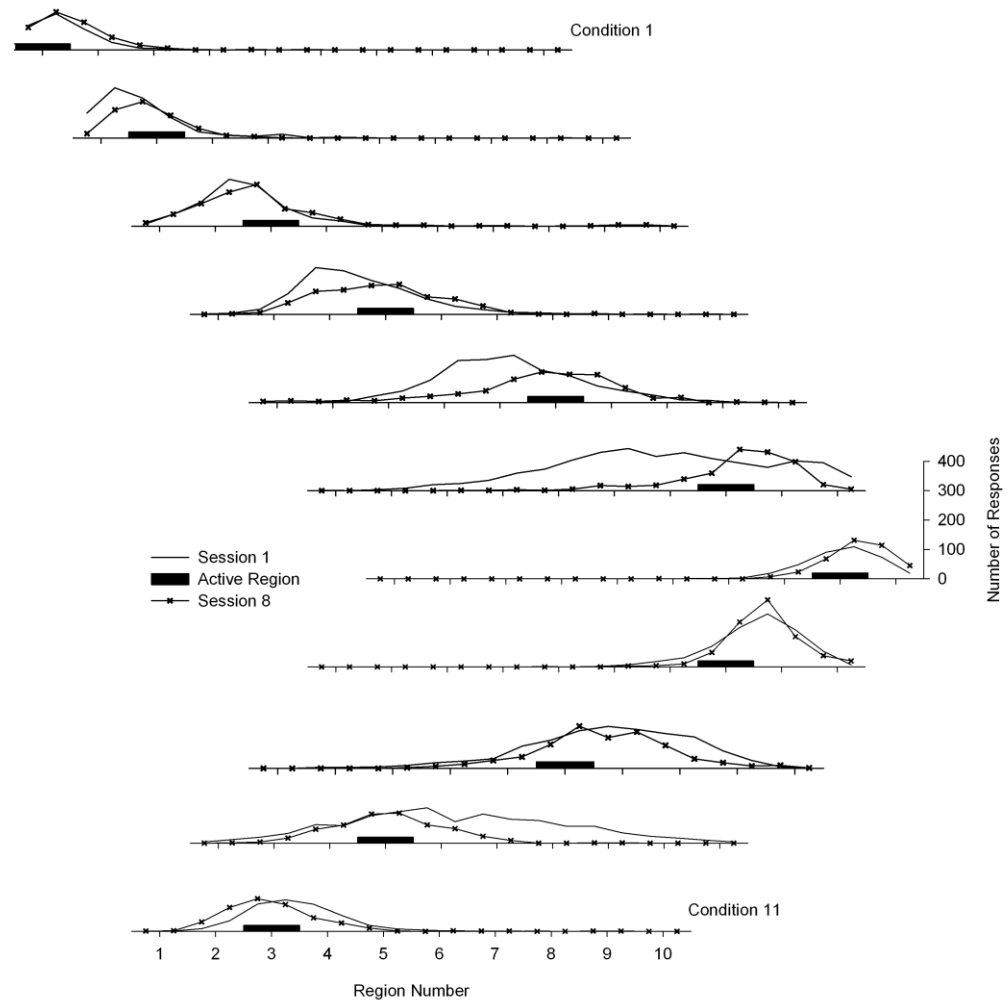


Figure 45. The distribution of responses for the first session to the last session of the condition for Conditions 1 through 11 for Hen 9.1.

Hen 9.2

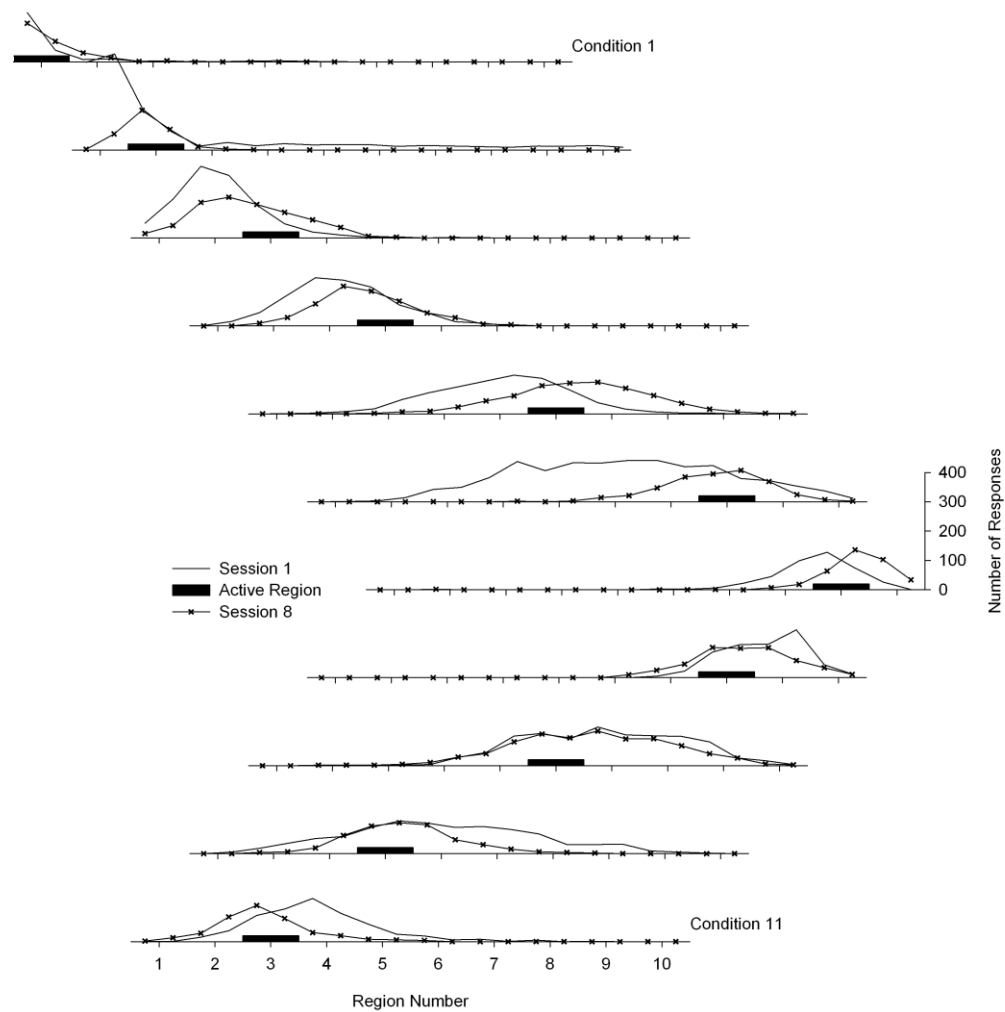


Figure 46. The distribution of responses of the first session to the last session of the condition for Conditions 1 through 11 for Hen 9.2.

Hen 9.3

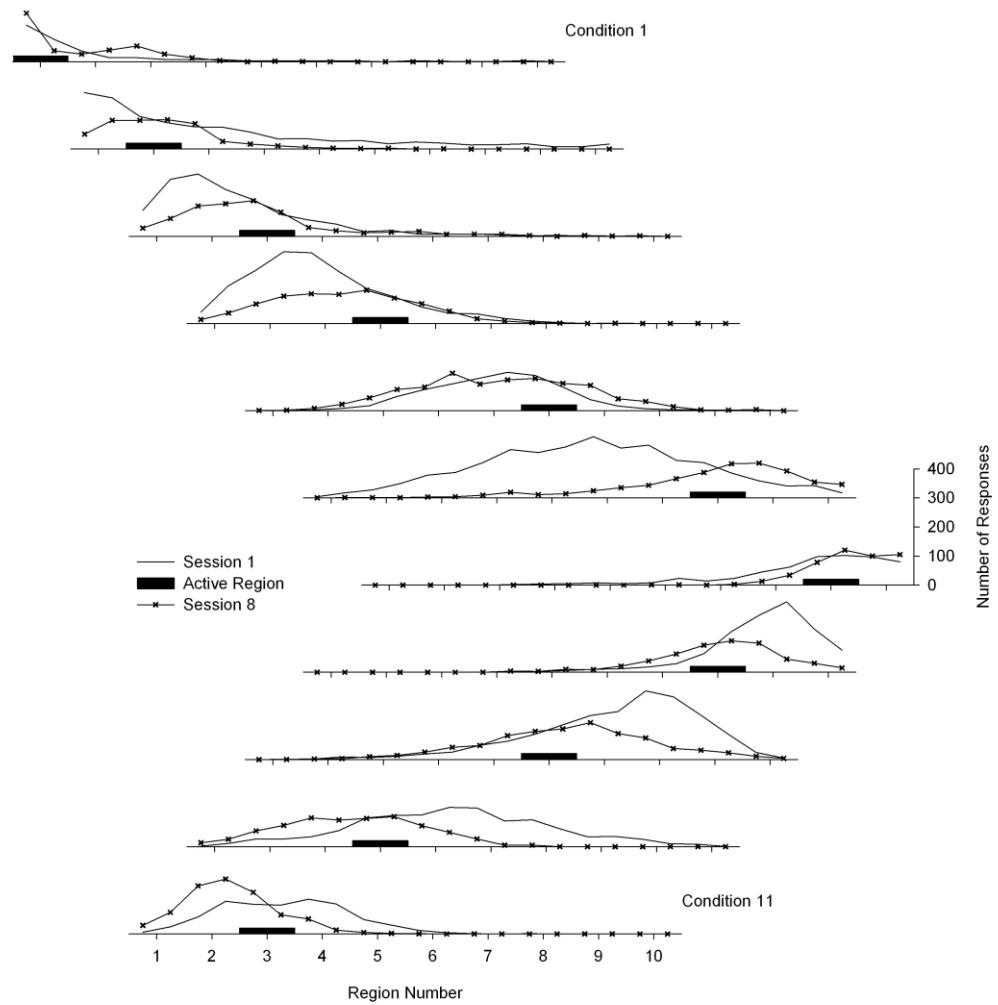


Figure 47. The distribution of responses for the first session to the last session of the condition for Conditions 1 through 11 for Hen 9.3.

Hen 9.4

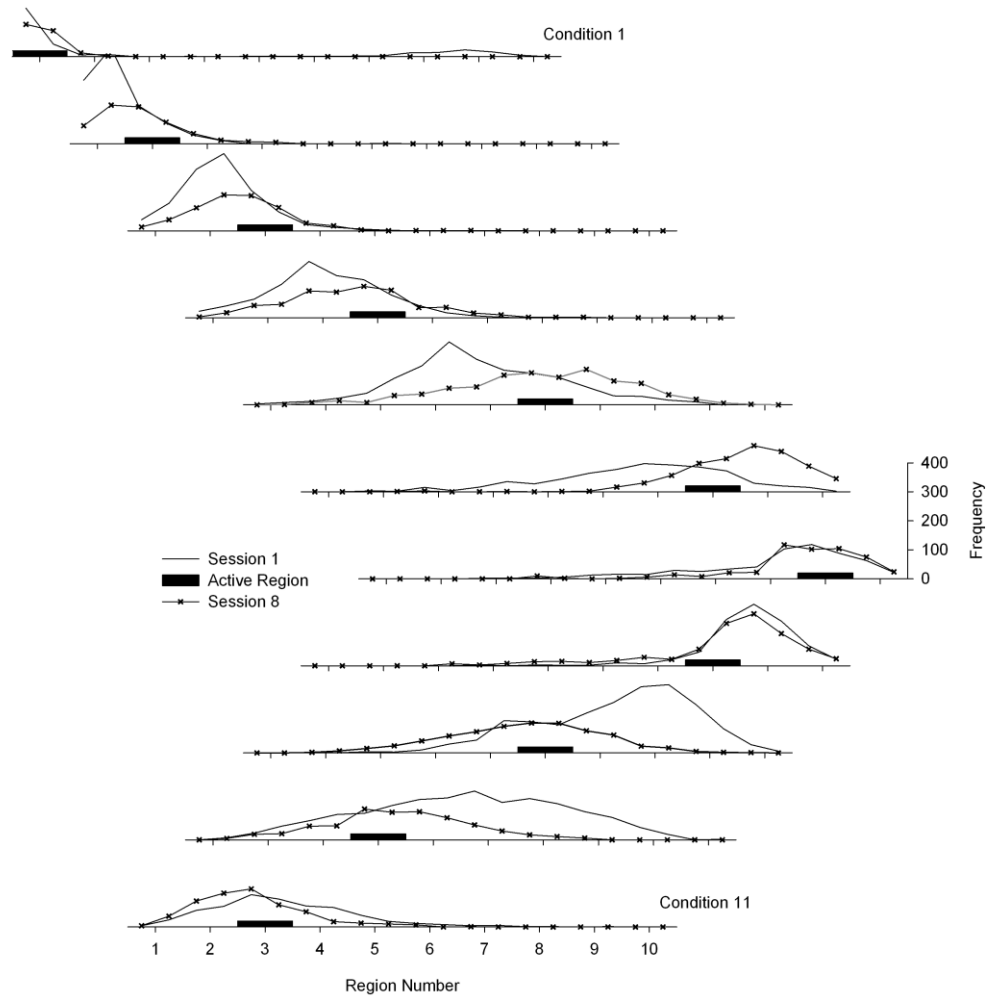


Figure 48. The distribution of responses for the first session to the last session of the condition for Conditions 1 through 11 for Hen 9.4.

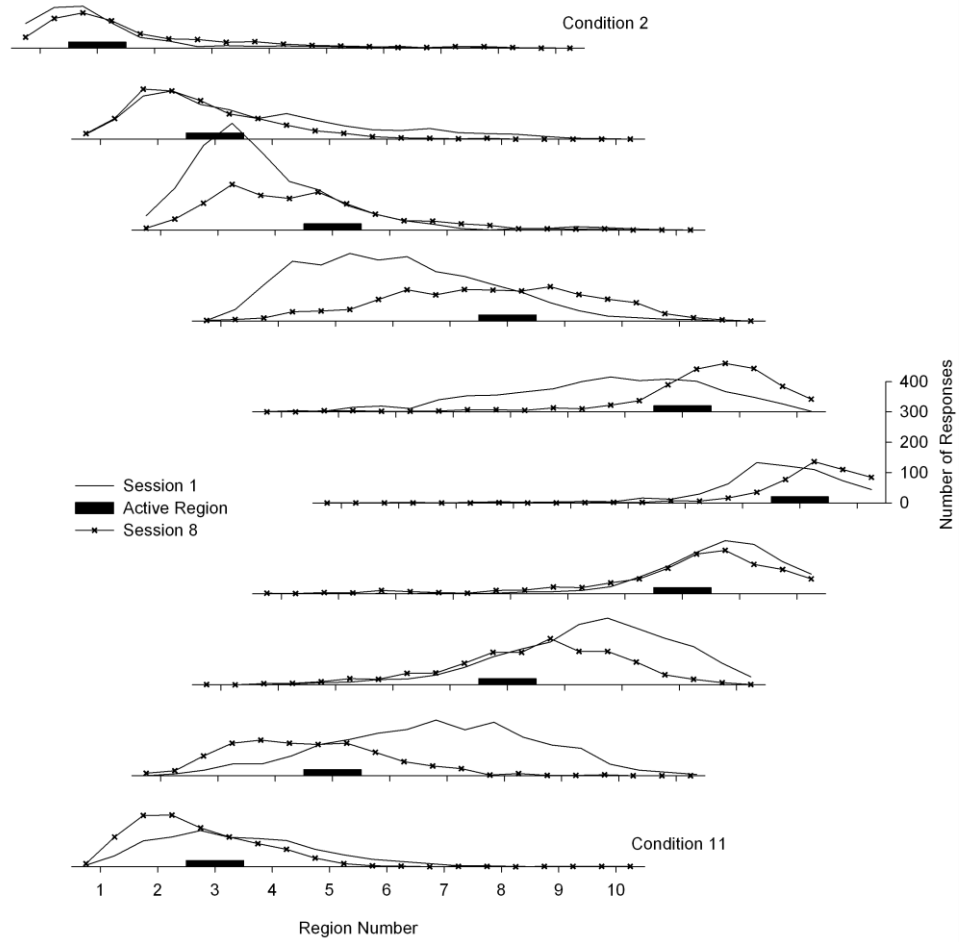


Figure 49. The distribution of responses for the first session to the last session of the condition for Conditions 1 through 11 for Hen 9.5.

Appendix B

Please find attached CD containing data files from the current study.