An investigation into the persistence-strengthening effects of differential reinforcement of alternative (DRA) behaviour.

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KAREN LORRAINE LAYTON

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Abstract

Ten experiments used hens to investigate the effects of different disruptive events and ways of introducing differential reinforcement of alternative behaviour (DRA), on the persistence of responding. Of interest was the persistence-strengthening effects of DRA on the target, or problem, behaviour, and whether this could be reduced by training an alternative behaviour in a *separate* context to that of the target behaviour. A DRA was compared to the effects of a procedure where the alternative and target behaviours were trained in the *same* context (traditional DRA). The different behaviours were pecking at different coloured keys, and responding was maintained by food reinforcement.

Baseline training involved a three-component multiple schedule; one component with two yellow keys available (DRA analogue using VI 37.5 s and 150 s) and the other two with one key available in each (analogous to target (blue and VI 150 s) and alternative (green and VI 37.5 s) behaviours trained separately). A disruptor test followed, also using three-component multiple schedules. This disruptor test included a component with the two yellow keys (Concurrent/DRA Component) and one which combined the, previously single, green and blue keys (Combined Component). In each experiment, the sequence of baseline followed by a disruptor test was repeated with different components in each test. Persistence was measured as the responses in the test as a proportion of baseline responses for that behaviour.

In Experiment 1 the disruptor was extinction and this showed that separate training reduced persistence of the target behaviour and extinction burst, as in previous research. Experiments 2 and 3 used the same procedures but the hens were exposed to a centre key alone (associated with one of VI 150 s (red centre key), 75 s (white centre key) or 37.5 s (pink centre key) schedule) prior to each baseline and this centre key then acted as the disruptor. Reinforcement was available on all keys in the tests. These found that the red key worked as a disruptor, and there were similar effects on persistence as in Experiment 1, regardless of the red key schedule. Experiment 4, using the same procedures but with no formal disruptor, also found the separate training gave reduced persistence of the target but not the alternative behaviour in the tests. Experiment 5 to 7 examined different disruptors (flashing light, sound, and a separate chamber), all with reinforcement continuing in tests. Target response persistence was reduced as a result of the separate training. Experiment 8 compared the effects on target persistence of separate training with the training schedule thinned prior combining and after combining. This found there was reduced target behaviour persistence when the schedules were thinned prior to being combined. Experiment 9 added a baseline with the target behaviour alone, prior to the previous procedure, and showed the same reduced target persistence even when both the target keys were initially presented alone. Experiment 10 showed the results were robust when each component was associated with a physically separate context. All experiments showed that training a target behaviour in a separate context to the alternative behaviour was successful at reducing the persistence-strengthening effects of DRA.

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Chapter 1: Introduction

Differential reinforcement procedures are frequently used in behaviour change programs (Cooper, Heron, & Heward, 2007; Vollmer & Iwata, 1992). One frequently used means of decreasing a problem behaviour is to differentially reinforce an alternative behaviour (Athens & Vollmer, 2010; Petscher, Rey, & Bailey, 2009). In *differential reinforcement of an alternative behaviour* (DRA) procedures, reinforcers are delivered for an alternative, desirable behaviour, while, when possible, reinforcers for the problem behaviour are withheld (Petscher et al., 2009; Vollmer & Iwata, 1992; Vollmer, Roane, Ringdahl, & Marcus, 1999). DRA has been found to reliably reduce the frequency of a broad range of problem behaviours (Petscher et al., 2009; St. Peter Pipkin, Vollmer, & Sloman, 2010).

Despite the success of DRA-based interventions, they may have some undesired side effects. Whilst some of these may be the result of treatment integrity failures (see St. Peter Pipkin et al. (2010) and Vollmer et al. (1999) for explanation), there is also significant evidence to suggest that, while DRA is effective in reducing problem behaviour, it can also increase that behaviour's resistance to disruption (i.e., persistence) (Mace et al., 2009; Mace et al., 2010; Nevin, Tota, Torquato, & Shull, 1990).

As outlined by Mace et al. (2009) increased persistence is a result of increases in the amount of reinforcement resulting from the addition of the reinforcers provided under the DRA. Such increases in reinforcers can, as suggested by behavioural momentum theory (Nevin, 1974), increase the persistence of all responses in the environment. While response persistence can be beneficial for desirable behaviours that are increasing in frequency, it is far from ideal for a problem behaviour (Nevin, 1974).

Pittenger (2002) defined persistence of problem behaviour as the “extent to which an individual pursued reinforcement that is no longer available” (p. 237). This definition assumes that the reinforcement maintaining the problem behaviour has been withheld during the treatment process (such as in an optimally implemented DRA procedure, e.g., Vollmer et al. (1999)). However, the assumption that the reinforcer maintaining the problem behaviour has been withheld does not always hold true. Additionally, it is not clear how ‘extent’ should be measured.

Podlesnik, Bai, and Elliffe (2012) and Podlesnik and Kelley (2015) define response persistence as the resistance of operant responding to disruption and suggest those responses that decrease less, relative to pre-disruption levels, are more resistant to change. Once again, this definition relies on the assumption that some form of disruption has been applied in the context in which the behaviour occurs. What constitutes a disruptor will be discussed later, but could be a change in conditions, such as a change in contingencies (e.g., the introduction of extinction, additional reinforcement (Podlesnik & Kelley, 2015)), or a change in the context (e.g., the addition of a novel sound or event). Avoiding the use of the word disruption, Nevin (1996) defines persistence as behaviour that continues after the intervention process ends. This acknowledges that regardless of the intervention used, or of any disruptor added during that intervention, behaviour is continuing. Additionally, when persistence of behaviour is discussed in the literature and elsewhere, there is usually mention of a problem behaviour;

suggesting that the behaviour that is persisting is actually detrimental, and that an intervention is required to change it.

Although it may often be the case that persistent behaviour may need to be reduced to avoid detrimental effects, the persistence of a behaviour is neither categorically good or bad (Craig, Nevin, & Odum, 2014). There are many occasions where it may be desirable for a behaviour to persist in the face of disruption, such as with skills that are taught and maintained by the use of reinforcers, and any definition of persistence should acknowledge this. Evaluating the conditions that both promote and decrease the persistence of behaviour seems to be important to further the understanding of how problematic behaviour can be reduced and behaviours that are desirable increased.

Whilst disruption in both experimental and applied contexts maybe possible, and essential to investigate continuing occurrences of behaviour in a controlled manner, there are circumstances where behaviour may persist even when no additional disrupting stimulus has been applied (Podlesnik & DeLeon, 2015). A definition of persistence that considers continuation of both prosocial and problem behaviour that persists both with and without disruption might be more useful to understanding what is meant by the term persistence. Due to the many different definitions of persistence, from here on persistence will refer to the continuation of behaviour, or change in responding, relative to the baseline levels. This allows for disruptors to be applied and for the responding that happens after the disruptor to be compared to the levels of responding during baseline. First a disruptor is introduced, and then persistence is assessed by the responding in the presence of that disruptor, taken as a proportion of the level of responding during baseline to assess.

There are several well-examined theories as to why a problem behaviour might continue or return after a successful intervention to remove it, one of which originates from basic research around behavioural momentum. Outlined by Nevin (1974), *behavioural momentum theory* (BMT) is a framework used to understand how training conditions impact response rate and persistence after the conditions in which the behaviour is occurring are altered (Nevin, 1996). It aims to understand how the responses and stimuli, or environmental conditions, associated with particular reinforcers impact response rate and persistence (Craig et al., 2014; Podlesnik & DeLeon, 2015).

BMT is based on a metaphor of Newton's Second Law, in which velocity is the effect reinforcement has on a behaviour (response rate), mass is the extent to which behaviour continues, or how persistent it is under conditions of disruption (resistance to change), and force is the external disruptor applied. The change of the response rates depends on the impact of the disruption, and is directly related to the reinforcement rate that was maintaining the behaviour prior to the disruptor being applied. This is expressed quantitatively by Nevin (2015), as show in Equation 1.

$$\Delta B = \frac{-\mathrm{x}}{m} \tag{1}$$

The data are usually presented in log form, and as proportion of baseline to allow accurate comparison of different baseline conditions after disruption has been applied (Craig et al., 2014; Nevin & Shahan, 2011) (for example two components of a multiple component schedule, or two different individuals). Persistence of behaviour is often examined, first, by establishing a baseline of responding, and then introducing some form of disruption. The change in response rate relative to baseline rate is assessed. If response decreases less, relative to its baseline rate, than another response, it is said to be more persistent (or resistant to change) than the other response. Greater persistence of responding is generally found for the response associated with the richer option of two reinforcement schedules in baseline, rather than the leaner option (Craig et al., 2014; Nevin, 1974; Nevin, 2015). Persistence has been shown to increase regardless of whether the reinforcement is contingent on the alternative behaviour, or is just presented in the environmental context in which the target behaviour is occurring (Nevin & Grace, 2000; Nevin & Shahan, 2011; Nevin et al., 1990). It is this finding particularly that raises concern for interventions that rely on adding reinforcement to a context, such as DRA, and other interventions (i.e., DRO, NCR etc.),

An increase in persistence may occur even if response rates reduce, as response rates and persistence are considered two independent measures (Craig et al., 2014). Not only are they considered two separate measures, but one of the fundamental assumptions of BMT is the notion that response rate and response persistence are maintained by two separable parts of the three-term-contingency (Craig et al., 2014). Firstly, the relationship between the stimuli in an environment and the associated reinforcement received in that environment governs resistance to change, or persistence, determined by Pavlovian stimulus-reinforcer relations (Bai, Chan, Elliffe, & Podlesnik, 2016). Secondly, response rates are maintained by the association between the response and its reinforcer, determined by the operant response-reinforcer relationship (Bai et al., 2016).

As previously mentioned, various disruptors are used in the experimental procedures that examine the persistence of a behaviour either in the presence of a disruptor, or after the disruptor has been applied. The different types of disruptors will be discussed in more detail later, but for clarification, disruptors will be referred to, here, as something that interferes with or adjusts the relationship between the response and the reinforcer as determined by the experimental procedure.

Disruptors can be categorised according to changes they may have caused to the organism (such as by pre-feeding), or whether they have changed the baseline contingencies under which the original behaviour was learned (such as by extinction) (Craig et al., 2014). Disruptors such as pre-feeding or extinction will change how motivated an organism is to work for food, whereas extinction or adding another stimulus to an operant chamber, will change the contingencies associated with that behaviour. The current studies examined different disruptors, but in all cases the criteria for selecting the disruptors was that they could be applied equally for comparison purposes to all components of the procedure, including within sessions and between subjects (Nevin & Grace, 2000).

Unwanted behaviour that persists has been of interest to clinicians and researchers for some time. Behaviour that returns after a treatment or intervention, otherwise known as *treatment relapse,* can have detrimental effects on the individual and those around them (Mace & Nevin, 2017). This is especially so, if the behaviour that relapses is violent or harmful, such as aggressive behaviour in the classroom, or drug use. On a larger scale, the cost of these types of relapses to society are overwhelming, so there is justification for determining what factors contribute to relapse and what can be done to reduce them.

Treatment relapse is defined in behaviour analysis as the return of a behaviour that was previously treated (eliminated) successfully, or a reduction in progress of treatment, once treatment conditions change (Pritchard, Hoerger, & Mace, 2014). In the behavioural momentum literature, there are three types of treatment relapse discussed: *renewal*, *resurgence* and *reinstatement.*

Renewal typically occurs with a change in contextual stimuli, usually when the stimuli which were paired with the training of the behaviour are re-presented again (Podlesnik, Kelley, Jimenez-Gomez, & Bouton, 2017). In basic renewal procedures, a behaviour is trained in Context A, before reinforcement for that behaviour is withheld in Context B. When an organism is then re-exposed to Context A, or placed in a novel environment (Context C), the previously reinforced behaviour returns (Podlesnik, Kelley, et al., 2017). *Context*, as used here, will refer to the wider environment surrounding a response and its association with a particular stimulus and/or reinforcement contingency.

During resurgence, alternative reinforcement, usually paired with a new prosocial behaviour, aimed to be taught in place of the problem behaviour is discontinued, causing the problem behaviour that had been extinguished originally to return (Lattal & St. Peter Pipkin, 2009; Nevin & Wacker, 2013). A typical resurgence procedure involves reinforcement for Response A, which is then put under extinction, while reinforcement occurs for a second response, Response B. Reinforcement is then withheld for Response B, at which point, Response A returns (resurges), even though the reinforcement initially provided for that response is no longer available (Ringdahl & St. Peter, 2017; Sweeney & Shahan, 2013).

Reinstatement occurs when reinforcers that originally maintained a behaviour are presented again, following an intervention phase to reduce the behaviour, causing the previously extinguished behaviour to return (Podlesnik & Shahan, 2009). Often, this reinforcer will occur independently of the original response, perhaps for another behaviour, but will still cause the previous behaviour to return (Lattal & St. Peter Pipkin, 2009).

As with a large amount of research in applied behaviour analysis, many specific interventions have been evaluated and are empirically grounded by the research done initially in animal laboratories. The findings related to behavioural momentum theory and DRA procedures both began with laboratory investigations with clinical significance (see Borrero, Vollmer, Samaha, Sloman, and Francisco (2007) and Dube, Ahearn, Lionello-DeNolf, and McIlvane (2009) for discussion). There are benefits of using animal models based in the laboratory to examine such issues because the degree of control possible over experimental variables is not usually possible with human subjects in a natural environment (Borrero et al., 2007). The increase in the number of studies exploring clinical matters in the animal laboratory has led to greater emphasis on translational research within behaviour analysis, an area in which BMT and DRA research particularly have received a large amount of attention. This is likely due to the clinical significance that investigations into matters such as decreasing problem behaviour, reducing persistence, and avoiding treatment relapse in general have, not only for the clients, but also for practitioners and researchers alike.

Nevin et al. (1990) investigated behaviour momentum theory through examining the relationship between reinforcement and persistence in the experimental laboratory with pigeons. They provided additional non- contingent reinforcement (NCCR) (food) in one component of a multiple schedule, changing the relation between the target response and the reinforcer in that stimulus context. The response rate was reduced in the non-contingent food component. Resistance to change (persistence) was examined for responses in both components through introducing extinction, and persistence was greater in the component with the additional food reinforcement and the lower baseline response rate. This suggested that persistence is established by Pavlovian stimulus-reinforcer relations, not operant response-reinforcer relations (Mace et al., 1990; Nevin et al., 1990; Podlesnik et al., 2012). In other words, greater reinforcement in a particular stimulus context, whether that be contingent on the target response, another response, or presented non-contingently, is sufficient to increase resistance to change of the original target response (Nevin & Grace, 2000; Nevin & Shahan, 2011).

There is extensive research in support of the above findings, and so this suggests that the added reinforcers do not have to be contingent on the problem behaviour to increase its persistence. Rather, increased frequency of reinforcer delivery in the same environment as the problem behaviour is sufficient to increase persistence of that problem behaviour (Mace et al., 2009; Mace et al., 2010; Nevin & Grace, 2000; Nevin et al., 1990; Nevin & Wacker, 2013). For example, during a traditional implementation of a DRA procedure, the alternative behaviour (e.g., raising one’s hand in a classroom) will often be taught and reinforced in the same context as the one in which the problem behaviour occurs (e.g., shouting out the answers). Furthermore, it is quite possible that these two behaviours may be maintained by the same reinforcer (e.g., attention from staff and peers in the classroom). Assuming that the shouting out does not stop instantaneously once the DRA procedure begins, both behaviours will be occurring in the same context at the same time. It is also quite likely that some attention will still be given to the shouting out behaviour, as controlling all attention from staff and peers is very difficult. As the above-mentioned research suggests, reinforcing the alternative (hand raising) behaviour, in the same context as the problem (shouting out) behaviour, could increase the persistence of that problem behaviour. These persistence-strengthening effects have been found regardless of how the additional reinforcers have been added to the environment; whether contingent on an alternative behaviour occurring or independent of any response (Nevin et al., 1990; Nevin & Wacker, 2013).

These findings have also been replicated across a variety of animal species, including goldfish (Igaki & Sakagami, 2004), pigeons (Podlesnik & Bai, 2015; Podlesnik et al., 2012), and rats (Mace et al., 2010), and persistence-strengthening effects have been demonstrated with humans (MacDonald, Ahearn, Parry-Cruwys, Bancroft, & Dube, 2013; Mace et al., 2010). These latter findings, among others, allow us to conclude that adding additional reinforcers to the same environment in which a problem behaviour is occurring may actually be strengthening the problem behaviour instead of reducing it. As DRA procedures are often implemented with the intention of reducing the probability of the target problem behaviour, these findings have serious implications for practitioners. Increasing the long-term persistence of a problem behaviour while attempting to reduce its frequency with DRA procedures could have detrimental effects (Nevin, 2015).

In a translational experiment, Mace and colleagues (2010) proposed a possible solution to the concern that a side effect of DRA treatment procedures could be increasing the persistence of the problem behaviour (hereafter referred to as the target behaviour). In a model with rats, used initially to control as many variables as possible, an alternative response was trained in a separate context to the one in which the target response occurred. Using extinction as a disruptor, the two stimuli associated with these responses were presented together and the persistence of these responses during extinction was measured. This was compared to the persistence of responding produced by a concurrent schedule, with one schedule associated with the alternative and one with the target responses. Under the concurrent schedule, the two responses were considered to be trained in the same context and so this was seen as analogous to a traditional DRA.

During baseline, rats were exposed to a three-component multiple concurrent schedule of reinforcement. In Component 1, the left light was dark, the left lever was inoperative and the right light flickered at a rate of one flick per s, while the right lever was associated with a reinforcement rate of 24 reinforcers per hour. In Component 2, the concurrent schedule component, both left and right lights flickered at a rate of five flicks per s, while the left lever was associated with 96 reinforcers per hour and the right with 24 reinforcers per hour. In Component 3, the left light was on continuously and the left lever was associated with 96 reinforcers per hour, while the right light was dark and the lever inoperative. Reinforcers were arranged so that the total amount of combined reinforcement available in Components 1 and 3 was equal to the amount of reinforcement available in Component 2. Component 2 was seen as analogous to the traditional DRA arrangement, while Component 3 was analogous to training an alternative response (i.e., lever presses to the lit lever on the left) in a separate context to the target response (i.e., lever presses to the lit right lever) which was trained alone in Component 1 (Mace et al., 2010).

These baseline sessions were followed by one extinction session that also involved a three-component multiple concurrent schedule but with no reinforcers available. Components 1 and 2 involved the presentation of the same stimuli (lights) as in Components 1 and 2 of baseline. In Component 3 the left light was on continuously (as in baseline in Component 3) and the right light flickered (as in baseline in Components 1 and 2). This enabled a direct comparison of the persistence of responding to the stimuli associated with the concurrent schedule during baseline, against the stimuli combined during extinction but associated with the single schedules during baseline (Mace et al., 2010).

Responding on the right lever in Component 3 in this test was less persistent than responding on the right hand side of Component 2 in this test, despite equal reinforcement rates during baseline. This demonstrated the potential for training an alternative (left lever) response in a separate context to the target (right lever) response as a possible method to reduce the rate of unwanted behaviour without increasing the persistence. In the same study, a clinical test of this model with humans was successful at reducing the persistence of responding by training the alternative behaviour in a separate context (Mace et al., 2010). The clinical test used different coloured clothing and rooms associated with different components to ensure component discrimination was clear.

Podlesnik et al. (2012) replicated this study with pigeons, changing the procedure slightly to account for the possible over-exposure to the target stimulus during Mace et al. (2010) procedure. This over-exposure came from the right side light being presented alone during Component 1 in both baseline and extinction sessions, and also being presented in Components 2 and 3 in the extinction test. Podlesnik et al. (2012) argued this was important as the increased exposure to that stimuli resulting from the extinction test could have been a reason for Mace and colleagues' (2010) findings of reduced responding to the right lever in Component 3 during the extinction tests.

In Component 1 there were two operative yellow keys and a concurrent VI 37.5-s VI 150-s schedule, providing reinforcers at rates equivalent to Mace et al.'s (2010) original procedure. No changeover delay was used. In Component 2, the left key was lit green and associated with a VI 37.5-s schedule, while the right key was darkened. In Component 3, the right key was lit blue and associated with a VI 150-s schedule while the left key was darkened. Once responding was established for all three components in baseline, extinction tests were carried out to investigate the persistence of responding. There was a return to baseline prior to each extinction test (Podlesnik et al., 2012).

There were five extinction tests. During the first, the stimuli presented in the various components were the two yellow keys, the green left and blue right keys combined (termed the Combined Component), and the blue right key alone, as in Mace et al. (2010). During the second extinction test, one component presented the two yellow keys, and the other presented the Combined Component (i.e., the green left and blue right keys). As in Mace et al. (2010), combining the stimuli that had previously been presented alone was seen as analogous to testing persistence after the target and alternative responses had been trained in separate contexts (Podlesnik et al., 2012). A further two extinction tests presented different combinations of these stimuli to examine a variety of effects (Podlesnik et al., 2012).

Results were consistent with Mace et al. (2010); responding on the yellow right key (target) was more persistent when this key was paired with the yellow left key than responding on the blue right key (target) when it was combined with the green left key. However, in baseline there were higher rates of responding to the green left key of Component 2 and to the blue right key of Component 3 than to the equivalent yellow keys of Component 1. This meant that increased persistence might have been due to combining two stimuli that had been associated with higher-rate baseline responses, rather than to the training of responding to these stimuli in separate contexts. To account for this, in a final condition that was designed to investigate reinstatement and relapse, both yellow and blue right keys (target) response rates were examined and blue right key responding (in the Combined Component) was found to be lower than that on the yellow right key (Podlesnik et al., 2012). This suggested that the reduced persistence of responding in the Combined Component during extinction was in fact due to the training in two separate contexts, and also supported the notion that responses are strengthened by any source of reinforcement in that environment, not just the reinforcement contingent on the target behaviour (Podlesnik et al., 2012).

These findings suggest that the persistence of responding is not necessarily reduced along with the rate of responding, and that the behaviour is likely to come back and potentially be more difficult to eliminate. Such findings support the idea that alternative context training could be a suitable adjustment to traditional DRA methods in applied situations. Mace et al. (2010) results are supported by other studies where higher rates of responding have been observed following exposure to greater reinforcement rates within a particular environment (Ahearn, Clark, Gardener, Chung, & Dube, 2003; Pritchard, Hoerger, Mace, Penney, & Harris, 2014; Romani et al., 2016), and by studies with different species, as previously mentioned.

One way of investigating the persistence of responding in differential reinforcement procedures has been with the use of disruptors, as mentioned earlier. The types of disruptors that have been used to demonstrate greater persistence of responding in the richer of two schedules, include pre-feeding, extinction, and response-independent food presentations (Nevin & Wacker, 2013). Other disruptors that have been studied include the magnitude and delay to reinforcement (McComas, Hartman, & Jimenez, 2008), changes to the schedule or contingencies maintaining the responding (Harper & McLean, 1992), signals indicating changes to contingencies (Bell, Seip, & Fitzsimmons, 2007; Doughty & Lattal, 2003; Shahan & Lattal, 2005) and the length of presentations in the initial link of a chain (Podlesnik, Thrailkill, & Shahan, 2011).

Although a variety of disruptors are possible, the persistence of responding in differential reinforcement procedures has typically been tested under extinction conditions, such as in the two studies described earlier (Mace et al., 2010; Podlesnik et al., 2012), and a further investigation of this methodology by Podlesnik and Bai (2015). Jessel, Borrero, and Becraft (2015) used extinction as a disruptor when testing the persistence of other behaviour during a differential reinforcement of other behaviour (DRO) procedure with human experimental subjects. Extinction is also often the disruptor choice in behavioural momentum procedures that are also investigating the persistence of target behaviour, or treatment relapse. For example, both resurgence and renewal are phenomenon typically reliant on extinction to demonstrate persistence (although see Lattal et al.

(2017) for a discussion on the use of extinction in the definition of resurgence). Typically, the use of extinction is also the case for both basic and applied investigations into these areas (for example, Kelley, Liddon, Ribeiro, Greif, and Podlesnik (2015)).

Pre-session feeding is another disruptor used in behavioural momentum research for some time, usually to test the impact of satiation as a disruptor on a particular type of responding (Podlesnik et al., 2011). For example, pigeons may be fed prior to the session, and then an experimental session is carried out. Once baseline is established, extinction is introduced and persistence of the response relative to baseline responding is examined. Disruption by satiation has been used in a number of experiments in varying ways, for example, in non-contingent reinforcement on a variable-time (VT) schedule (Nevin et al., 1990); fixed-time (FT) schedules (Marsteller & St. Peter, 2014; McLean & Blampied, 1995); and during inter-component-interval feeding (Nevin, 2015), as well as in pre-session feeding.

Throughout the literature, the most common effect from pre-feeding is that responding is reduced (Nevin, Milo, Odum, & Shahan, 2003). However, pre-feeding has been found to have another effect and that is the increased persistence of the behaviour when tested during disruption after pre-feeding outside of the experimental context (Podlesnik et al., 2011). This is suggested to be through the enhancement of the stimulus-reinforcer relation, in the opposite way to which the added food effects the response-reinforcer relation. With few exceptions, additional food either through the form of pre-feeding or response independent food delivery, shows that response rates in the richer component are more persistent than those in the leaner component once extinction is introduced (Nevin, 2015).

As noted, most of this research has relied on extinction to assess persistence. However, Nevin (2015) and others have stated, extinction is just one of many possible methods to disrupt behaviour maintained by reinforcement, but there are other disruptors possible which do not change the reinforcement schedules in effect. Since extinction has been the disruptor of choice in most of the translational research relevant to DRA, the phenomenon of increased persistence of the target behaviour has seldom been demonstrated with other disruptors besides that of distracting stimuli (see Schieltz, Wacker, Ringdahl, and Berg (2017) for a summary of disruptors used in translational research on persistence).

From a translational viewpoint, this could be problematic because extinction is often impossible or impractical to implement in applied settings (Athens & Vollmer, 2010). Not only is it unhelpful, and sometimes unethical, to extinguish a new behaviour that has been taught as the alternative behaviour within a differential reinforcement procedure, there are often multiple reinforcers and/or sources of reinforcement controlling the problem behaviour which cannot be easily controlled or removed. Observation of a typical classroom setting suggests that there are often so many contingencies in effect that it would be impossible to eliminate all of the maintaining consequences, even if it were possible to identify them all. For example, off-task, or disruptive behaviours in the classroom, can be maintained by peer attention that is difficult to control, making extinction impractical (Podlesnik & DeLeon, 2015). Extinction is also problematic when behaviour is thought to be maintained by automatic reinforcement (Podlesnik & DeLeon, 2015) and the reinforcers in these cases are often difficult to identify (Vollmer, 1994). In addition, there have been some cases observed where extinction might not be the best approach due to the harmful, usually aggressive behaviour carried out by the individual, causing a risk to both the person themselves and those around them (Athens & Vollmer, 2010; Lerman, Iwata, & Wallace, 1999). Finally, the possibility of an extinction burst of this type of behaviour can be too great a risk.

DRA procedures are especially useful in scenarios such as those described above in that they arrange for the richer reinforcement of an alternative behaviour whilst reinforcement for a target response (i.e., problem behaviour) might still be available or uncontrollable. DRA procedures are effective at reducing problem behaviour in some of the most challenging cases (Petscher et al., 2009). However, it is a real concern if these procedures are inadvertently increasing the persistence of the very problem behaviour they are designed to reduce.

There have been solutions suggested to decrease the persistence of responding of the target behaviour during interventions using differential reinforcement (see Pritchard, Hoerger, and Mace (2014) for a full review). One of those suggestions includes longer-term DRA interventions, with less treatment relapse likely as time progressed (Shahan & Sweeney, 2011; Wacker et al., 2011). A limitation of this however is time; whilst it has been shown that resurgence is less likely when the intervention is carried out for extended periods (up to 16 months), the practicalities of this can be challenging (Lit & Mace, 2015). Furthermore, many studies examining persistence do not measure this persistence after the intervention has ended, meaning that long term persistence-reducing effects are not really known (Kelley et al., 2015).

Other proposed solutions to this problem involve manipulating the reinforcement rates; reinforcing the alternative behaviour using a lower rate of reinforcement (also known as low-rate DRA) (Pritchard, Hoerger, Mace, et al., 2014), and thinning the reinforcement schedules associated with the alternative behaviour (Sweeney & Shahan, 2013). Whilst the latter two solutions will be discussed in more detail later in this thesis, commonality amongst all of these solutions is that they are based on translational research done in the laboratory.

Therefore, a translational approach appears to be a fruitful one for exploring solutions to this issue. Some of the issues experienced in applied research, such as the problematic use of extinction in certain situations, can be addressed under more controlled experimental conditions. The non-human laboratory allows control over variables which cannot easily be controlled without great difficulty in applied situations (Borrero et al., 2007). Methods developed in the laboratory provide an insight into why persistence of both proactive and harmful behaviour exists (Nevin, 2015). Examination of training an alternative behaviour in a separate context to the target behaviour, using different disruptors in an experimental setting, seems like a valid approach to testing this method as a possible way to examine the use of other disruptors besides extinction and further investigate the persistence of behaviour.

Chapter 2: Experiments 1-3

Experiment 1: Extinction

The research described previously highlights current concerns both regarding the increased persistence of the problem behaviour that could result from DRA procedures and the use of extinction when measuring this persistence. Both these areas warrant further investigation. One aim of these next experiments was to investigate further the effects on persistence when the problem behaviour was trained in a separate context from the alternative behaviour as compared to a traditional DRA procedure, where the alternative behaviour is trained in the same context as the problem behaviour. Another aim was to assess persistence without the use of extinction.

The three-component multiple schedule procedure with rats (Mace et al., 2010) and with pigeons (Podlesnik et al., 2012) provides a potential method to study this further. The aim of the first experiment was to replicate this work with hens. This would test the generality of the findings and see if the same results would be found with another species (Experiment 1). The present experiment used a three-component multiple schedule in baseline, with Component 1 designed to replicate the conditions of a DRA procedure, where a target behaviour is reinforced on a leaner schedule (right yellow key) and an alternative behaviour is reinforced on a richer schedule (left yellow key) in the same environment (i.e., concurrent schedules). Component 2 presented a stimulus associated with a richer reinforcement schedule alone (left green key) and Component 3 presented a stimulus associated with a leaner reinforcement schedule alone (right blue key). The training of responding to the stimuli in these latter two components in separate contexts enabled us to compare this to that of training responding in the same context (i.e., Component 1). Stimuli from Components 2 and 3 were then combined during the extinction tests to measure the persistence of responding as a proportion of baseline responding. These results could then be compared to previous findings. If the replication was successful, then Experiment 2 was designed to investigate the use of this procedure with a different disruptor; an additional source of reinforcement. The two experiments used the same hens to allow within-subject comparison between disruptors.

Method.

Subjects

The subjects were six domestic Brown Shaver hens, numbered 8.1 to 8.6, all less than two years old at the start of the study. The hens were housed in individual cages with a 12 hour light and dark cycle. The hens had free access to water at all times, were weighed daily and kept at a body weight of 85% (+/- 5%) of their free-feeding body weight by supplemented feeding after each experimental session. In the home cage the hens were fed using a commercial laying pellet. During the experiment, wheat was used as a reinforcer. In addition the hens received grit weekly and vitamins when necessary as part of their usual feeding routine.

Apparatus

Three keys were situated at one end of an experimental chamber, approximately 360mm above the floor of the chamber. Multi-colour LED light panels at the front of each of the keys allowed a number of different colours to light each key as required. The chamber was 600mm long by 450mm wide and made of plywood. A 100mm wide rectangular hole below the keys allowed the hen’s access to wheat in the magazine when the hopper was raised and lit. The magazine was operated automatically and situated outside of the chamber. The walls inside the chamber were painted white, and a black rubber mat was situated on the floor of the chamber to enable easy removal for cleaning. A nearby computer running MED Associates software programmed and recorded all experimental conditions and data.

Procedure

Part 1. Shaping and Training

All hens had served in an undergraduate psychology laboratory, in which they were trained to eat from a magazine and to peck a key, then experienced four sessions each with a manually operated progressive-ratio schedule with wheat or puffed wheat as a reinforcer. For the present experiment, training started by presenting both the left and right key concurrently during three different components, each of which lasted 40s. Each component was presented twice each in a random order, with six presentations in total. Both keys in each component were associated with a VI 10-s schedule. During Component 1, both left and right keys were lit yellow. During Component 2, both left and right keys were lit green, and in Component 3, both left and right keys were lit blue. This training stage was completed to train equal responding to both keys before baseline training began. No changeover delay was used. The components were separated by an inter-component-interval (ICI) of 10-s during which time the keys were blacked out. At times, if a hen responded exclusively to one key, the other key was turned off until the hen was responding reliably to the lit key. Once all hens were responding steadily to both keys in each component (approximately 25 days), the 30-day baseline period began, as outlined below.

Part 2. Experimental Procedure

Baseline

The baseline procedure involved the repeated presentation of three components each 1-min in length. In Component 1, there were two concurrently available yellow keys; on the left a VI 37.5-s schedule and on the right a VI 150-s schedule.

In Component 2 the left key was lit green and associated with a VI 37.5-s schedule. When this component was active, the right key remained dark and inoperative.

In Component 3, the right key was lit blue and associated with a VI 150-s schedule. As with the previous component, whenever Component 3 was active, the left key remained dark and inoperative. Figure 1.1 shows the arrangement of the keys and schedules for each component.

The three different components were each presented 12 times, totalling 36 component presentations per session. Components were presented in random order and were separated by a 20-s ICI. The sessions started and ended with an ICI, and 3-s access to wheat was provided for reinforcement. The first baseline was in place for 30 sessions to establish stable baseline responding, after which baseline conditions were implemented for six sessions between extinction tests.

Extinction Tests

Table 1 displays the arrangement of the components and keys during the extinction tests. Each extinction test involved different combinations of the stimuli presented in the components outlined during the baseline condition, but in all cases food reinforcement was withheld. The first four extinction tests ran for six sessions each.

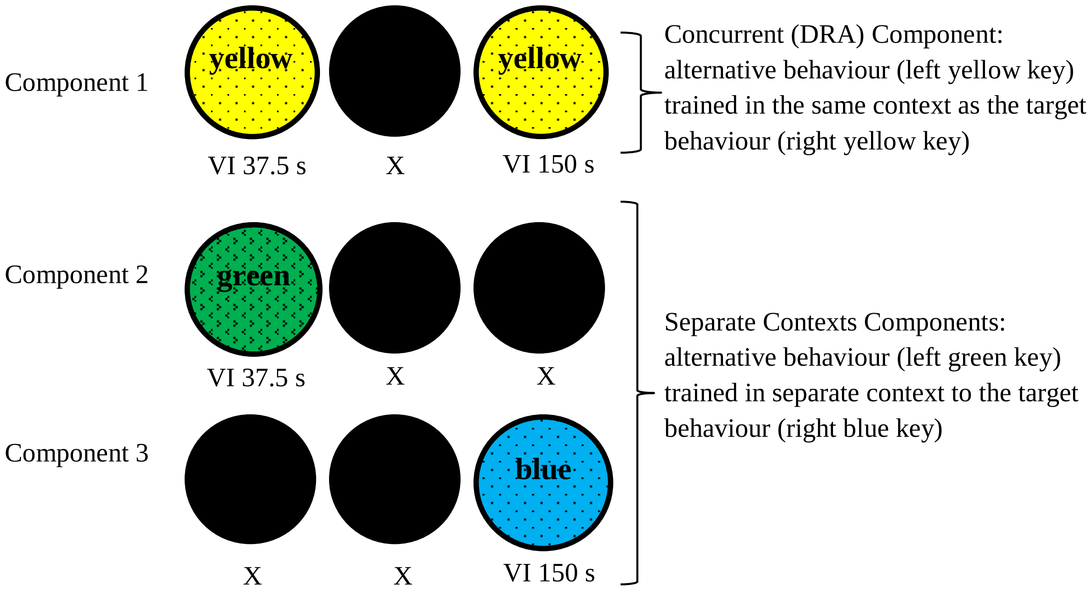


Figure 1.1. The key colours and schedules as arranged for each component.

Table 1.1. The component combinations and key colours as presented during the extinction tests. 0 = reinforcement withheld, FT = fixed-time food presentations as described in the text.

Extinction Test	Components	Key colours	
extinction 1	comp. 1	🟨 0	🟨 0
	comp. 2	🟩 0	🟦 0
	comp. 3	▨	🟦 0
extinction 2	comp. 1	🟨 0	🟨 0
	comp. 2	🟩 0	🟦 0
extinction 3	comp. 1	🟩 0	🟨 0
	comp. 2	▨	🟦 0
extinction 4	comp. 1	▨	🟨 0
	comp. 2	🟩 0	▨
	comp. 3	▨	🟦 0
extinction 5	comp. 1	🟨 0	🟨 0
	comp. 2	🟩 0	🟦 0
fixed-time condition	comp. 1	🟨 FT	🟨 FT
	comp. 2	🟩 FT	🟦 FT

After stable baseline was established, Component 1 keys remained as they were during baseline (two concurrently available yellow keys), however, the left key from Component 2 (green key) was presented with the right key from Component 3 (blue key) in one component, hereafter referred to as the Combined Component. These two components (concurrent yellow keys, and combined green and blue keys) were then presented randomly following the lengths and times described during baseline. Three hens (Group 1) were exposed to these conditions in Extinction Test 1.

The other three hens (Group 2) were presented with Extinction Test 2, remaining on a three-component schedule; Component 1 (Concurrent) and the Combined Component were presented as described above, and Component 3 was presented as described during baseline, a blue key presented alone on the right side. Following this extinction test, baseline was reinstated, and Group 1 hens were exposed to the three-component multiple schedule, and Group 2 hens were exposed to the two-component multiple schedule.

After these two extinction tests, all hens were then exposed to the remaining extinction sessions in the same order. Extinction Test 3 featured only two components; the left green key from Component 2 paired with the right yellow key from Component 1 in one concurrent schedule, while the right blue key from Component 3 remained alone. During Extinction Test 4, Components 2 and 3 were presented exactly as they were in baseline (left green key in Component 2, right blue key in Component 3), however in Component 1, only the right yellow key was lit and the left key darkened. These combinations of component presentations are also outlined in Table 1.

Extinction Test 5 was a replication of the first; using alternations of the Concurrent Component (both yellow keys presented together), and the Combined

Component (left green key from Component 2 and the right blue key from Component 3). Extinction continued until all hens dropped below 10% of baseline responding; it took five sessions for all hens to meet this criterion. In the final condition of the present study, the same two-component schedule as just described was presented, but with three fixed-time food presentations added to each component. The hopper was raised at 5s, 10s, and 15s, respectively, during the first presentation of each of the two components during a session, but then no further food was available for the remainder of that session. There were five of these fixed-time sessions in total.

Results

Baseline

Figure 1.2 displays the mean baseline response rates for each hen and for each component over the six baseline sessions prior to each extinction test. For all hens, response rates were lower on the right yellow key of Component 1 than any other key. Response rates in Component 2 (green left key) were typically higher than all other response rates, with Hen 8.3 being the exception to this and Hen 8.4 showing very similar rates between the left yellow and right yellow key responses in Component 1 and the left green key responses in Component 2. A two-way repeated measures ANOVA across responses on all keys during the five baseline tests was significant; $F(12,60) = 5.670$, $p < .05$, $\eta_p^2 = .531$, main effect of response type $F(3,15) = 16.568$, $p < .05$, $\eta_p^2 = .768$, but no main effect of session, $F(4,20) = 2.272$, $p > .05$, $\eta_p^2 = .312$.

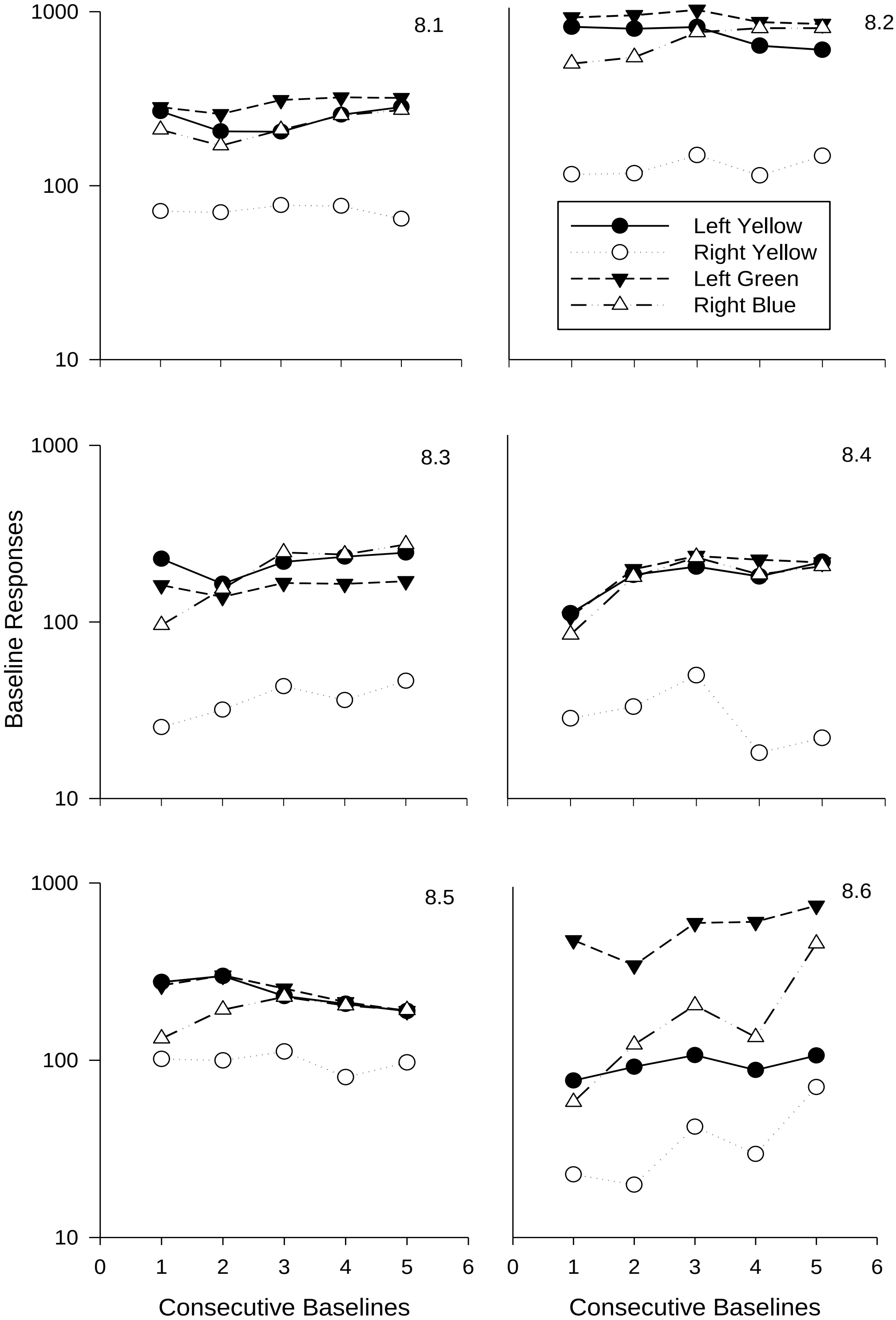


Figure 1.2. Mean baseline response rates from the last six sessions prior to each extinction condition. The y-axis is presented on a log scale. Circles represent Component 1 (filled circles = left yellow key VI 37.5s, open circles = right yellow key VI 150s) and triangles represent Components 2 and 3 (filled triangles = left green key VI 150s, open triangles = right blue key VI 150s).

Extinction Tests 1 and 2

Figure 1.3 shows responding as a proportion of baseline on a log scale plotted across successive sessions of Extinction Test 1, in the left panel, and Extinction Test 2 in the right panel for each hen. Proportion of baseline was calculated first by finding the mean response rates on each key for each of the six baseline sessions preceding that extinction test. The mean number of responses for each extinction session was then divided by the mean number of baseline responses for each individual key to determine the proportion of baseline responding. This method of calculation was used for the proportion of baseline data presented throughout.

As seen in Figure 1.3, the proportions of baseline responding on the right yellow key responses (Concurrent Component) were higher than those on the right blue key responses (Combined Component). In addition, these measures for 8.1, 8.2, 8.4, and 8.5 were lower on the right blue key (Combined Component) during extinction than they were for any other key. A clear pattern was not evident for the other two hens (8.3 and 8.6). These findings were supported by a two-way repeated measures ANOVA between sessions and the three types of right key responding (right yellow key, Combined right blue key, alone right blue key); $F(10,50) = 19.225$, $p < .05$, $\eta_p^2 = .794$, main effect of session $F(5,25) = 17.409$, $p < .05$, $\eta_p^2 = .777$, and type of response $F(2,10) = 7.109$, $p < .05$, $\eta_p^2 = .587$.

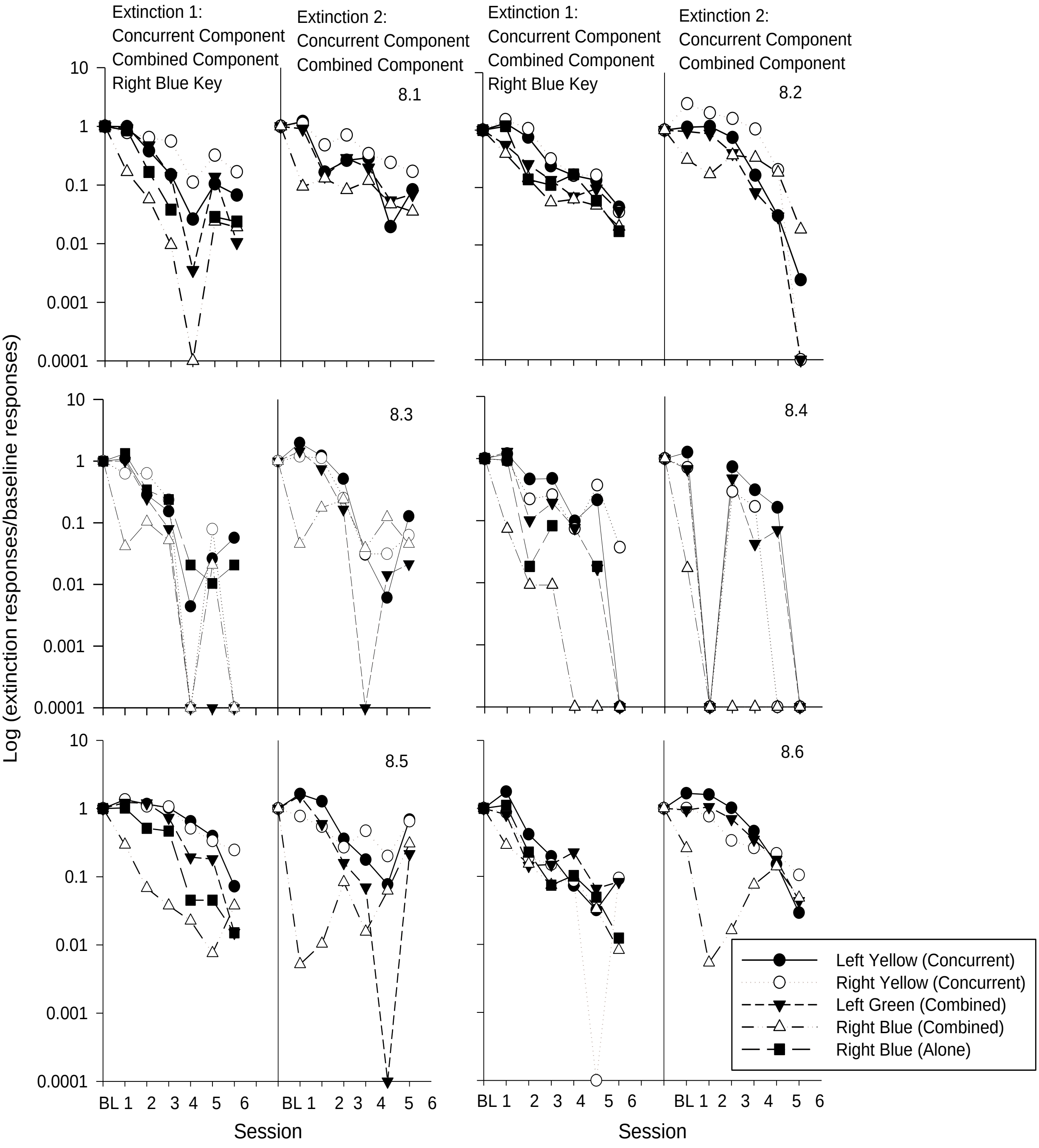


Figure 1.3. Responding plotted as a proportion of baseline responding during the first and second extinction tests. In both columns, the y-axis is on a log scale, circles represent the Concurrent Component (filled circles = left yellow key, open circles = right yellow key), triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key) and the closed squares represent the right blue key presented on its own. Data points at 0.0001 represent zero responses.

Extinction bursts, defined as rises in response rates above the baseline level (greater than 1 in Figure 4), were evident for all hens in Session 1 of the extinction tests as shown by the second data point in each figure. These bursts occurred on all keys except for the right blue key of the Combined Component for every hen. Overall, right key responding was greater during the Concurrent Component (yellow) than during the Combined Component (blue).

Extinction Test 2 also presented the concurrent yellow keys and the green and blue keys (Combined Component) in extinction. For all hens but 8.3, the responding proportionate to baseline on the right blue key was lower than on all other keys, with this measure dropping most rapidly on the blue key during the first 1-3 sessions. While responding proportionate to baseline on the blue key did increase again for most hens between sessions 2-4, it continued to decrease after the fourth session for all hens other than 8.4 and 8.5. Hen 8.4's responding ceased on this blue key altogether in session two, and Hen 8.5's responding proportionate to baseline on all keys increased over the sessions. Left key responses on both the yellow key and the green key remained fairly similar across sessions. Extinction bursts were observed for all hens during one of the first two sessions, on all keys except the right blue key. Right key responding was consistently greater proportionate to baseline on the right yellow key than on the right blue key, and this finding was supported by a two-way repeated measures ANOVA. There was a significant interaction between sessions and responding on the two right keys (yellow and blue), $F(5,25) = 6.573$, $p < .05$ $\eta_p^2 = .568$, main effect of session, $F(5,25) = 3.014$, $p < .05$, $\eta_p^2 = .376$, and of response type, $F(1,5) = 9.421$, $p < .05$, $\eta_p^2 = .653$.

The total number of responses in the Concurrent Component (both yellow keys) and the Combined Component (green and blue keys) were summed and then plotted as a proportion of baseline responses for each hen as a means of comparing responding between the two extinction tests (with and without the blue key presented alone). This allowed a comparison of whether there was a noticeable difference in the total amount of responses when the right blue key from Component 3 was presented as an additional component.

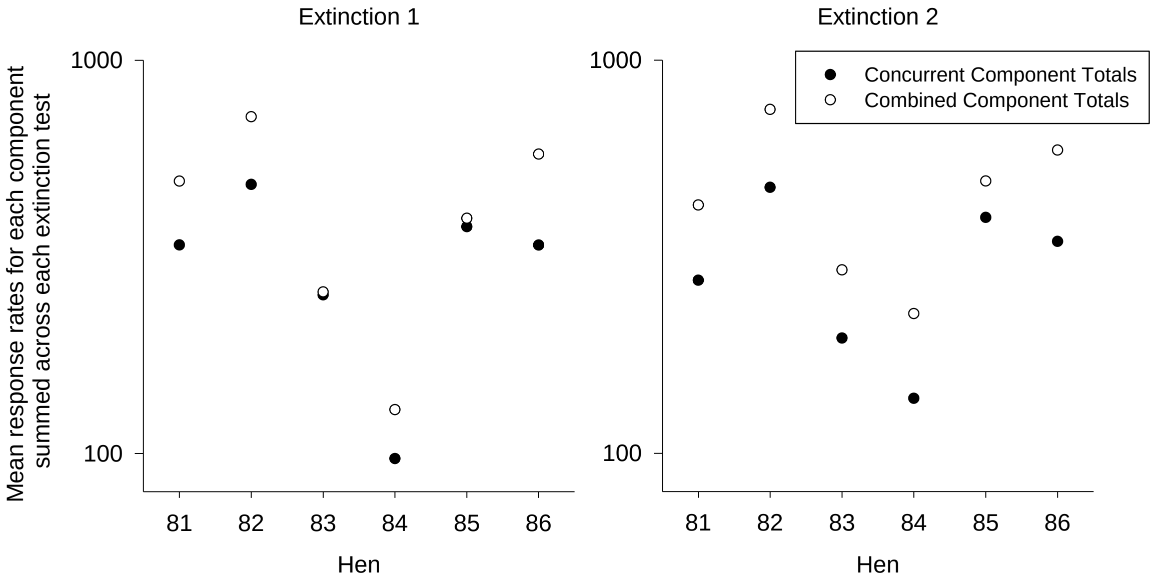


Figure 1.4. Mean number of responses during the first extinction test with the right blue key alone (left panel) and the second extinction test without the right blue key alone (right panel), summed for each component. The y-axis is presented on a log scale with Component 1 (yellow keys) represented by a filled circle, and the Combined Component (green and blue keys) represented by an open circle.

Total responding on the yellow keys (Concurrent Component) was generally lower than total responding on the green and blue keys (Combined Component), regardless of whether the right blue key was presented alone or not, as shown in Figure 1.4. Overall there was very little difference in responding when the right blue key was presented alone (right column of Figure 1.5). Hens

8.3 and 8.5 both responded less in the Concurrent Component keys when the right blue key was available in another component, and Hen 8.4's responding increased overall when the right blue key was not available.

Responding on the right yellow key of the Concurrent Component was greater proportionate to baseline than responding on the right blue key of the Combined Component regardless of whether the right blue key was available alone as well (see Figure 1.3). No other differences between the two extinction tests were noticeable.

Extinction Tests 3 and 4

The richest of the three baseline components was Component 1, which was intended as an analogue to a DRA procedure in which an alternative response is reinforced under a rich schedule of reinforcement alongside a target response that is reinforced under a lean schedule of reinforcement. Reinforcers from both of these response types were available in the presence of the same key colour, yellow, on both keys. In order to determine if both yellow keys were viewed as one stimulus context associated with the colour yellow, and to evaluate persistence of responding to the left green key of Component 2, in the third extinction test the left green key of Component 2 was combined with the right yellow key of Component 1. Component 3 (right blue key) was also presented. Reinforcement was withheld across all components.

Figure 1.5 shows responding on the left green key and the right yellow key when presented in the same component, and the right blue key when presented on its own during the third extinction test, plotted as proportions of the corresponding baseline responses on a log scale. For five hens (the exception being Hen 8.6), the response proportion was greater on the right yellow key when compared to the right blue key. Of those five hens, responding proportionate to baseline was greater on the right yellow key than on the left green key. Hen 8.2 showed a slightly different pattern of right yellow key responding proportionate to baseline, this was only greater than all other keys on the first session of the test, and then reduced continuously until the final two days of the test, when responding on the right yellow key stopped completely. At that point, responding on the right blue key increased.

The fourth extinction test presented the same key colours as in the previous test, but individually in each component rather than combined at any time. Figure 1.6 displays the number of responses as a proportion of baseline plotted across the sessions of the fourth extinction test. It is evident for all hens, except 8.6, that responding proportionate to baseline was greater on the right yellow key during extinction than on either the left green or right blue keys. Hen 8.6’s responding on the right yellow key ceased altogether by the fourth session of the extinction test, while responding on both the left green and right blue key continued.

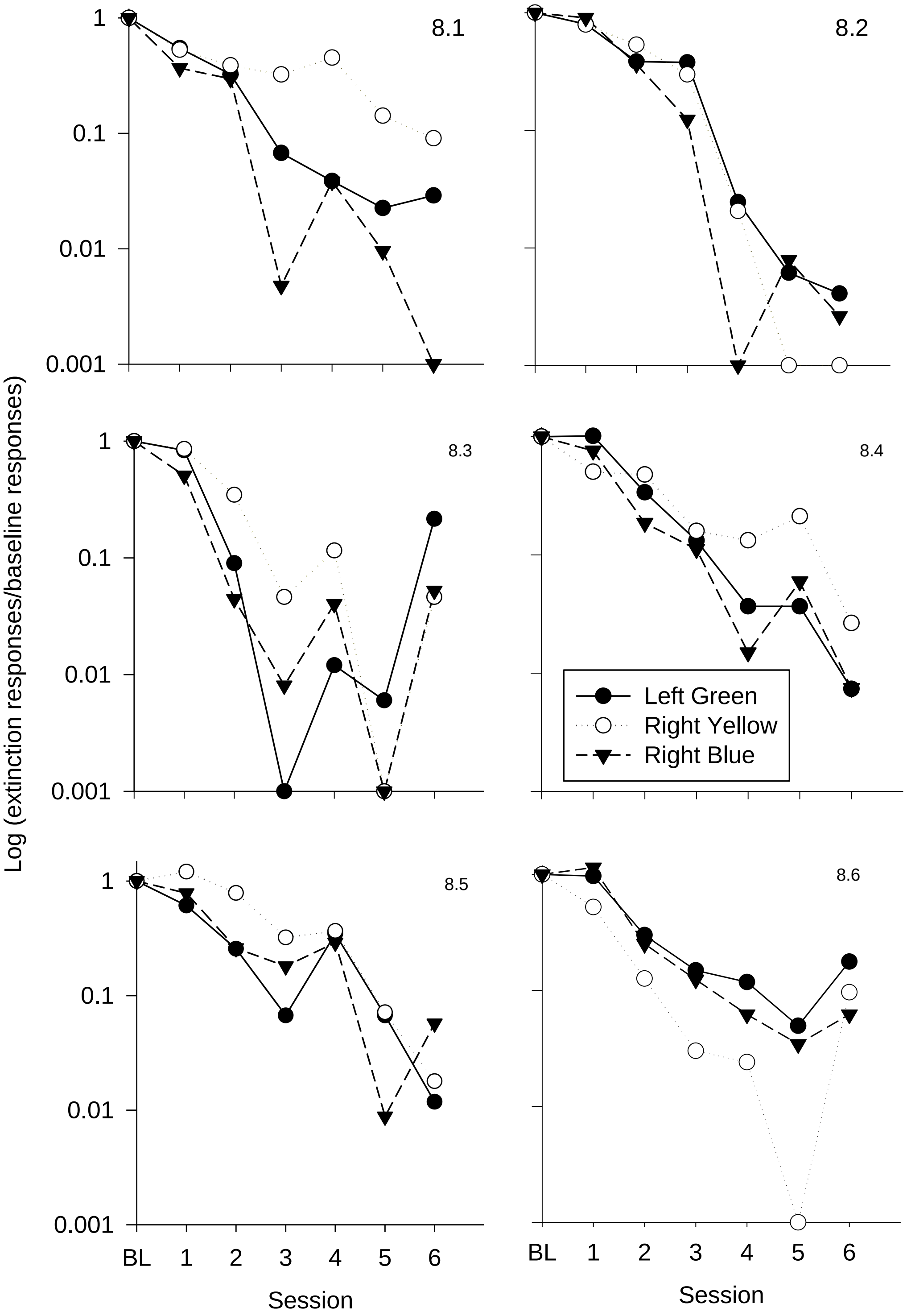


Figure 1.5. Responding plotted as a proportion of baseline responding for each hen during the third extinction test, where the left green key and right yellow key were presented together in one component, and the right blue key was presented individually in a second component. The y-axis is presented on a log scale, with the circles representing the first component (filled circles = left green key, open circles = right yellow key) and the triangles representing the second component (right blue key). Data points at 0.001 represent zero responses.

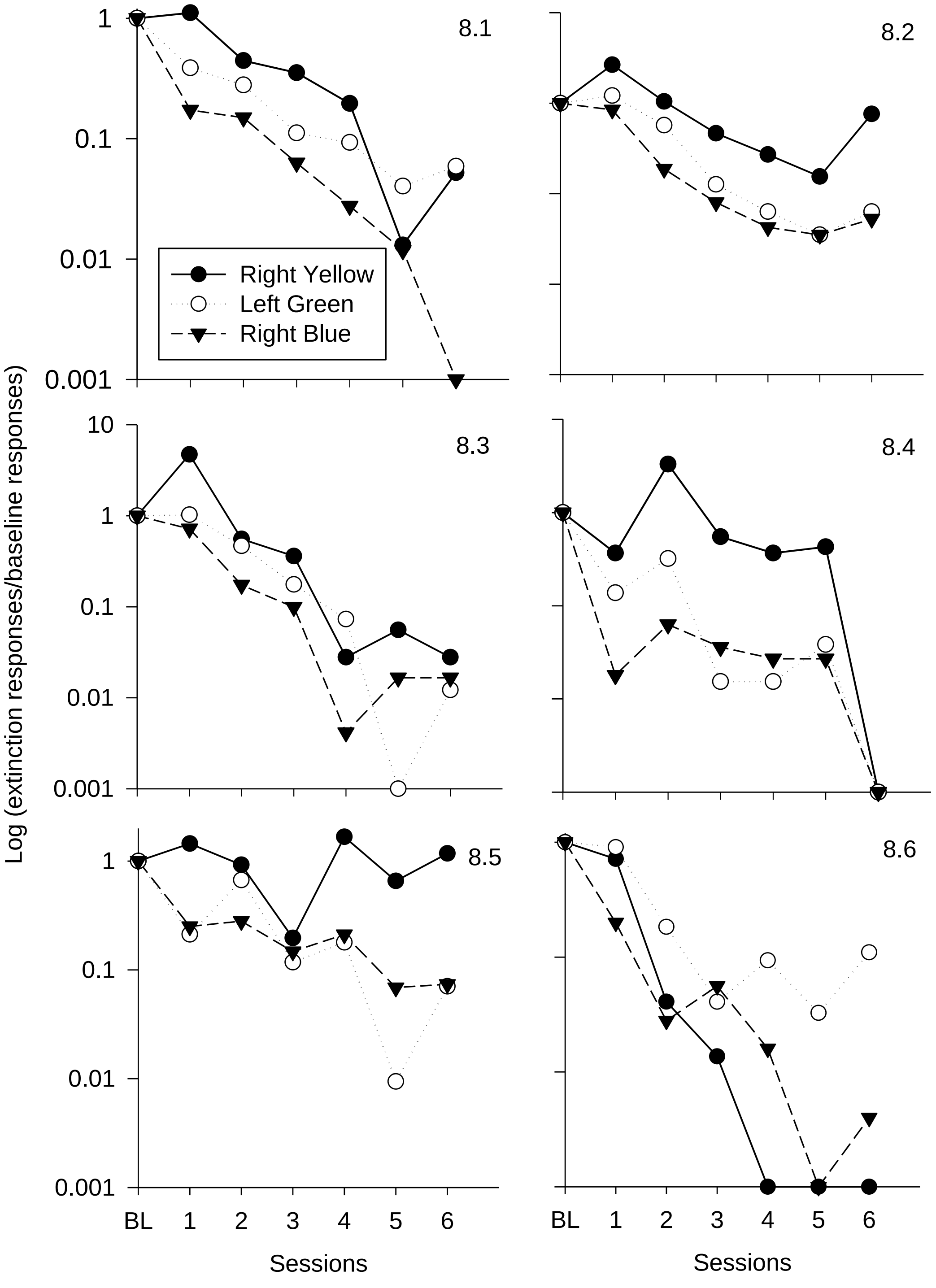


Figure 1.6. Responding plotted as a proportion of baseline responding for all hens during the fourth extinction test, where the right yellow key, left green key and right blue key were presented individually in three components. The y-axis is plotted on a log scale, with filled circles representing the right yellow key, open circles representing the left green key, and the triangles representing the right blue key. Data points at 0.001 represent zero responding.

Extinction Test 5

The final extinction test involved response-independent food presentations on a fixed-time schedule after responding during extinction had dropped to below 10% of baseline for all hens. This took five sessions. As seen in Figure 1.7, for four of the hens in this test, responding on the right yellow key was once again greater proportionate to baseline than responding on the right blue key. Unlike other extinction tests, this finding was not statistically significant when a two-way repeated measures ANOVA was carried out comparing responding on the right yellow key with that of the right blue key; $F(4,20) = 2.540$, $p > .05$, $\eta_p^2 = .337$, no main effect of response type $F(1,5) = .069$, $p > .05$, $\eta_p^2 = .014$, but there was a main effect of session $F(4,20) = 4.326$, $p < .05$, $\eta_p^2 = .464$.

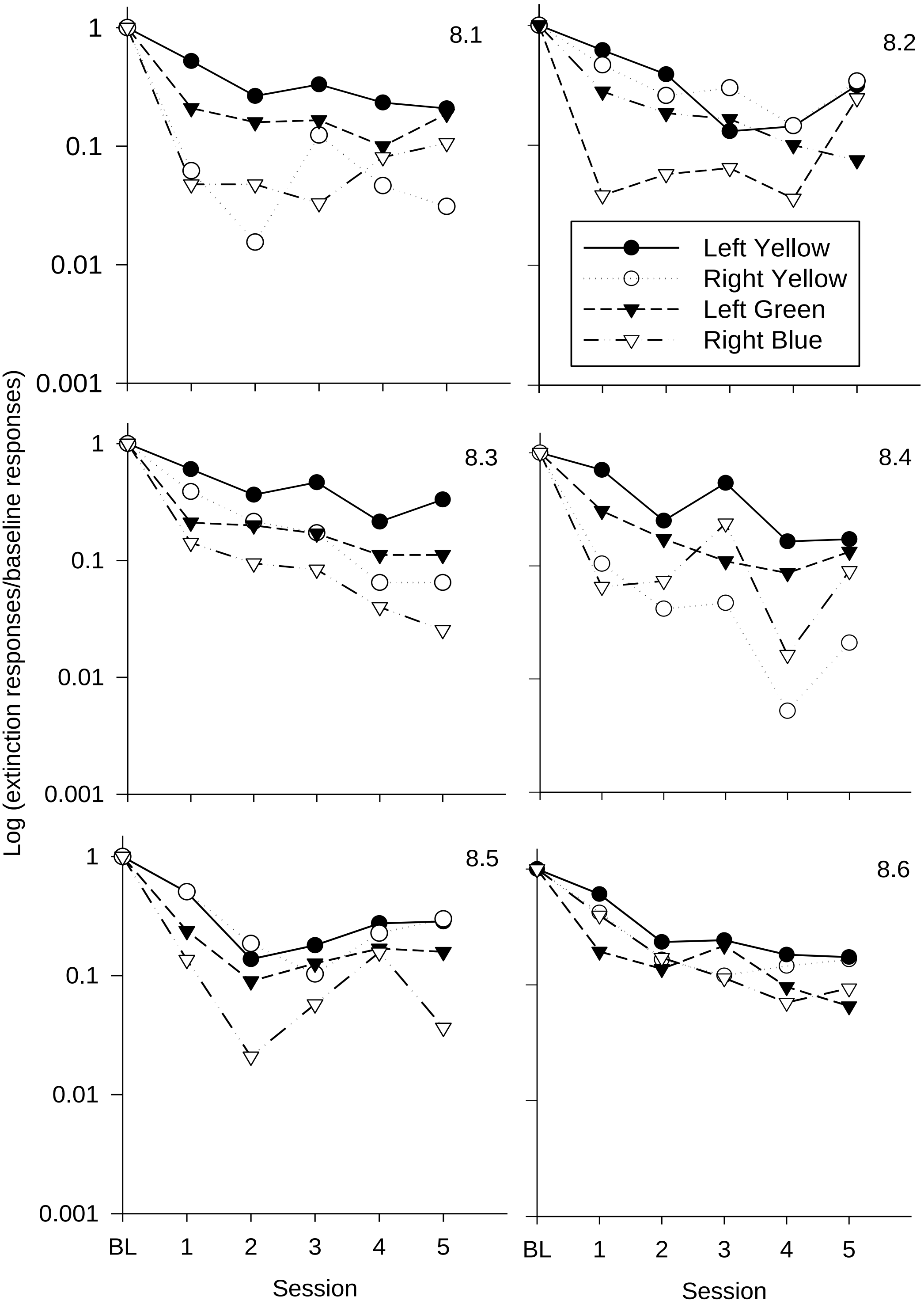


Figure 1.7. Responding plotted as a proportion of baseline for all hens during the final extinction test, in which both yellow keys were presented in one component, and the left green and right blue keys were presented in a second component. Response independent food was presented three times at the start of both components. The y-axis is plotted on a log scale, with circles representing the Concurrent Component and triangles representing the Combined Component.

Discussion

Experiment 1 aimed to replicate Podlesnik et al. (2012) with hens as subjects. Throughout all extinction tests, we found that training a richer alternative behaviour (left green key of Component 2) in a separate context to that of the target behaviour (right blue key of Component 3), reduced the persistence of the target behaviour in extinction when compared to a richer alternative (left yellow key) trained concurrently with a leaner target (right yellow key) in the same context. This was a successful replication as the present findings are similar to those found by Podlesnik et al. (2012).

Overall, the mean number of responses during each repeated baseline was similar to that of Podlesnik et al. (2012). Both studies also found highest levels of responding on the left green key, and lowest levels of responding on the right yellow key. This latter finding was to be expected given that there was a richer alternative (left yellow key) to choose from during the concurrent schedules component. However, Podlesnik et al. (2012) found that baseline rates of responding on the left yellow key of the concurrent component were lower than those found here. Baseline responding remained relatively stable across all five baseline presentations carried out between extinction tests in both studies.

During all extinction tests that examined the responding on the two yellow keys presented concurrently in direct comparison with the responding on the green and blue keys presented as one combined component, responding on the right yellow key was consistently more persistent during extinction than responding on the three other keys in most sessions. There were no systematic differences in the data depending on whether the right blue key (Component 3) was presented or not. This suggests that, as had been found in previous research, there was no impact of additional exposure to the right blue key, (Podlesnik et al., 2012).

As shown in Figure 1.3 across both extinction tests, persistence of responding was initially greater to the right yellow key when compared directly to the responding on the right blue key. Additionally, for Hens 8.1, 8.2, 8.4 and 8.5, responding on the right yellow key was more persistent than that on any of the other keys available, including both the keys (left yellow and left green) which were associated with richer reinforcement schedules during baseline. This effect was replicated in the second extinction test; across all hens with the exception of 8.3 and 8.4, responding on the right yellow key was not only more persistent than that on the right blue key, but was also more persistent than responding on both of the keys (left yellow and left green) previously associated with the richer reinforcement schedules as well. This is an interesting finding, because the right yellow key was associated with a leaner schedule (VI 150-s) during baseline than the concurrently available left yellow key (VI 37.5-s) that was concurrently available. This right yellow key was also associated with a leaner reinforcement schedule than the left green key (VI 37.5-s). According to behavioural momentum theory, one would expect responding to be more persistent on either of the left keys (yellow or green), as behavioural momentum theory suggests that responding will be more persistent during extinction on the option previously associated with the richer context (Craig et al., 2014; Nevin, 2015).

There are several possible explanations as to why this greater persistence of responding was found toward the right yellow key previously associated with the leaner reinforcement schedule. Firstly, both yellow keys were always concurrently available during the analogue DRA Component in baseline, and most extinction tests, and so may be viewed as one stimulus context, rather than as two individual stimuli. As the yellow keys were presented concurrently, they provided an overall richer context during baseline than was previously provided by either of the other two components (in which the left green key was presented alone and the right blue key was presented alone). However, behavioural momentum theory suggests that, when there is more than one option to respond to, responding on the richer schedule is typically more resistant to change in the face of disruption (Nevin, 2015). If the combined yellow keys presented as the analogue DRA component were seen as one richer context, one might expect persistence of responding during the extinction tests to be about equal on *both* yellow keys – and this was not the case. Responding on the right yellow key often persisted to a greater level than responding to the left yellow, left green and right blue keys, regardless of the combinations in which they were presented. This finding does not support the idea that both the yellow keys in the concurrent component, analogue to a DRA, were seen as one richer context, neither is this consistent with behavioural momentum theory. Whilst the data suggest that training an alternative behaviour in a separate context to the target behaviour is an effective method to reduce the persistence of that target behaviour, the exact mechanism as to why this effect is found is not yet clear.

In addition to the reduced persistence found in responding to the right blue key once it was combined with the left green key in the Combined component during the first two extinction tests, it was also found that increased responding in the form of extinction bursts occurred when both yellow keys and the left green key were presented during the second and sometimes third session of extinction. Podlesnik et al. (2012) also observed the greater extinction bursts on the right yellow key, analogous to the target behaviour in a traditional DRA, which is often associated with a leaner reinforcement schedule during baseline. Typically, greater extinction bursts have been seen during extinction with richer schedules (Nevin, 2015) so this finding may also suggest that both yellow keys presented concurrently were being treated as one combined, richer stimulus context. However, the differences in the response rates on those two keys individually during extinction do not support this idea, as mentioned previously. Despite this lack of clarity regarding the mechanisms responsible for these observations, the possibility that an extinction burst can be minimized or prevented by training an alternative response in a separate context to the target response is noteworthy because, in many applied circumstances, extinction bursts are undesirable side effects of interventions (Lerman et al., 1999). Although preliminary, these results suggest that if extinction were to be used during an intervention, training the alternative behaviour elsewhere first may reduce the likelihood of the initial extinction burst occurring. This could be especially useful if the problem behaviour is putting either the individual carrying it out, or others around them, at risk (Athens & Vollmer, 2010).

Data from the third and fourth extinction test are also not consistent with behavioural momentum theory. For five out of the six hens, responding was more persistent during extinction on the right yellow key, even when this was paired and presented simultaneously with the left green key which had been presented alone during training. As the baseline schedule for the left green key was richer than the baseline schedule paired with the right yellow key, one would expect persistence during extinction to be greater on the left green key. This finding further supported our idea that the two concurrent yellow keys may have been viewed as one stimulus context, but this finding is not consistent when those two keys are presented together in extinction, as previously discussed.

Overall, the present findings supported those of Podlesnik et al. (2012), and suggest that training an alternative behaviour in a separate context to the one in which the target behaviour is occurring could reduce the persistence-strengthening outcomes associated with traditional DRA methods and, therefore may be a useful alternative approach to conducting DRA procedures. Given this success, Experiment 2 was designed to further investigate if an alternative behaviour trained in a separate context to the target behaviour and then combined in the presence of a disruptor other than extinction, would be less persistent than alternative and target behaviours trained in the same context (such as in a traditional DRA).

Experiment 2: VI 150-s Centre Key Disruptor

Introduction

As outlined earlier, of interest was the persistence of behaviour when assessed using disruptors other than extinction. A further issue with the use of extinction is the increased likelihood of extinction bursts during DRA. Experiment 2 examined the disruptive effects an adding a key, lit red and associated with a lean reinforcement schedule, instead of extinction. Additional reinforcement available on a centre key has previously been used to investigate persistence in chained schedules (Nevin, Mandell, & Yarensky, 1981), however chaining was not used in the present experiment. Furthermore, an alternative stimulus associated with reinforcement is often used as a disruptor in resurgence procedures, but the use of an additional key associated with a reinforcement schedule differed in this experiment. Usually, in a resurgence procedure, there is only one alternative introduced in Context B (see Introduction for a description of a resurgence procedure) and there is no additional response option available at this time. In the present experiment, the alternative and target response options still existed as part of the DRA and Combined Components, and then an additional alternative response option in the form of the red key was added. The hens were free to allocate responding to the red key as they chose, with the exception of during ICIs and when the magazine was raised.

Hens were exposed to the red key on a lean reinforcement schedule in a separate chamber with all other keys unlit and inactive for six sessions prior to the experimental conditions beginning, as it was considered to be possible that the red key would not function as a disruptor without any prior exposure. Replicating the procedure without extinction meant that the fixed-time reinforcement given during the final extinction test of Experiment 1 was problematic when three reinforcement schedules would remain in effect. Therefore, tests with this disruptor were modified as outlined below.

Method

Subjects

The subjects were the same six domestic hens from Experiment 1, numbered 8.1-8.6. Hens were all kept and fed in the same conditions as previously described.

Apparatus

An experimental chamber identical to the one in Experiment 1, but with a single red key in the centre of the panel, was used in the first phase of this experiment. The chamber size and layout were otherwise identical to the first experiment, including the magazine that gave access to wheat as a reinforcer. A computer running MED-PC also controlled all conditions and data collection. The same apparatus as described in Experiment 1 was then used after this first phase.

Procedure

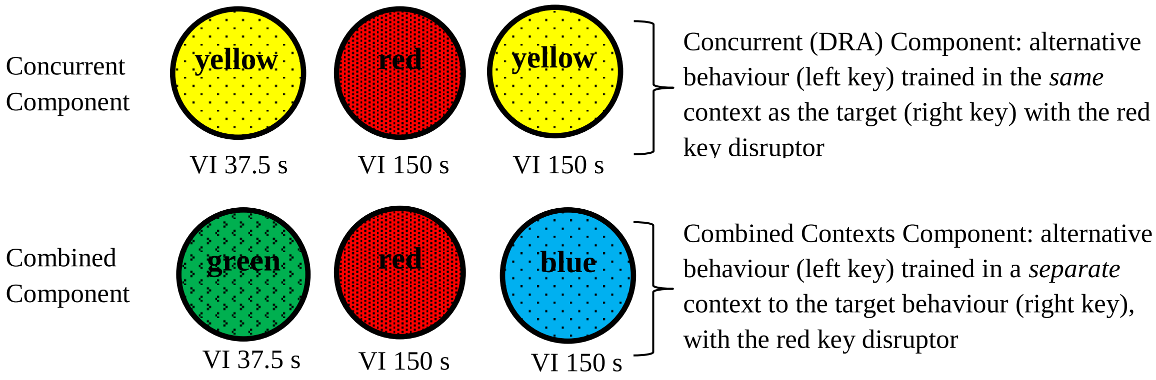
Part 1. Exposure to Centre Key

Hens were trained to respond to a single red key, under a VI 150-s schedule. Sessions ran for 12 minutes, the same length as the total time for one presentation of a component during the baseline procedure previously used. There were a maximum of six reinforcers available during these sessions. These conditions continued for 12 sessions.

Part 2. Experimental Procedure

Following training with the red key, the hens were returned to the same baseline procedure as Experiment 1 (a three-component multiple schedule), for six sessions. This baseline procedure remained the same as in Experiment 1 for the duration of the experiment, in which Component 1 presented two yellow keys concurrently available, associated with a VI 37.5-s schedule on the left and a VI 150-s schedule on the right. Component 2 featured a green key on the left associated with a VI 37.5-s schedule, while the right key was darkened, and Component 3 presented a blue key on the right with a VI 150-s schedule while the left key was darkened. As with Experiment 1, six sessions of baseline occurred before each disruptor test. An additional six sessions of exposure to the red key alone occurred immediately after the disruptor test.

The main difference between Experiment 1 and this experiment was that, in this experiment, a red key associated with a VI 150-s schedule of reinforcement was used as a disruptor rather than extinction. During tests, the red key was presented as shown in Figure 2.1.



Concurrent (DRA) Component: alternative behaviour (left key) trained in the *same* context as the target (right key) with the red key disruptor

Combined Contexts Component: alternative behaviour (left key) trained in a *separate* context to the target behaviour (right key), with the red key disruptor

Figure 2.1. An example of the key colours and schedules during the disruptor components, demonstrating the positioning of the red key. Exact combination of components and keys is shown in Table 2.

The red key was lit and operative during all disruptor tests. The testing conditions are outlined in Table 2. The same combinations of stimuli and keys as used in Experiment 1 were used. However, the right blue key was not presented on its own during the first and third disruptor tests as it was in Experiment 1. During the third disruptor test, this omission was a procedural error, so the data from this disruptor test needs to be interpreted with caution. The fifth and final disruptor test had to be modified from the previous experiment, as that final test using Fixed-Time reinforcement only worked when extinction was in effect, so the same stimulus arrangements as in the first two disruptor tests were presented, but with no change to the reinforcement schedules. Schedules of food reinforcement associated with each key position and colour remained in effect throughout baseline and all testing components.

Table 2.1. The component combinations and key colours as presented during the disruptor tests. The numbers indicate the schedules active on each of the keys.

Disruptor Test	Components	Key Colours and Schedules		
1	comp. 1	🟨 37.5	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	🟦 150
2	comp. 1	🟨 37.5	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	🟦 150
3	comp. 1	🟩 37.5	🟥 150	🟨 150
	x	▨	▨	▨
4	comp. 1	▨	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	▨
	comp. 3	▨	🟥 150	🟦 150
5	comp. 1	🟨 37.5	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	🟦 150

Results

Baseline

Figure 2.2 displays the mean baseline response rates for each hen for each component over the six baseline sessions prior to each disruptor test on a logarithmic scale. All hens responded less to the right yellow key than to the left yellow key, left green key, or right blue key during each repeated baseline test. Responding on both the yellow and green left key options was very similar across baselines for all hens except for Hens 8.3 and 8.6, who both responded at consistently higher rates to the right blue key. Baseline responding was reasonably stable across repeated tests, especially for Hens 8.2 and 8.6. A two-way repeated measures ANOVA comparing the mean number of responses on all keys across baseline sessions showed a significant interaction across the five repeated baselines, $F(12,60) = 1.859$, $p < .05$, $\eta_p^2 = .271$, a significant main effect of response type, $F(3,15) = 9.741$, $p < .05$, $\eta_p^2 = .661$, and of session $F(4,20) = 3.251$, $p <.05$ $\eta_p^2 = .394$.

Disruptor Test 1 and 2

Figure 2.3 shows the responses as a proportion of baseline response rates plotted across successive sessions of the first disruptor test. For all hens, proportional responding on the right yellow key was higher than that on the right blue key. Hen 8.4 consistently did not respond on the right blue key until the second to last session of the disruptor test, and Hen 8.5 did not respond on this key either until the very last session of the test. For all hens other than 8.4, responding on the left yellow key and the left green key tended to decrease over sessions, even though the reinforcement schedule was still in effect.

Overall, right yellow key responding continued to be proportionally greater than right blue key responding for all hens throughout the duration of the test. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key with those on the right blue key during the disruptor was significant; *t*(5) = 6.359, *p* = .001, *d* = 2.488.

Figure 2.4 shows the response rates as a proportion of their baseline response rate plotted across successive sessions for the second disruptor test. Once again, proportion of baseline responding on the right blue key was lower than that of both yellow keys and the left green key for five out of the six hens.

Proportionate to baseline, responding on the right yellow key was consistently higher than responding on the other (left) yellow key and on both the green or blue keys for Hens 8.1 and 8.2 throughout, and for Hen 8.5 for the last four sessions of the test. For Hens 8.3 and 8.4, responding on the right blue key was still less than all other keys proportionate to baseline, but responses on all other keys rose above baseline levels of responding from the third session onwards. Responding proportionate to baseline on both the left yellow and left green keys was very similar across all sessions for five out of the six hens. Hen 8.6 displayed inconsistent patterns of responding compared to the other hens, and responses remained approximately level with baseline on all keys throughout all disruptor test sessions. A paired-samples t-test compared the mean proportion of baseline responding on the right yellow key with those on the right blue key during the disruptor tests, and was significant, *t*(5) = 3.338, *p* = .021, *d* = 2.049, showing that responding, proportionate to baseline, was lower on the right blue key than on the right yellow key.

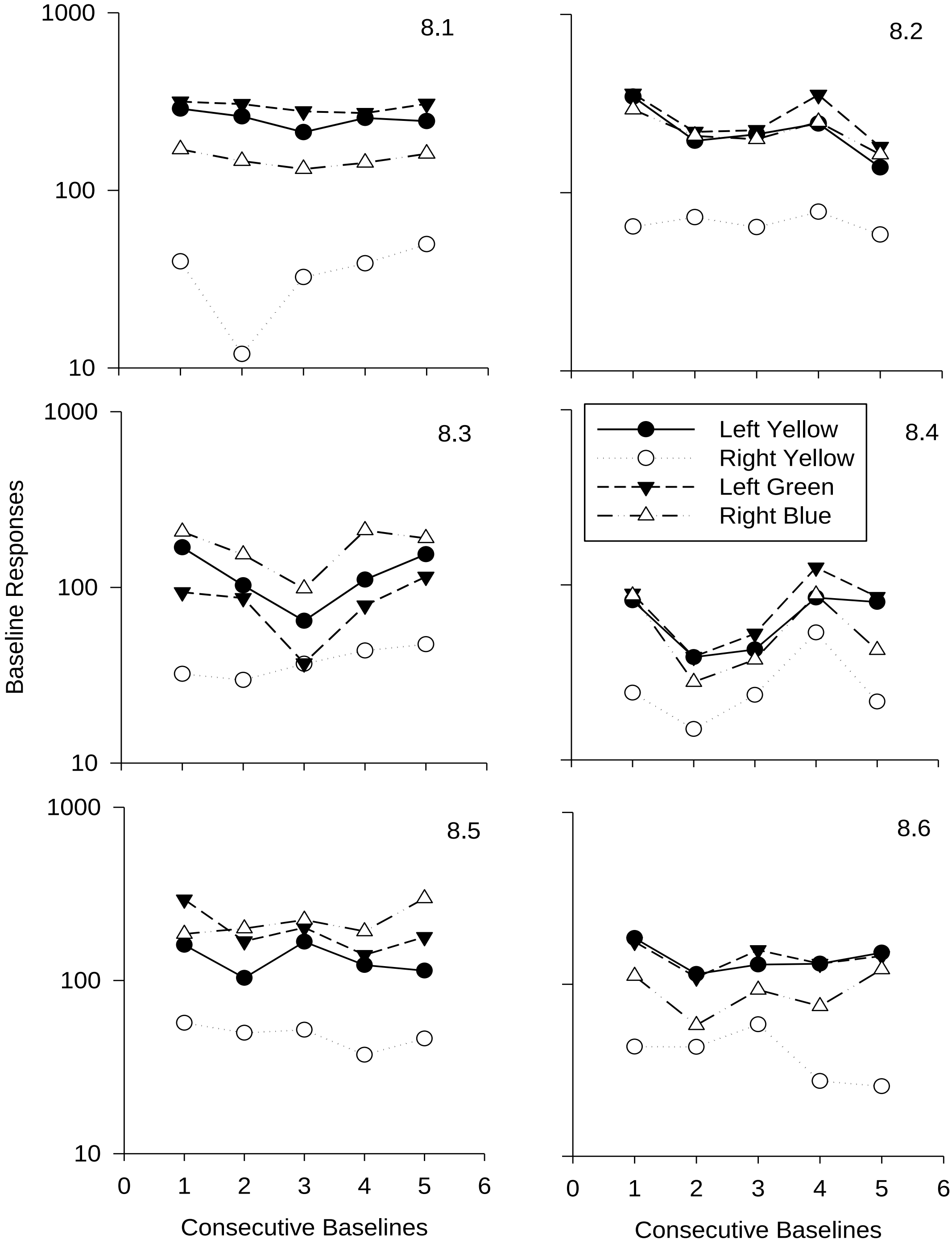


Figure 2.2. Mean baseline response rates from the last six sessions of baseline prior to each disruptor condition. The y-axis is presented on a log scale. Circles represent Component 1 (filled circles = left yellow key, open circles = right yellow key) and triangles represent Components 2 and 3 (filled triangles = left green key, open triangles = right blue key).

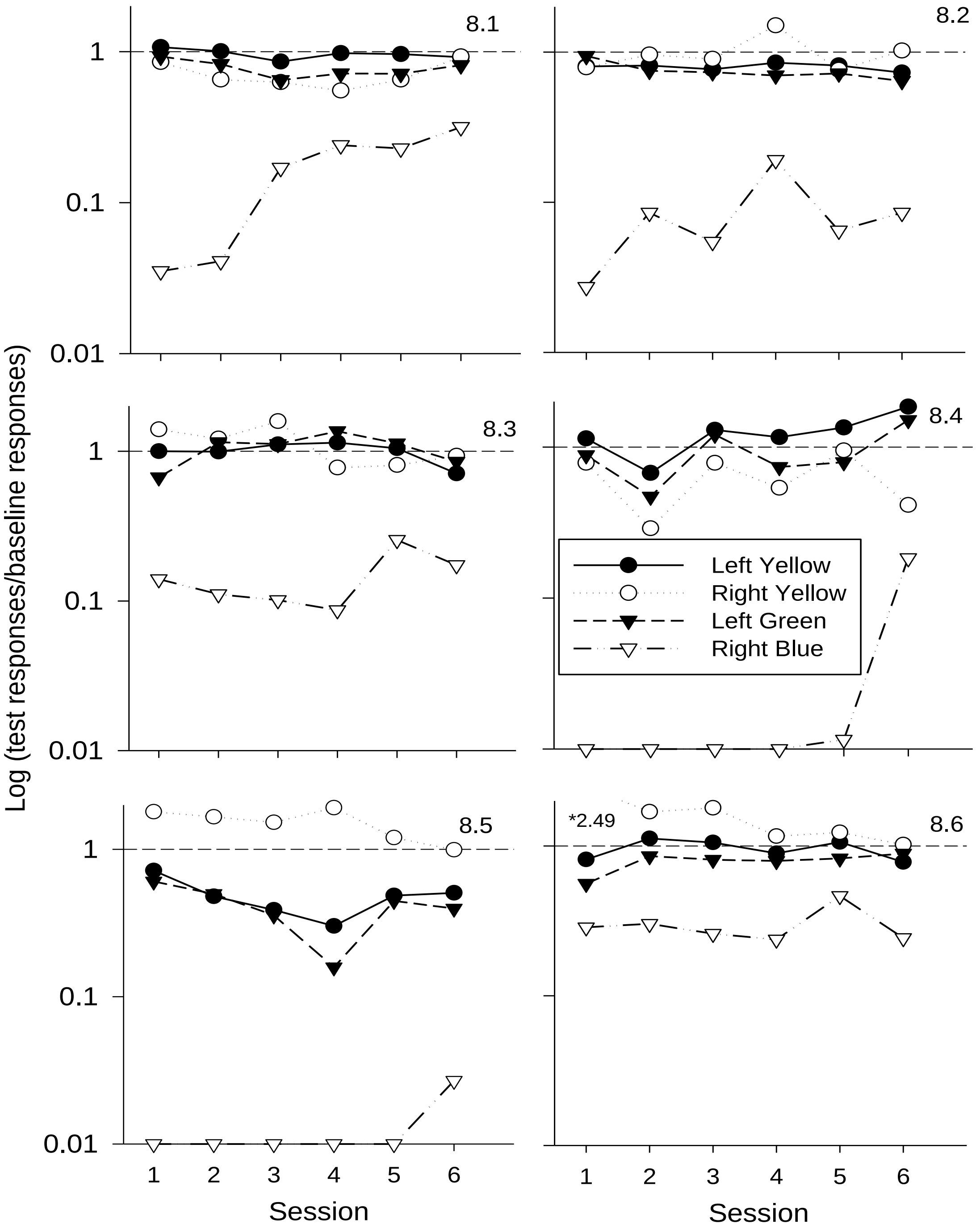


Figure 2.3. Responding during the first disruptor test plotted as a proportion of baseline responding for all hens. The y-axis is on a log scale and baseline responses are represented by the dashed line. Circles represent the Concurrent Component (filled circles = left yellow key, open circles = right yellow key), and triangles represent the Combined Component (filled triangles = green left key, open triangles = right blue key). In both components the red key was presented as the disruptor (not shown on graph). Data points at 0.001 represent zero responding.

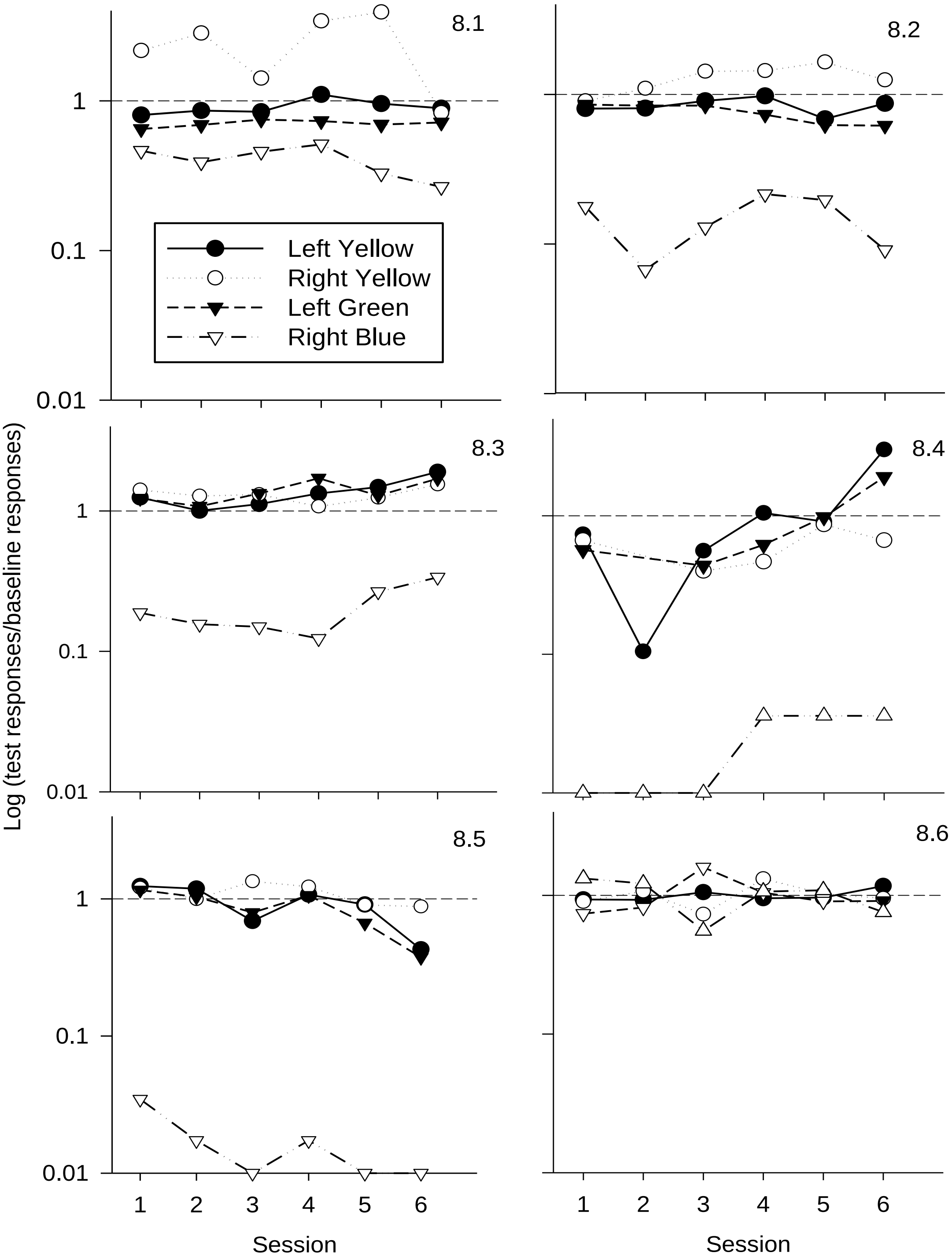


Figure 2.4. Responding during the second disruptor test plotted as a proportion of baseline responding for all hens. The y-axis is on a log scale and baseline responses are represented by a dashed line. Circles represent the Concurrent Component (filled circles = left yellow key, open circles = right yellow key), and triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key). In both components the red key was presented as the disruptor (not shown on graph). Data points at 0.001 represent zero responding.

Figure 2.5 displays the number of responses on the red (disruptor) key during the first two disruptor tests. During the initial few sessions of the first disruptor test, the number of responses on the red key disruptor was very low. Responding on the red key however changed between disruptor tests 1 and 2, even though the stimuli presented were the same in both tests. In the second disruptor test, Hen 8.1's red key responding reduced when presented alongside the combined green and blue keys, but increased when presented alongside both yellow keys, resulting in similar rates of responding on the red key in both components. Hen 8.2, who had only started to respond to the red key during the second to last session of the first disruptor test, responded at a higher rate than any other hen to the red key during both components in which it was presented during disruptor 2. Hen 8.6's response rate also increased in the second disruptor test, particularly towards the end. Hen 8.3 and 8.5 responded similarly in both disruptor tests with only the occasional peck on the red key, and Hen 8.4's responding stayed quite similar across both tests.

Figure 2.6 shows the mean number of responses on each key summed for all sessions for all hens during the initial baseline and the first disruptor test using the red key disruptor. This was calculated to examine any potential increase or decrease in responding overall in the presence of the red key disruptor. The mean number of responses in the presence of the red key as a disruptor, decreased compared to baseline levels of responding, however numbers of responses on the red key itself (shown in Figure 2.5) were relatively low for all hens other than 8.1 and 8.4 during the first disruptor test. Despite low response rates on this key however, there was also a reduction in the number of responses emitted to the other response options, relative to baseline levels. A paired-samples t-test compared the mean number of responses overall in baseline on yellow, green and blue keys with the mean number of responses overall during the disruptor tests, and showed there was a statistically significant difference between the total number of responses emitted in the presence and the absence of the red key disruptor, $t(5) = 4.584$, $p = .006$.

Figure 2.7 shows the mean number of responses on each key summed for all sessions for all hens during the second baseline exposure and the second disruptor test using the red key disruptor. On average, the number of responses for all hens during the disruptor test reduced comparative to baseline levels. Exceptions to this were Hen 8.2, whose right blue key responding increased in the presence of the disruptor, and Hen 8.6 whose right blue key and left yellow key responding also increased in the presence of the disruptor. Even though the number of responses on the red key increased during this test (see Figure 2.5), the mean number of responses on the other available keys decreased again, similar to that of Disruptor Test 1. A paired-samples T test compared the mean number of responses on all keys in the second baseline exposure with the mean number of responses overall during the second disruptor test revealed a statistically significant difference between the number of responses in the presence and absence of the red key; $t(5) = 2.837$, $p = .036$.

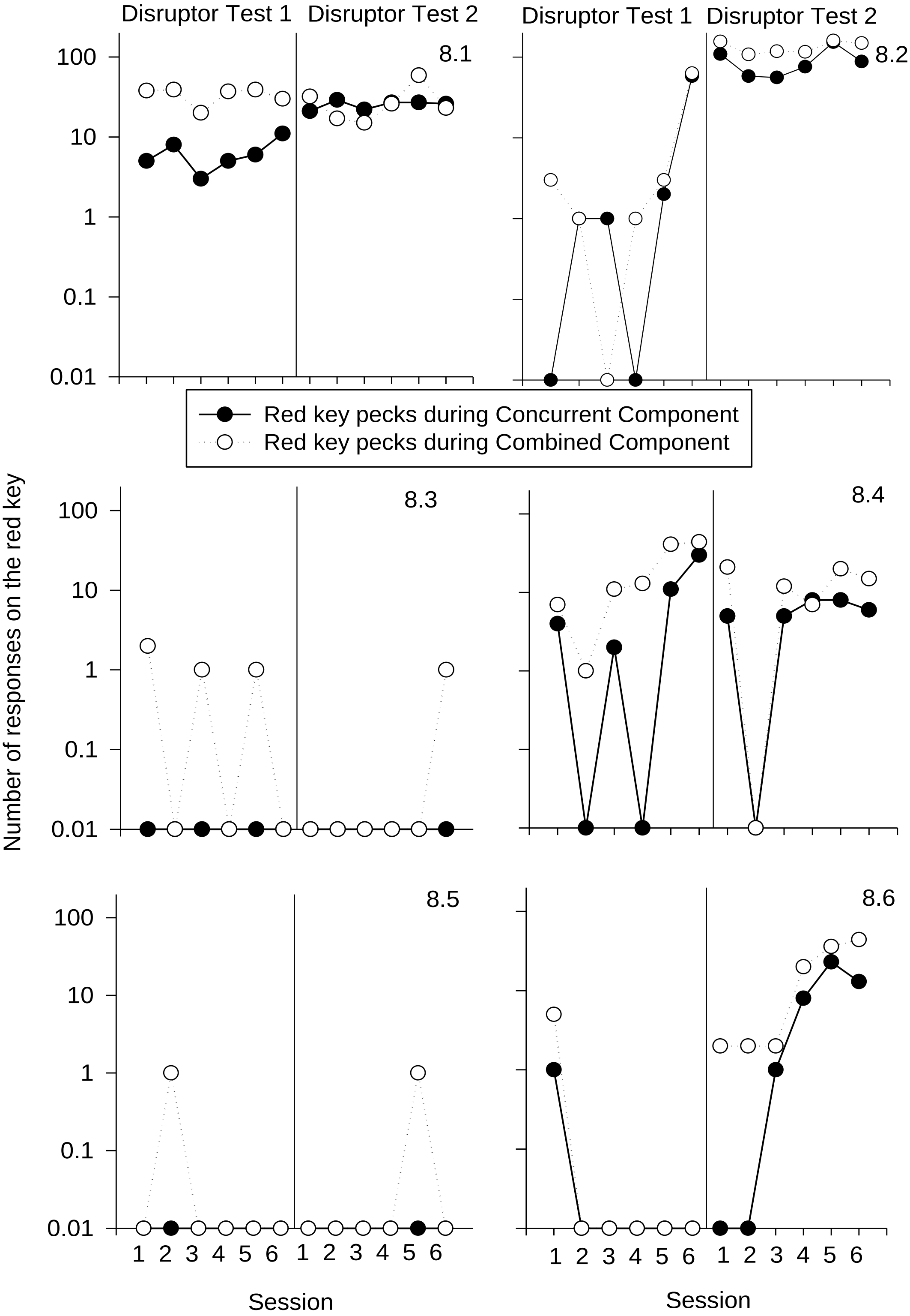


Figure 2.5. Number of responses on the red key for all hens during the first (left columns) and second (right columns) disruptor tests. The y-axis is on a log scale. Red key responses during the Concurrent Component are represented by a filled circle and red key responses during the Combined Component are represented by an open circle. Data points at 0.01 represent zero responding.

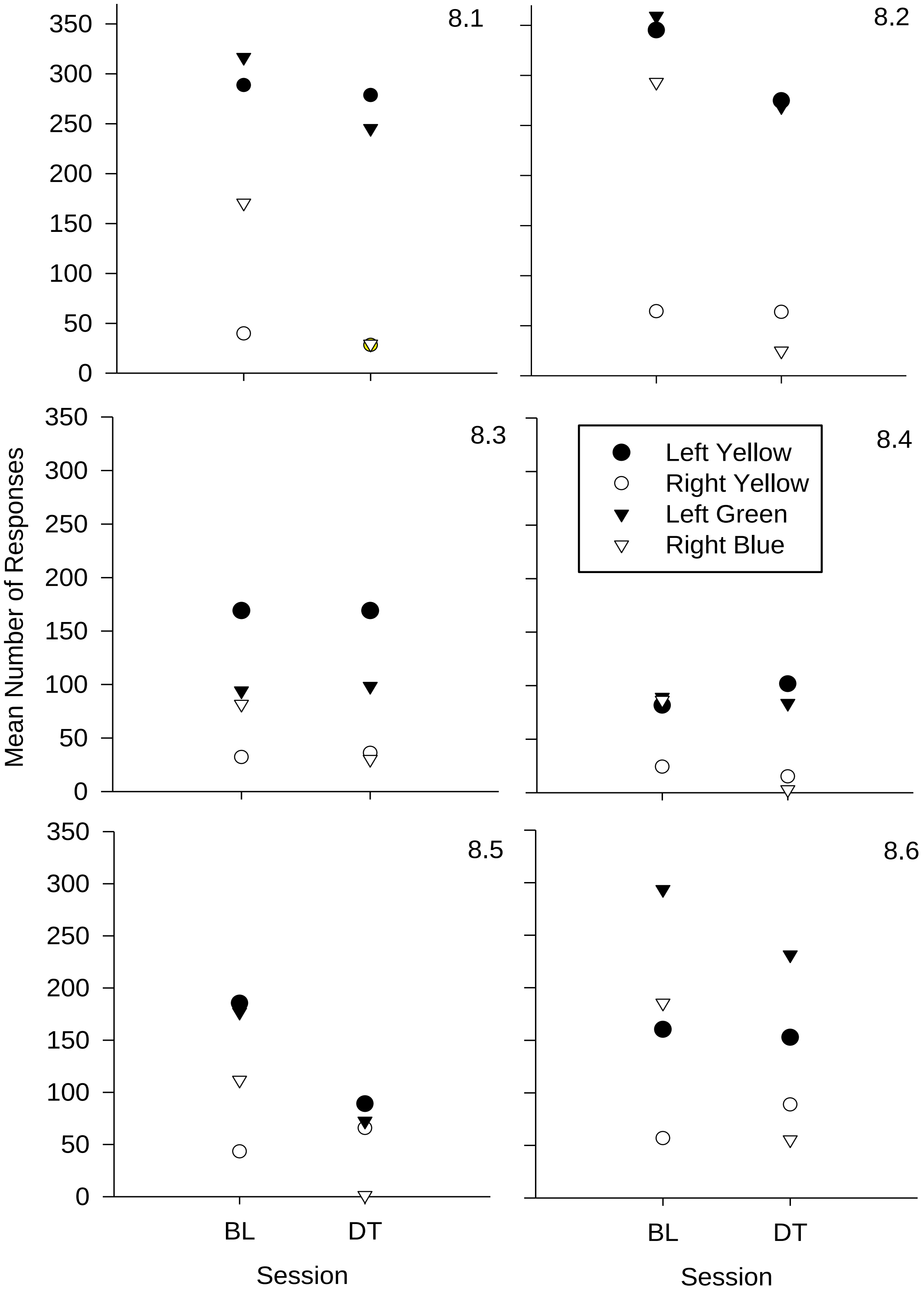


Figure 2.6. Mean number of responses on each key for all six hens during baseline and the first disruptor test. The Concurrent Component is represented by the circles and the triangles represent the stimuli trained separately during baseline, and then presented as the Combined Component during the first disruptor test.

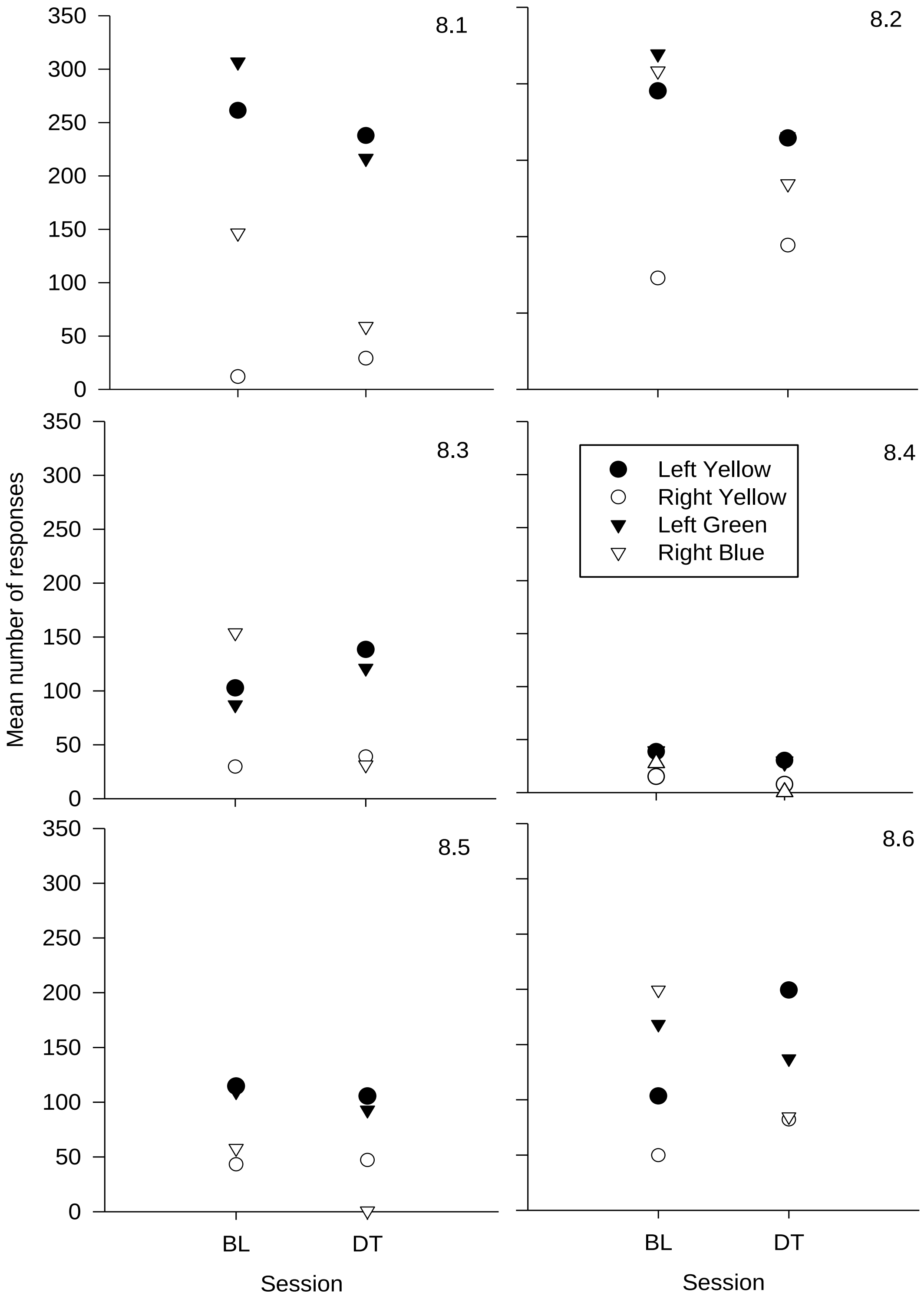


Figure 2.7. Mean number of responses on each key during baseline and the second disruptor test for all six hens. Circles represent the Concurrent Component and triangles represent the stimuli trained separately during baseline, and then presented as the Combined Component during the second disruptor test.

Disruptor Tests 3 and 4

Due to a procedural error, presentations of the right blue key were not programmed during the third disruptor test, and so no comparison to this key was possible. Despite this, the data from this disruptor test, which paired the left green key with the right yellow key in one component, are shown in Figure 2.8. For four out of six hens, responding was greater proportionate to baseline on the left green key throughout the duration of the disruptor test. Responding remained near to baseline levels for all hens with the exception of 8.2's responding on the right yellow key. Proportion to baseline responding was however greater on the right yellow key for Hen 8.1 throughout the entire disruptor test, and for Hen 8.6 during the second and third session. Overall the data from this disruptor test are non-conclusive due to the absence of comparison to responding on the right blue key.

Figure 2.9 shows responding as a proportion of baseline for the right yellow key, the left green key, and the right blue key presented during the fourth disruptor test. Responding proportionate to baseline on the right yellow key was greater than that on the left green key, and the right blue key for all hens, with the exception of 8.4 in the final session, and Hens 8.5 and 8.6 on their last two sessions of the test. Despite this, there was less responding, proportionate to baseline, on the right blue key than there was on the right yellow key, and this difference was significant; $t(5) = 4.640$, $p = .006$, $d = 1.749$. Responding on the left green and right blue keys dropped comparative to baseline levels (less than 1) for most of the hens in the presence of the red key in this disruptor test, with 8.4's responding dropping to below baseline levels on all keys from the second session onwards.

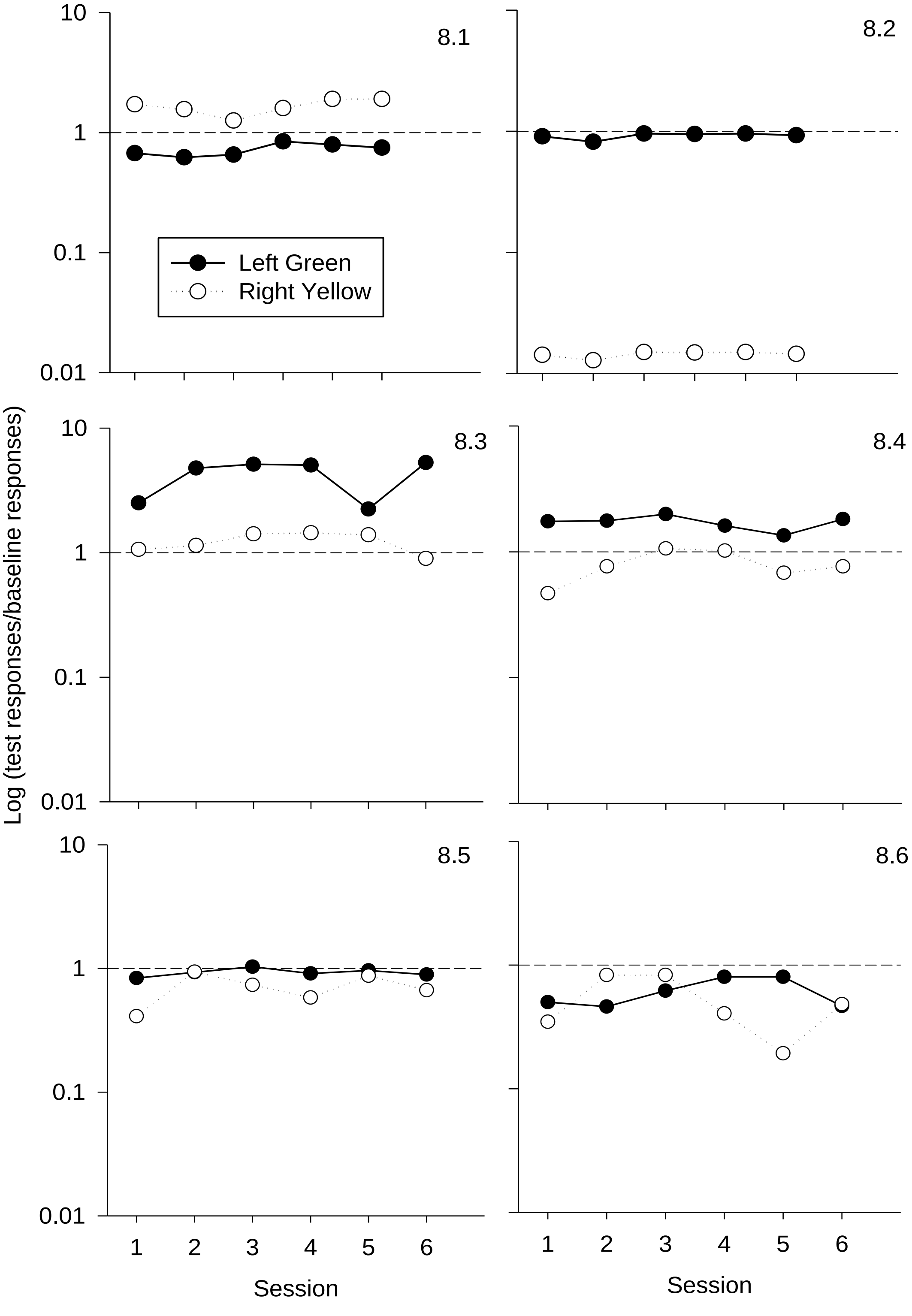


Figure 2.8. Responding plotted as a proportion of baseline for all hens during the third disruptor test which presented the left green key (filled circles) and the right yellow key (open circles) in one component with the red key situated in between (not shown on graph). The y-axis is on a log scale and the dashed line represents levels of baseline responding.

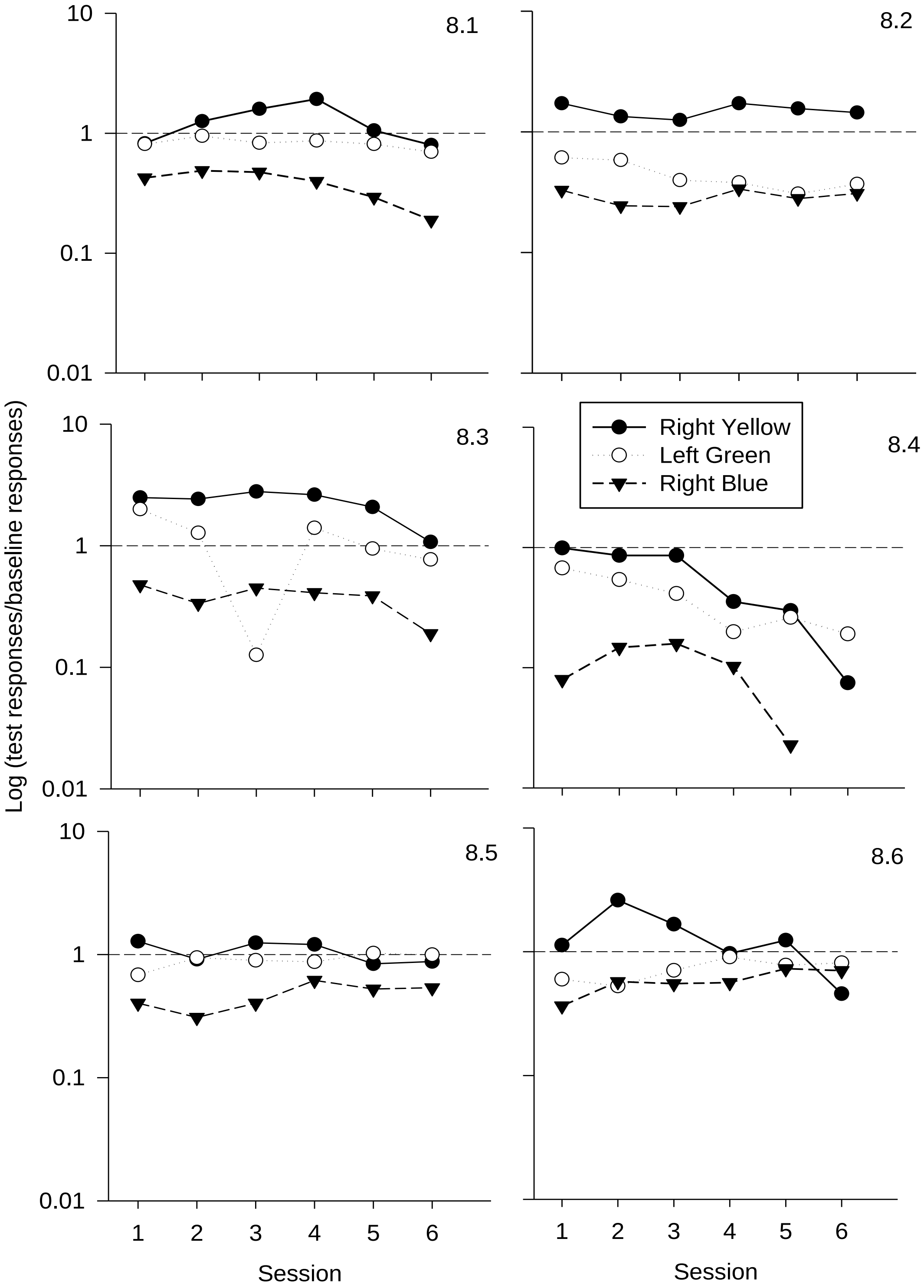


Figure 2.9. Responses plotted as a proportion of baseline responding for all hens during the fourth disruptor test, which presented the right yellow key, the left green key, and the right blue key individually, all paired with the red key as a disruptor (not shown on graph). The y-axis is on a log scale, with the dashed line representing levels of baseline responding. Filled circles represent the right yellow key, open circles represent the left green key and filled triangles represent the right blue key.

Figure 2.10 shows the number of responses on the red key during the third and fourth disruptor tests. Interestingly, the number of responses on the red key changed during Disruptor Test 4. As shown in Figure 2.10, for five hens, 8.4 being the exception, responding on the red key increased at the start of the test (right columns), in the three components in which it was presented, compared to the previous disruptor test (left columns). Responding on the red key then decreased over the course of the test for all hens other than 8.5, but for most hens the levels of responding on the red key did not return to the levels previously seen during the first two disruptor tests (see Figure 2.5). Responding on the red key was greater in the component in which the right keys were presented alone (Components 1 (right yellow key) and 3 (right blue key)).

As suggested by the proportion of baseline data for Disruptor Tests 3 and 4, the number of responses on the keys in the presence of the red key disruptor remained fairly similar to baseline levels of responding. Figure 2.11 shows the mean number of responses on each key across baseline sessions preceding the disruptor test (left columns), and the mean number of responses on each key during the disruptor tests (right columns). The mean number of responses for Hens 8.1, 8.2, 8.5 and 8.6 all decreased on the left green key once it was paired with the right yellow key in Disruptor Test 3 and presented alongside the red key disruptor. Responses on the right yellow key however reduced for all hens other than 8.1 and 8.4. The mean number of responses in baseline and Disruptor Test 4, however, show more conclusive results. For all hens, responding on the left green key and the right blue key dropped between baseline and the disruptor test, but responding on the right blue key remained higher than responding on the right yellow key for three out of the six hens. Responding on this right yellow key also increased during the disruptor test compared to baseline levels for most of the hens.

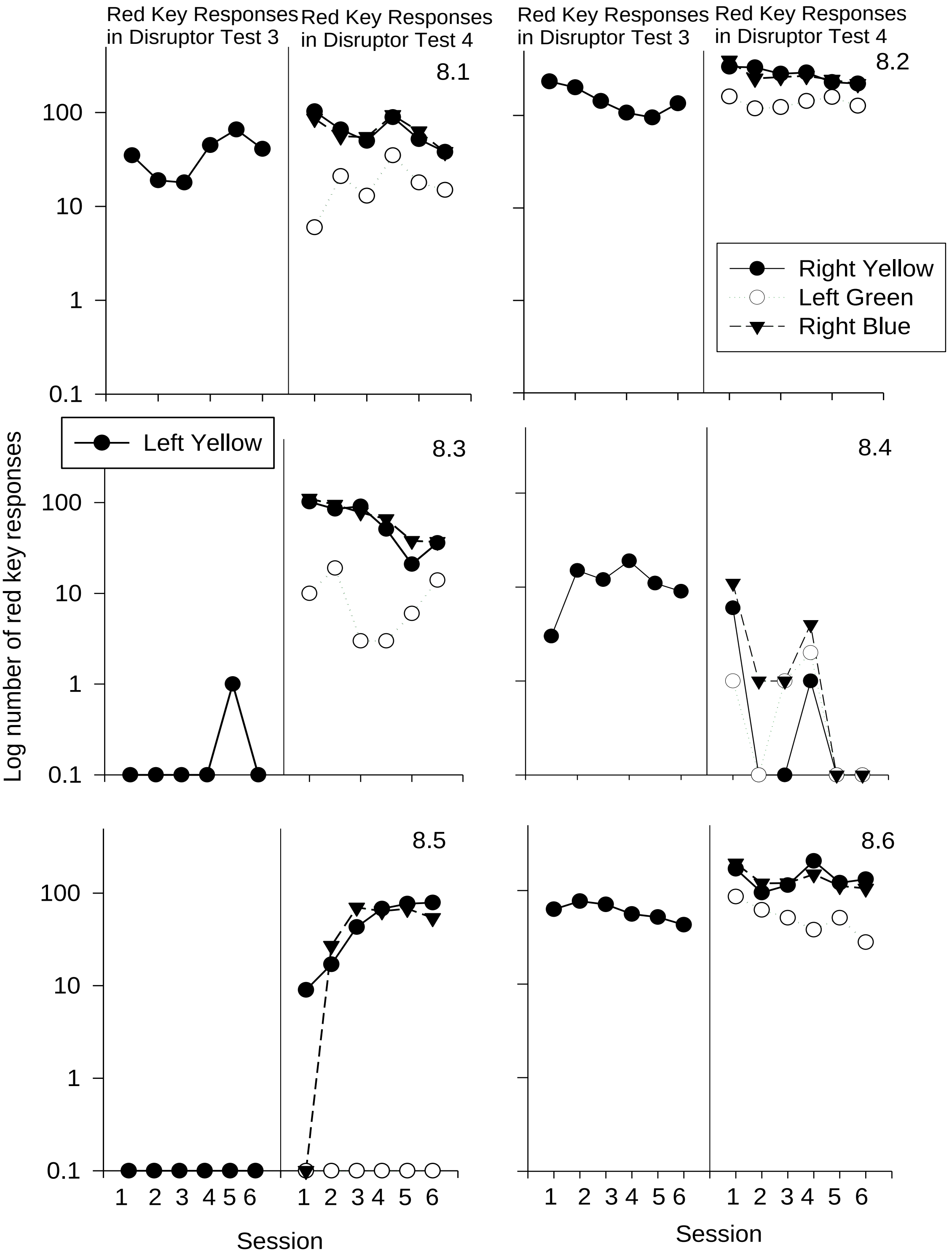


Figure 2.10. Number of responses on the red key during the third (left columns) and fourth (right columns) disruptor test. The y-axis is on a log scale. Red key responses during the only component of Disruptor Test 3 are represented by a filled circle (left columns), with data points at 0.01 equaling no responding on the red key. Red key responses during Disruptor Test 4 are shown by filled circles (responding on the red key in the presence of the right yellow key), open circles (responding on the red key in the presence of the left green key) and the filled triangles (responding on the red key in the presence of the right blue key).

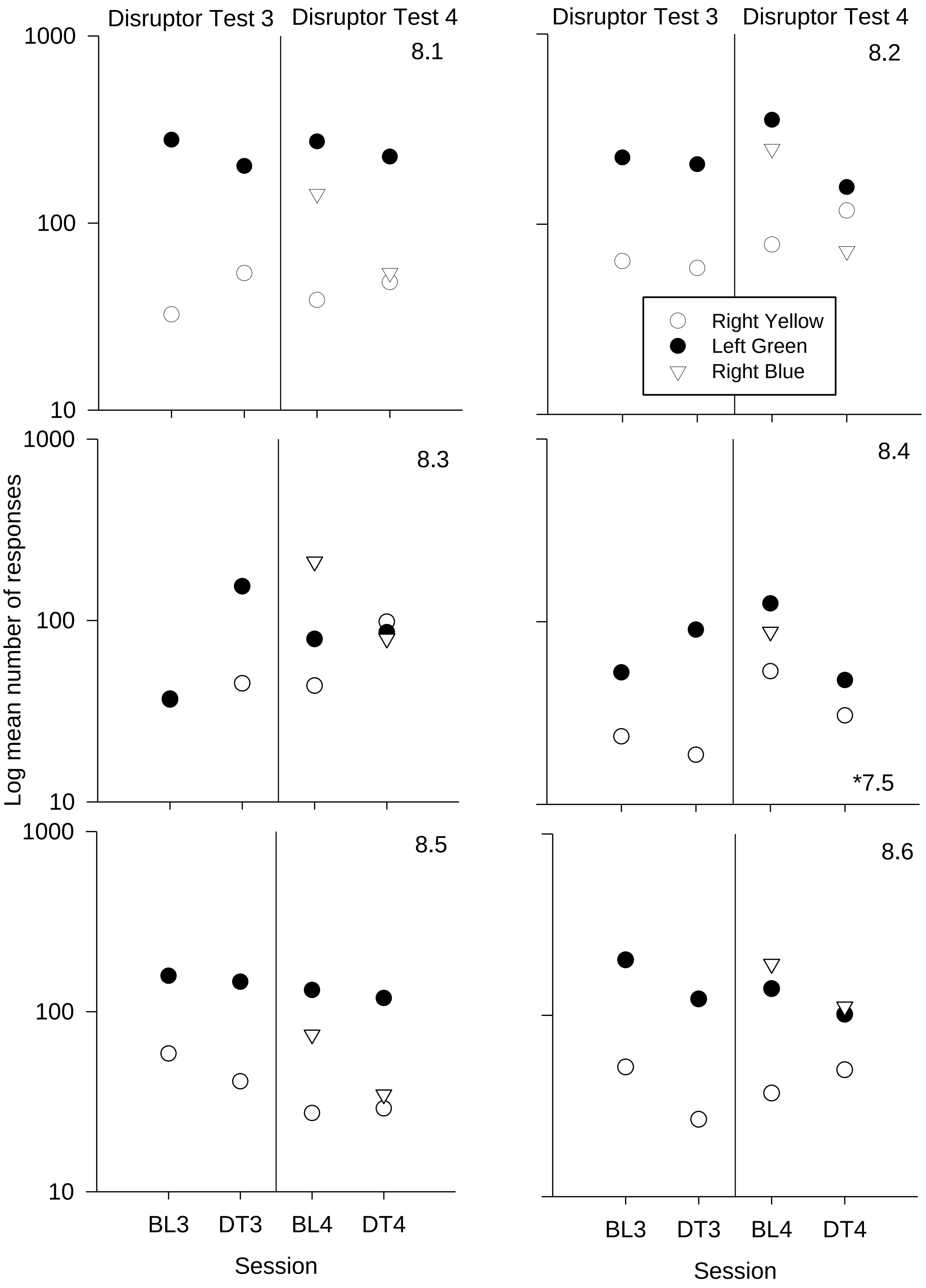


Figure 2.11. Mean number of responses on each key for all hens during baseline and the third (left columns) and fourth (right columns) disruptor test. The y-axis is on a log scale. Disruptor Test 3 presented the left green key (filled circles) and the right yellow key (open circles) in one component with the red key situated in between (red key responses not shown here). Disruptor Test 4 presented the right yellow key (open circles), the left green key (filled circles) and the right blue key (open triangles) in individual components alongside the red key disruptor (red key responses not shown here).

Disruptor Test 5

Figure 2.12 shows responding as a proportion of baseline for the fifth disruptor test; in which both yellow keys were presented concurrently and the left green key and the right blue key were presented concurrently along with the red key as a disruptor. Once again, the number of responses proportionate to baseline was lower on the right blue key than on both yellow keys and the left green key, and this is especially notable for Hens 8.4 and 8.5, who's responding dropped to zero for more than one session as seen in Figure 2.12. A paired-samples t-test compared the mean proportion of baseline responding on the right yellow key with that on the right blue key during the disruptor tests, and was significant, *t*(5) = 7.321, *p* = .001, *d* = 2.448, showing that responding, proportionate to baseline, on the right blue key was lower than on the right yellow key. Responses on the red key, as shown in Figure 2.13, dropped compared to the fourth disruptor test, to the levels of responding on this key seen during the first two disruptor tests.

Figure 2.14 shows the mean number of responses on each key summed for all sessions for all hens during the final baseline presentation and the fifth disruptor test using the red key disruptor. For all hens, the average drop in the number of responses in the presence of the red key is evident in the right hand side of each of the graphs. The most noticeable reduction in the mean number of responses was on the right blue key for all hens except 8.4 whose responses on this key actually rose during the disruptor test. A paired-samples T test between the mean number of responses on all keys in the final baseline exposure and the mean number of responses overall during the fifth and final disruptor test and revealed a statistically significant difference between the number of responses in the presence and absence of the red key; *t*(5) = 5.104, *p* = .004.

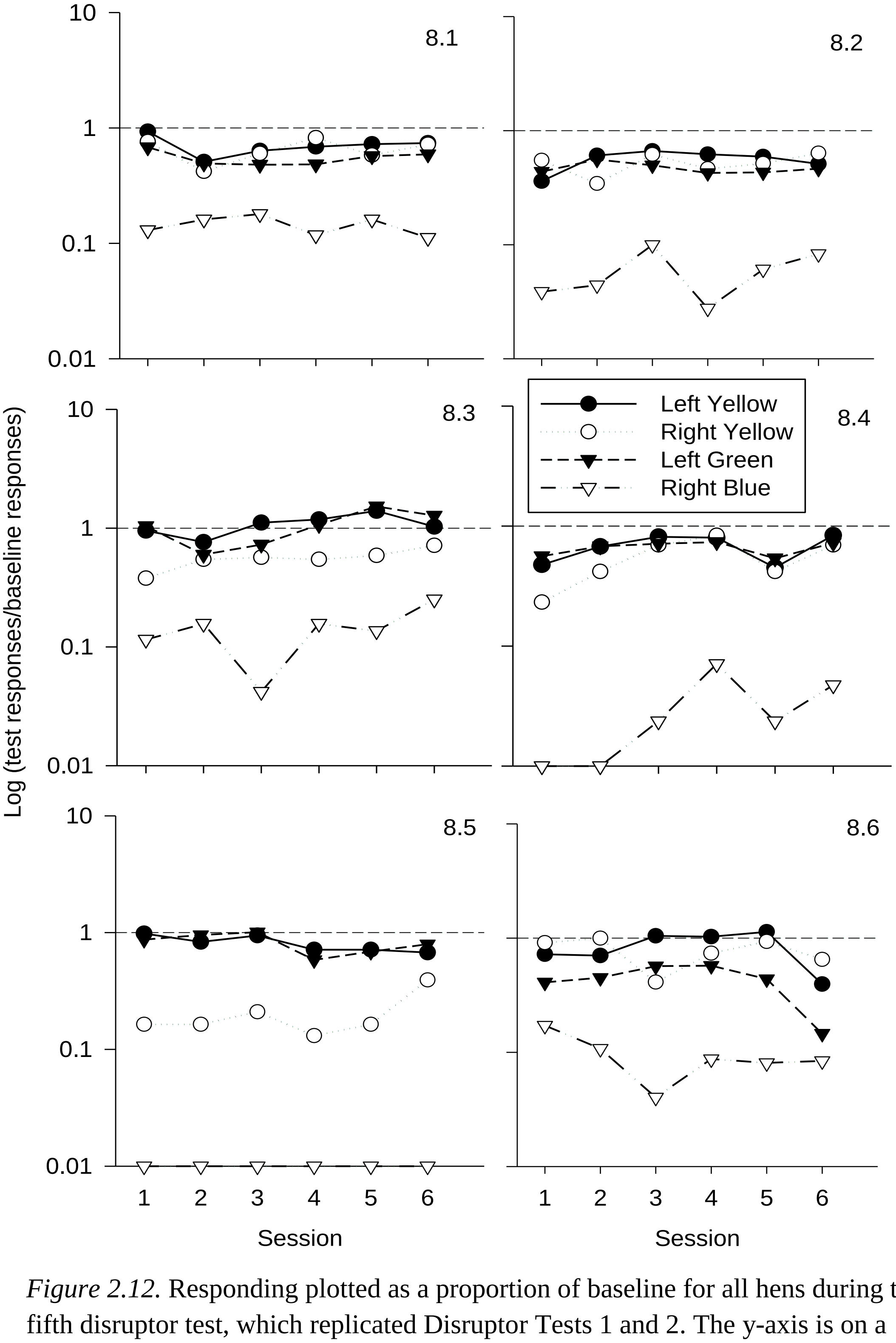


Figure 2.12. Responding plotted as a proportion of baseline for all hens during the fifth disruptor test, which replicated Disruptor Tests 1 and 2. The y-axis is on a log scale, and levels of baseline responding are shown by the dashed line. Circles represent the Concurrent Component (filled circles = left yellow key, open circles = right yellow key), and triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key). In both components the red key was presented as the disruptor (not shown on graph). Data points at 0.01 represent zero responding.

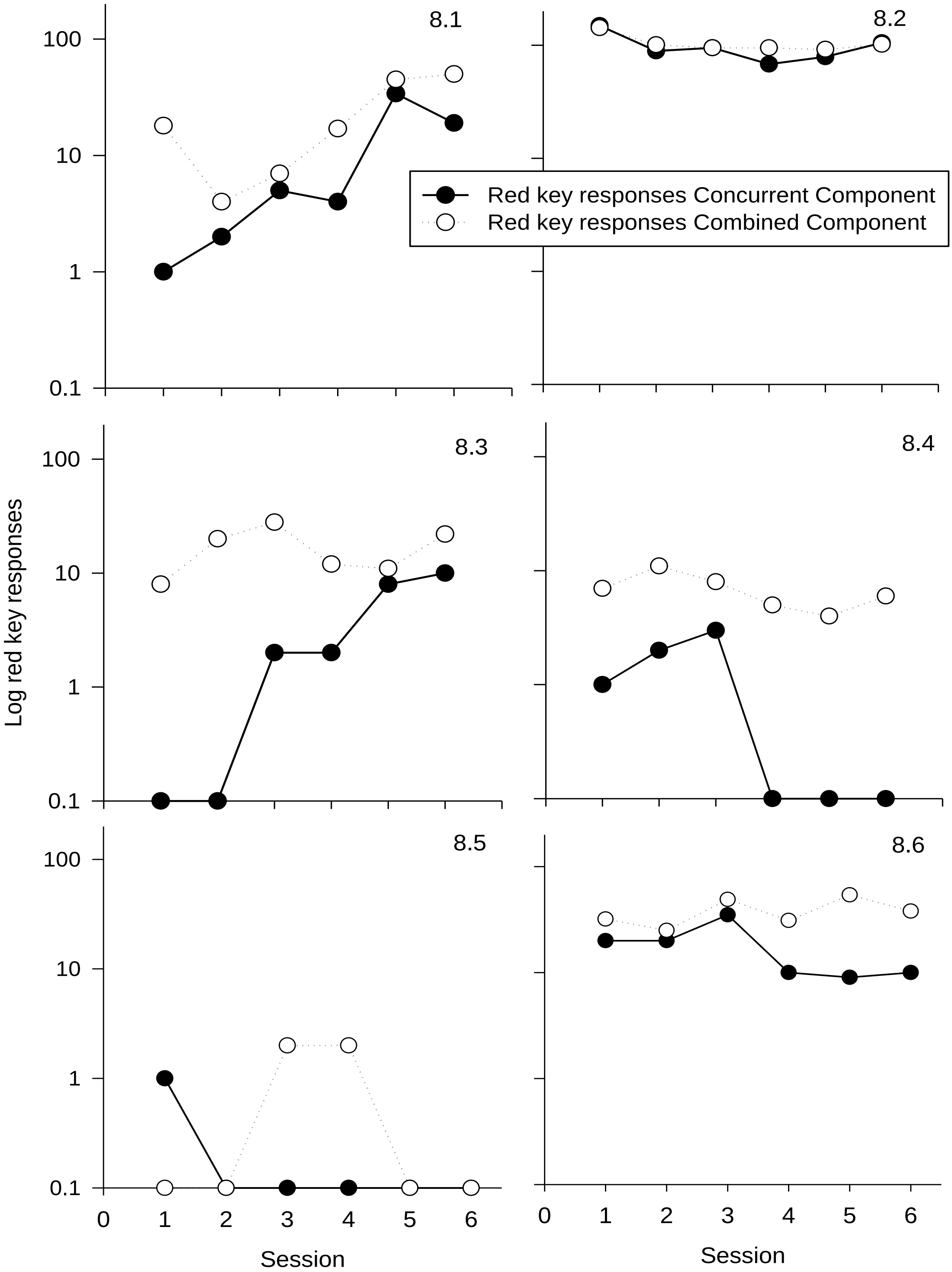


Figure 2.13. Number of responses on the red key for all hens during the fifth disruptor test. The y-axis is on a log scale. Red key responses during the Concurrent Component are represented by a filled circle and red key responses during the Combined Component are represented by an open circle. Data points at 0.01 represent zero responding.

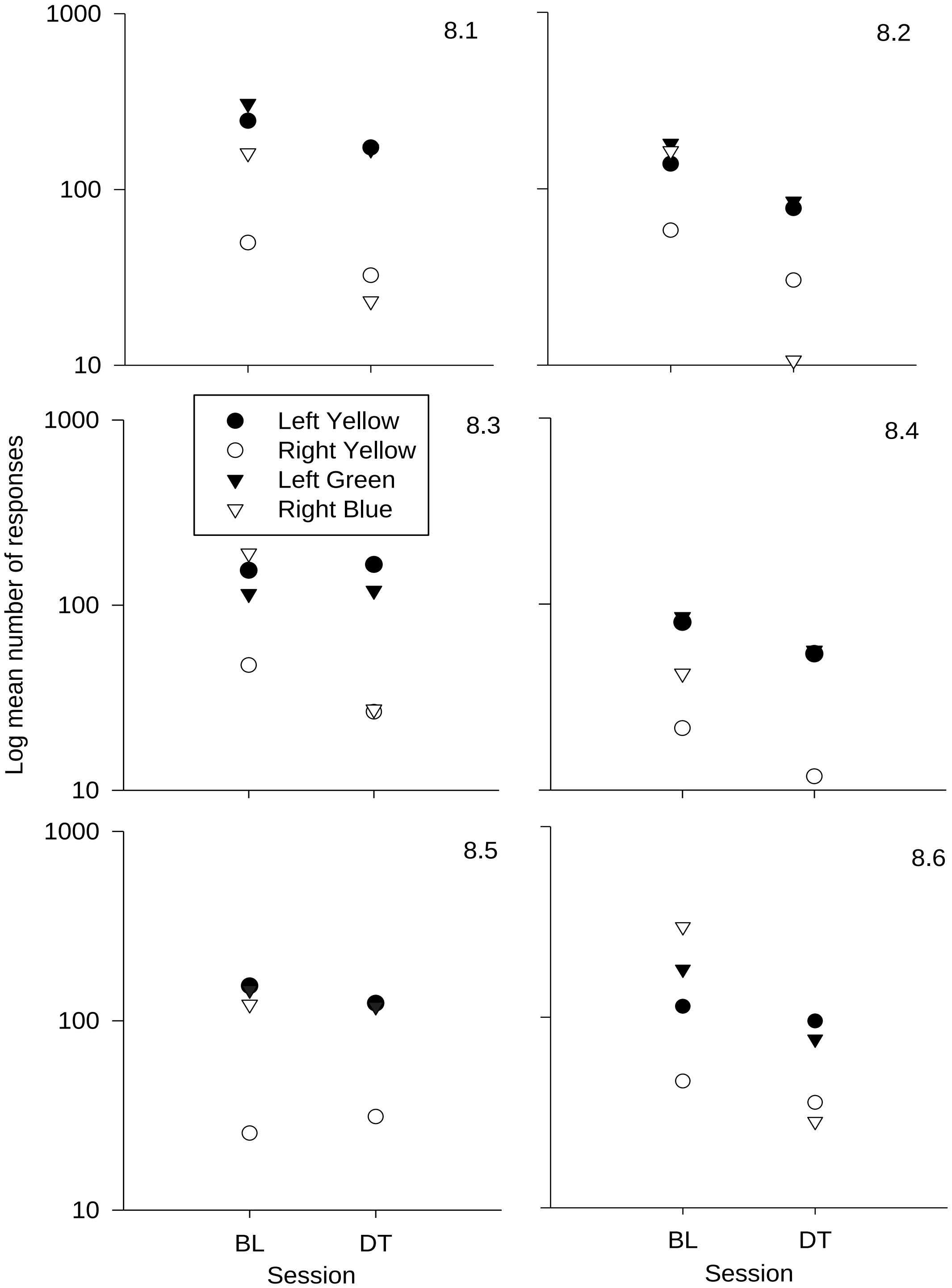


Figure 2.14. Mean number of responses on each key during baseline and the fifth disruptor test for all hens. The Concurrent Component is represented by the circles (filled = left yellow key, open = right yellow key) and the triangles represent the stimuli trained separately during baseline, and then presented as the Combined Component during the fifth disruptor test (filled = left green key, open = right blue key).

Discussion

Experiment 2 aimed to extend the findings of Experiment 1, and the existing literature (Mace et al., 2010; Podlesnik et al., 2012), by investigating the effects of training an alternative behaviour in a context separate to that in which the target behaviour is occurring, in the presence of a disruptor.

Data from the first two disruptor tests conducted in Experiment 2 showed promising results for the possibility of training an alternative behaviour in a separate context to the target behaviour, when compared to the traditional DRA method of training the alternative behaviour alongside the target in the same environment (Concurrent Component).

What is interesting about these findings is that whilst most measures of persistence are examined using a proportion of baseline measure, the mean number of responses during the first two disruptor tests also decreased on the right blue key following alternate context training. As shown in Figures 2.6 and 2.7, with a few exceptions, the average number of responses on the right blue key decreased comparative to baseline levels, and in many cases decreased below the average number of responses on the right yellow key as well. This data analysis supports the use of proportion of baseline responding as a measure in a procedure using a disruptor other than extinction, and warrants further investigation to see if these effects are replicable with other disruptors maintaining reinforcement.

There is little comparison possible for the third disruptor test due to the right blue key not being presented during the experiment so the data are shown here to highlight the red key responses during this disruptor test (see discussion below). It is however worth noting that for three of the hens, right yellow key responses during some sessions were as persistent (proportionate to baseline) as the left green key responses, which had been trained and consistently maintained on a richer schedule. The left column of Figure 2.11 suggests a reduction in responding on the right yellow key compared to the preceding baseline exposure, and a decrease in responding on the left green key for most of the hens compared to baseline as well. It is not clear if this change in responding between baseline and the disruptor test was due to the pairing of two stimuli previously trained separately, or due to the presence of the red key.

In the fourth disruptor test, earlier findings were once again supported with the reduced persistence of responding on the right blue key compared to the right yellow key. Whilst responses overall did not drop as greatly as Disruptor Tests 1 and 2, there was still a noticeable difference between the average number of responses during the fourth baseline exposure and the average number of baseline responses during the disruptor test (see Figure 2.11, right columns). The average number of right blue key responses dropped greatly during the disruptor tests, even though in this particular test, the right blue key was presented alone with the red key, and not combined with the left green key. This suggests that responding on the right blue key will be less persistent in the presence of the disruptor.

In most cases however, mean right blue key responses did not drop below the mean number of right yellow key responses during this disruptor test. The mean number of responses on the right yellow key increased during the disruptor test compared to the baseline levels of responding for five out of the six hens, whereas right blue key responding decreased. This suggests that responding on the right yellow key was more likely to increase in the presence of the disruptor, whereas right blue key responding was more likely to decrease.

One possible explanation for this is that in baseline exposures, and most other disruptor tests, the right yellow key is always paired with the left yellow key, and as behavioural momentum theory would suggest, this combination of reinforcement schedules would result in an association with both yellow stimuli and greater availability of reinforcement. The right blue key on the other hand, is always trained in a separate context to any other key and was presented this way just in the presence of a disruptor. The reduction in responding on the right blue key, and the subsequent increase in responses on the right yellow key, both in the presence of the red key disruptor, suggest that responding to the right blue key trained alone will be less persistent than responding to the right yellow key trained and associated with the richer reinforcement schedule occurring on the left yellow key.

In applied terms, this finding is significant, because it shows that when the richer alternative reinforcement is no longer available for pro-social behaviour (similar to when the left yellow key is no longer presented alongside the right yellow key), the rate of problem behaviour maintained on the leaner schedule (similar to right key responding in the experiment) is likely to increase again. Conversely, this finding also suggests that training an alternative behaviour on a richer reinforcement schedule (the left green key in the experiment) in a separate context to the problem behaviour (right blue key in the experiment), will reduce the persistence of the problem behaviour when persistence to the individual stimuli is tested. Both of these findings have strong implications to how clinicians address challenging behaviour and its likely persistence following DRA interventions.

The replication of the components and key presented during the fifth and final disruptor test clearly showed that responding on the right blue key was less persistent than responding on all other keys. Whilst it was predicted that lower levels of responding would be seen on the right blue key, it was not predicted that responses would stop altogether (as seen for two out of the six hens), because reinforcement still remained in effect. Furthermore, responding overall clearly reduced significantly on most keys between the fifth disruptor test and the baseline sessions that preceded it, even more so than it did during the first two disruptor tests. Responding on the right blue key in particular reduced comparative to baseline levels (see Figure 2.14) suggesting that training the alternative behaviour in a separate context to that in which the problem behaviour is occurring could lead to reduced persistence of that target behaviour. This is supported by the general findings, and the reduction of target responding to very low levels after the target stimuli had been combined with the stimuli associated with the alternative response. These findings also support further investigation for the possible use of this procedure to reduce the persistence-strengthening effects of DRA interventions.

During the first disruptor test, responding on the red key was minimal, so it appeared that it was not diverting the hens away from the main keys on which they were responding. However, analysis of the total number of responses, throughout both the baseline sessions and the disruptor test that followed, revealed a statistically significant drop in the number of responses overall in the presence of the red key. This reduction of responding in the presence of the red key disruptor suggests that the red key is a successful disruptor to keep reinforcement in place under testing conditions. As previously discussed, analysing persistence under conditions which do not remove reinforcement for previously established positive behaviours is beneficial (Nevin, 2015).

Responding on the red key changed throughout the course of the experiment. For three of the six hens, responding on the red key began to rise during the second disruptor test (see Figure 2.5), and for all hens responding on the red key was greater during the Combined Component than during the Concurrent Component. Responding on the red key was minimal for most hens during the third disruptor test (see Figure 2.10), but during the fourth disruptor test, especially in the first session, responding on the red key increased.

There is no methodological reason that explains the increase in red key responding during the second disruptor test. During the fourth disruptor test, the increase in responding on the red key might have been a result of pairing with a single stimulus, as there was only one other response option (as opposed to two during the other disruptor tests). What remains less clear, however, is why this increase was greater in the presence of the right side keys of Components 1 (yellow) and 3 (blue), both target keys associated with the leaner schedules of reinforcement during baseline. The red key was on the same schedule as the two right side keys, so one might expect responding across both the red key and the right key it was paired with to be approximately equal, which they were not. Despite the increase in red key responses, responses still remained higher on the right keys. It is possible that the increased reinforcement in the context from responding on both the red key and the right key together encouraged high rates of responding on the red key, but even that combined rate of reinforcement did not equal the reinforcement rate available on the left green key available in another component. It is also possible that the novelty of the red key in the environment with the right side keys accounted for some of the increased responding.

During the fifth and final disruptor test, the red key responses reduced again (see Figure 2.13) and in most cases returned to the levels seen at the start of this experiment. Perhaps previous exposure to the red key accounted for this, or more competitive interference with the other active keys on richer schedules which were present again in this disruptor test. However, future studies might consider re-testing the fourth disruptor test in which individual stimuli are paired with the red key, to see if the greater responding there was related to the presence of individual keys or not.

The present study evaluated the persistence of behaviour using a disruptor that did not involve extinction of the target or alternative responses. Given the previously discussed multitude of contingencies and reinforcers acting in any environment (Craig et al., 2014), the possibility of removing all of these, if they could even be identified, are remote. The addition of new and similarly effective reinforcement as a disrupting stimulus, in comparison to reinforcement of target behaviour, may be feasible in applied situations where extinction cannot be implemented. The results of Experiment 2 showed that the persistence of target behaviour was reduced folloing alternate-context training compared to traditional DRA methods, even when assessed using the addition of reinforcement as a disruptor, rather than extinction. Of course, it is not possible to conclude that this effect would occur irrespective of what else is going on in the environment, but it does support the further investigation of this approach.

Despite these promising findings, Experiment 2 did produce some unexpected results. In the first two disruptor tests, overall response rates decreased (in the presence of the red key) yet responding on the red key itself was minimal until the third disruptor test. This suggested that the reduced responding on the active keys was not being allocated to the red key. One possible theory, supported by the literature (Nevin et al., 1981; Nevin et al., 1990), is that offering an alternative source of reinforcement can reduce response rates because it changes the association between the initial response and the reinforcer. That would suggest that presenting the red key (which is an alternative source of reinforcement if the hens choose to respond on it) changes the context surrounding the operant contingency, between both left and right yellow keys and reinforcement (DRA Component), and the left green and right blue keys (Combined Component) and available reinforcement.

Whilst these context changes might be the case, the context associated with the operant contingency in effect during the disruptor tests is slightly different from that in baseline. During the disruptor tests, the left green key and the right blue key which were in separate components during baseline are combined into one component to test for persistence of responding to the blue right (target) key in the face of disruption. Whilst the basic contingency of pecking keys and earning reinforcement is still in effect, it could also be argued that altering the stimuli by combing the two coloured keys and so creating a new context has already altered the contingency (DeLeon, Podlesnik, & Miller, 2015; Podlesnik et al., 2012). Not only has a new context been created, but target, or right key responding, could have been disrupted by the addition of the alternative stimuli and the additional reinforcement available on the left key (Podlesnik et al., 2012). Therefore, it is not clear if the reduced responding on all keys during the disruptor tests was due to combining stimuli during testing, or if it was due to the additional source of reinforcement provided by the introduction of the red key, a combination of these influences, or additional behavioural processes influenced by the combination of stimuli (Podlesnik & Bai, 2015). As the added new source of reinforcement was on such a low schedule, it would be interesting to see if similar reductions in responding on other keys occurred if the centre key reinforcement rate was increased further. This would further investigate the effects on the persistence of behaviour of adding an additional richer source of reinforcement to the context.

Despite seeing some increases in the red key responding throughout this experiment, at no point did the combined amount of red key and other active key responding reach the same number of responses seen in baseline. This, along with the figures showing the reduction of responding on most keys during the disruptor tests, show clear reduction in responding overall in the presence of the red key, and in particular reduced persistence of responding to the right blue (Combined Target) key in the presence of the disruptor.

Discussion of Experiments 1 and 2

These two experiments replicated and extended the previous findings by Podlesnik et al. (2012) and Mace et al. (2010). Overall, it was found that training an alternative behaviour (left green key) in a separate context to that of the target (right blue key), before combining them during extinction (Combined Component), resulted in less persistent target responding than did training the alternative behaviour in the same context as the target behaviour (both yellow keys; Concurrent Component). Furthermore, we extended the generality of these findings from using extinction as a disruptor, to also using a disruptor (red key) in which reinforcement was retained, for all responses. Additional reinforcement was also provided for responding to the disrupting stimulus. Overall, the findings of reduced persistence of responding of a target behaviour trained in a separate context support the growing evidence suggesting alternative context training may be an effective solution to avoid the increased persistence of the target found in traditional DRA interventions.

Although it was predicted that Experiment 2 would also result in reduced persistence to the right blue (Combined Target) key during the disruptor tests based on the findings from Experiment 1, it was not predicted that persistence would reduce to the extent that it did. During the first disruptor test, responding stopped altogether on the right blue (Combined Target) key for two hens, and this trend continued during all the disruptor tests in which the left green and right blue keys were presented together as the Combined Component. This meant that similar levels of persistence were seen for some hens during Experiment 2 when reinforcement was maintained, as were shown during in Experiment 1 when reinforcement was discontinued under extinction conditions.

It is possible that history effects could account for this finding, by the time the hens were exposed to the Combined (left green and right blue) Component in Experiment 2, they had already been exposed to that key combination three times throughout Experiment 1. However, during each extinction test of Experiment 1, there is responding on the right blue key for the first few sessions of each of tests, so one might expect to see a similar pattern during the disruptor tests of Experiment 2. This was not the case, responding from the first session of the first disruptor test did not occur on the right blue key at all. Therefore, this suggests that this absence of responding towards the Combined Target (right blue) key, has more to do with its combination with the richer Combined Alternative (left green) key during the disruptor test, than its previous exposure to this combination during extinction tests.

The findings from Experiment 1 had raised some questions as to how the analogue DRA context (Concurrent Component) was functioning, as response rates on the right yellow key were typically proportionally greater than responding to the left yellow, left green, and right blue keys. Experiment 2 produced similar results, with at least two hens responding at a higher rate to the right yellow key, proportionate to baseline, than any other key during every disruptor test. As discussed in greater detail in the specific Discussion sections, this could suggest that the concurrent yellow keys, analogous to the DRA, were functioning as one richer context, as might be predicted by behavioural momentum theory (Nevin, 2015). If so, one might expect responses during the disruptor tests on the both left and right yellow keys to be about equal. This was not found in either of the two experiments.

Despite the similarities in the persistence of the DRA Target (right yellow) key and the Combined Target (right blue) key between Experiments 1 and 2, persistence of responding on all others keys was very different between the two experiments. The reduction in responding on all keys seen in Experiment 1 was typical to data under extinction conditions, where it reduces gradually across sessions after the initial extinction burst. In Experiment 2 however, although responding on the left yellow key and the left green key did in most cases reduce comparative to their baseline rates, they did not reduce gradually as seen in Experiment 1, but started off below baseline levels and remained fairly stable throughout the rest of the disruptor tests (note individual differences in both disruptor tests and hens, as mentioned in the Results section of Experiment 2).

In summary, Experiments 1 and 2 successfully replicated previous findings showing that combining an alternative behaviour trained separately with a target behaviour during extinction decreased the persistence of that target behaviour when compared to a traditional DRA procedure which trained the alternative behaviour in the same context. These findings were also extended to include a test of a disruption procedure in which reinforcement remained in effect. The addition of the red key, providing an alternative source of reinforcement, resulted in the target behaviour that had been trained in a separate context being less persistent than the target behaviour in the traditional DRA procedure.

Experiment 3: VI 75-s & VI 37.5-s Centre Key Disruptors

Introduction

In Experiment 2, responses on the red centre key increased in some of the disruptor tests, especially when the red key was paired with individual stimuli. Despite this increase in red centre key responding, responding on the other keys decreased, but total amount of responding on all available keys during disruptor tests, including the red centre key, was still less than responding during baseline. Whilst it was argued that the addition of the red centre key was potentially enough to change the context sufficiently to alter what is associated with the operant contingencies already in effect, it was still not clear why responding declined in the presence of the red centre key. The red centre key was associated with the same reinforcement schedule as the right yellow and blue (target) keys, one question this raised was what would happen if the reinforcement schedule on that centre key was increased?

One possibility is that responding on the centre key would increase further, which would be expected of responding under a richer schedule of reinforcement, especially a schedule richer than other available options (i.e., richer than the active keys in the Concurrent and Combined Components). Typically, disruptors used in previous studies that have added reinforcement to a context have done so by making reinforcement available non-contingently; for example, provided on a fixed-time (FT) schedule (Podlesnik et al., 2012), or variable-time (VT) schedule (Doughty & Lattal, 2003), or given during an ICI or blackout (Nevin & Wacker, 2013). In the present experiments however, the hens could respond on the centre key to earn additional reinforcement. The next experiment replicated Experiment 2 but with two different schedules on the centre key.

Adjusting the schedule on the centre key enabled further investigation into persistence, in particular in the combined context procedure previously examined. Research suggests that when two stimuli that have been trained in separate contexts are combined, response rates could increase comparative to responding in the presence of either stimulus alone (Podlesnik & Bai, 2015; Podlesnik et al., 2012; Podlesnik & DeLeon, 2015). Findings from Experiments 1 and 2 however contradicted this, as combining the individually trained stimuli into the one Combined Context resulted in a decrease in persistence and in mean number of responses, comparative to the Concurrent Component. Further investigation into this method as a means to reduce the persistence of unwanted behaviour, particularly the persistence of responding to the right blue (Combined Target) key, compared to the right yellow (DRA Target) key seemed to be worthwhile. Therefore, the aims of Experiment 3 were to continue to investigate combining stimulus contexts in comparison to DRA methods, and to examine what effect increasing the reinforcement schedules on the centre key had on the persistence of the target behaviour.

Three main changes were made to the procedure for this experiment. Firstly, the centre key colour was changed from red, in order to present a novel stimulus with no history associated with the colour. Secondly, the centre key reinforcement schedule was increased twice, firstly to a VI 75-s schedule (half way between the richer and leaner options available on the left and right keys of the experimental procedure). It was then increased again to a VI 37.5-s schedule, which was equal to the richer of the options available on the left keys of the experimental procedure. During Part 1, the centre key was lit white and provided a VI 75-s schedule, and during Part 2, the centre key was coloured pink and provided a VI 37.5-s schedule.

Finally, two of the disruptor tests were removed from these experiments with the aim of focusing on measuring the persistence of responding to the target (right) keys primarily during the Concurrent (DRA) and Combined Components and then to measure the persistence of responding to individual stimuli. These changes are further outlined in the method below.

Method

Subjects

The subjects were five of the six domestic hens used in the previous experiments, and a replacement hen for 8.1 who was removed between experiments due to illness. Hens were all kept and fed in the same conditions as previously described.

Apparatus

The same experimental chambers as in Experiment 2 were used throughout this experiment. The only change in the apparatus was that the centre key used both in the chamber alone for exposure to the centre key, and during the disruptor test, was lit white when operative during Part 1, and lit pink when operative during Part 2.

Procedure

Part 1. VI 75-s Schedule

Exposure to Centre Key

Hens were trained to respond to a single white key, associated with a VI 75-s schedule. Sessions ran for 12 minutes once per day. There were a maximum of 12 reinforcers available during these sessions, and there were six sessions in total.

Baseline

Following training with the white key, the hens were returned to the main experimental chamber and the same baseline procedure as Experiments 1 and 2, for six sessions. The white key was not present during these sessions. Six sessions of baseline occurred before each disruptor test. A further six sessions of exposure to the white key alone occurred immediately after the disruptor tests, as outlined in Table 3.1.

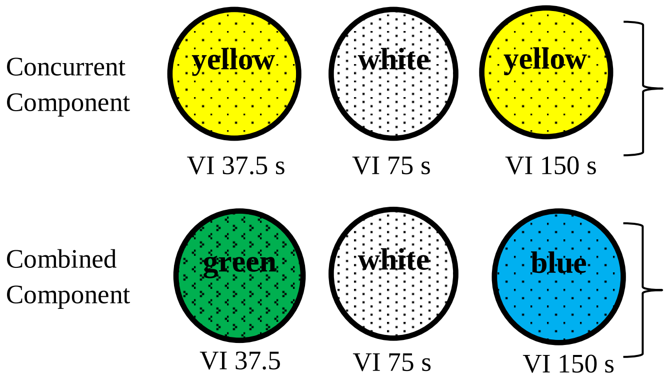
Table 3.1. The outline of conditions presented during Experiment 3.

Name	Number of Sessions	Description
Exposure to Centre Key	6	VI 75-s, white centre key VI 37.5-s, pink centre key
Baseline	6	Three component multiple schedule: Component 1 - concurrent yellow keys, VI 37.5-s left, VI 150-s right Component 2 – green left key VI 37.5-s, right key unlit Component 3 – blue right key VI 150-s, left key unlit
Disruptor Tests	6	Different stimuli presented and paired with the reinforcement schedules shown in Tables 3.2 and 3.3

Disruptor Tests

The disruptor tests ran similarly to Experiment 2, with two differences. The reinforcement rate on the centre key, now coloured white, was VI 75-s for all disruptor tests. At no time was food withheld during any part of the experiment. The positioning of the white key is shown in Figure 3.1. There were three disruptor tests in total, as shown in Table 3.2. The total session duration of

Disruptor Tests 1 and 3 was 32.5 minutes, and the duration of Disruptor Test 2 was 48 minutes.



Concurrent (DRA) Component: alternative behaviour (left key) trained in the *same* context as the target (right key) with the white key disruptor

Combined Contexts Component: alternative behaviour (left key) trained in a *separate* context to the target behaviour (right key), with the white key disruptor

Figure 3.1. Key colours and schedules during the first disruptor component demonstrating the positioning of the white key.

Table 3.2. The component combinations and key colours as presented during the disruptor tests of Experiment 3 Part 1. The numbers indicate the schedules active on each of the keys.

Disruptor Test	Components	Key Colours and Schedules		
1	comp. 1	37.5	75	150
	comp. 2	37.5	75	150
2	comp. 1		75	150
	comp. 2	37.5	75	
	comp. 3		75	150
3	comp. 1	37.5	75	150
	comp. 2	37.5	75	150

Part 2. VI 37.5-s Schedule

Exposure to Centre Key

Hens were trained to respond to a single key lit pink that was associated with a VI 37.5-s schedule. Each session was 12 minutes and there were a maximum of 12 reinforcers available during these six sessions.

Baseline

Following training with the pink key, the hens returned to the same baseline procedure as described previously. Six sessions of baseline occurred before each disruptor test, and a further six sessions of exposure to the pink key alone occurred immediately after the disruptor tests. Table 3.1 outlines the order of conditions presented.

Disruptor Tests

The only change from Part 1 was to the centre key, now coloured pink, and increased to a VI 37.5-s reinforcement schedule for all disruptor tests. At no time was food withheld during any part of the experiment. The positioning of the pink key was the same as the white key (shown in Figure 3.1). The components used in each of the three disruptor tests are outlined in Table 3.3.

Table 3.3. The component combinations and key colours as presented during the disruptor tests of Experiment 3 Part 2. The numbers indicate the schedules active on each of the keys.

Disruptor Test	Components	Key Colours and Schedules		
1	comp. 1	37.5	37.5	150
	comp. 2	37/5	37.5	150
2	comp. 1	▨	37.5	150
	comp. 2	37.5	37.5	▨
	comp. 3	▨	37.5	150
3	comp. 1	37.5	37.5	150
	comp. 2	37.5	37.5	150

Results

Experiment 3 Part 1

Baseline

Figure 3.2 displays the mean baseline response rates for each hen and for each component over the six baseline sessions prior to each of the disruptor tests in Part 1 of this experiment. Overall, baseline responding was lower on the right yellow key of the Concurrent Component. Responses on both the left yellow and left green key were similar for all hens across the three baselines, but responses on the right blue key varied, and there were few consistent trends across baseline sessions and hens. Hen 8.6's responding on this key was considerably higher compared to her responding on all other keys and other hens. Hen 8.1 did not complete the first baseline phase of this experiment.

Disruptor Test 1

Figure 3.3 shows responses across successive sessions of the first disruptor test plotted as a proportion of baseline. Hen 8.1 did not complete this part of the experiment. For all hens, responding proportionate to baseline was consistently higher on the right yellow key of the Concurrent Component, than on the right blue key of the Combined Component. As with Experiment 2, Hen 8.5 did not respond at all on the right blue key of the Combined Component until nearing the end of the test.

For Hens 8.2, 8.3 and 8.5, responding on the left keys was mostly stable and similar across the disruptor test, with a slight decrease for Hen 8.2 over the sessions. Hens 8.4 and 8.6, on the other hand, showed less consistent patterns, but continued to show lower responses proportionate to baseline on the right blue key of the Combined Component.

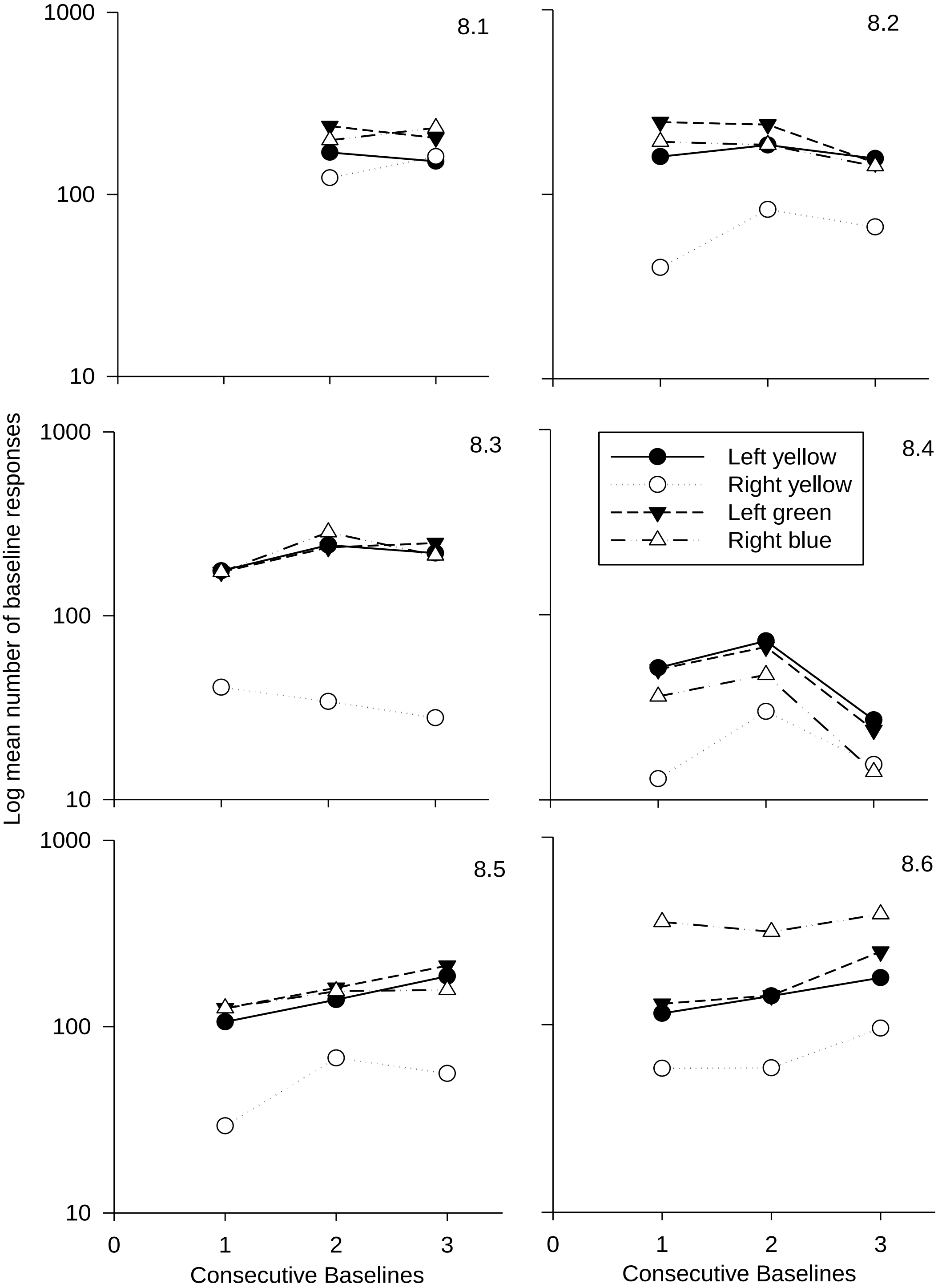


Figure 3.2. Mean response rates from the last six sessions of baseline prior to each disruptor test. The y-axis is presented on a log scale. Circles represent Component 1 (filled circles = left yellow key VI 37.5s, open circles = right yellow key VI 150s) and triangles represent Components 2 and 3 (filled triangles = left green key VI 150s, open triangles = right blue key VI 150s).

Overall, right key responding remained greater proportionate to baseline during the Concurrent Component (yellow keys) than during the Combined Component (green and blue keys) for all hens over all sessions. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key during the disruptor test with the mean proportion of baseline responding on the right blue key during the disruptor tests was significant, $t(5) = 4.810$, $p = .005$, $d = 2.183$, showing that there were less responses proportionate to baseline on the right blue key than on the right yellow key.

Figure 3.4 displays the total average number of responses on each key for each hen throughout the first baseline exposure and the first disruptor test. As with Experiment 2, this analysis was conducted to investigate any potential reduction in responding overall in the presence of the white centre key. As shown in Figure 3.4, the number of responses on the right blue key of the Combined Component dropped for all hens in the presence of the disruptor. Responding on all other keys produced somewhat inconsistent results across the five hens. For Hens 8.2 and 8.3, the average number of responses on all the keys decreased in the presence of the disruptor, as shown by the data points on the right hand side of the graphs. For Hen 8.4 however, responding on both keys of the Concurrent Component and the left key of the Combined Component actually increased in the presence of the disruptor. Hens 8.5 and 8.6 also showed varied response rates here, Hen 8.5’s responding decreased on all keys other than the right yellow key of the Concurrent Component, which increased noticeably. Hen 8.6 however, showed a slight increase in responding in the presence of the disruptor on both keys of the Concurrent Component but a decrease in responding on both keys of the Combined Component.

A paired-samples t-test comparing the mean number of responses overall in baseline on yellow, green and blue keys with the mean number of responses overall during the disruptor test revealed a statistically significant difference between the number of responses emitted in the presence and the absence of the white key disruptor, *t*(5) = 3.112, *p* = .027.

Disruptor Test 2

Figure 3.5 shows responses as a proportion of baseline plotted across successive sessions of the second disruptor test, where each of the three stimuli were presented individually with the disruptor (see Table 3.2 in Method). Responding proportionate to baseline on the right yellow key was consistently higher, than on the right blue key. In addition, for all hens other than 8.6, responding proportionate to baseline on the right yellow key was consistently higher than responding on either the left green or right blue keys. Right yellow key responding was greater, proportionate to baseline, than right blue responding. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key during the disruptor test with the mean proportion of baseline responding on the right blue key during the disruptor tests was significant, *t*(5) = 3.045, *p* = .029, *d* = 1.206.

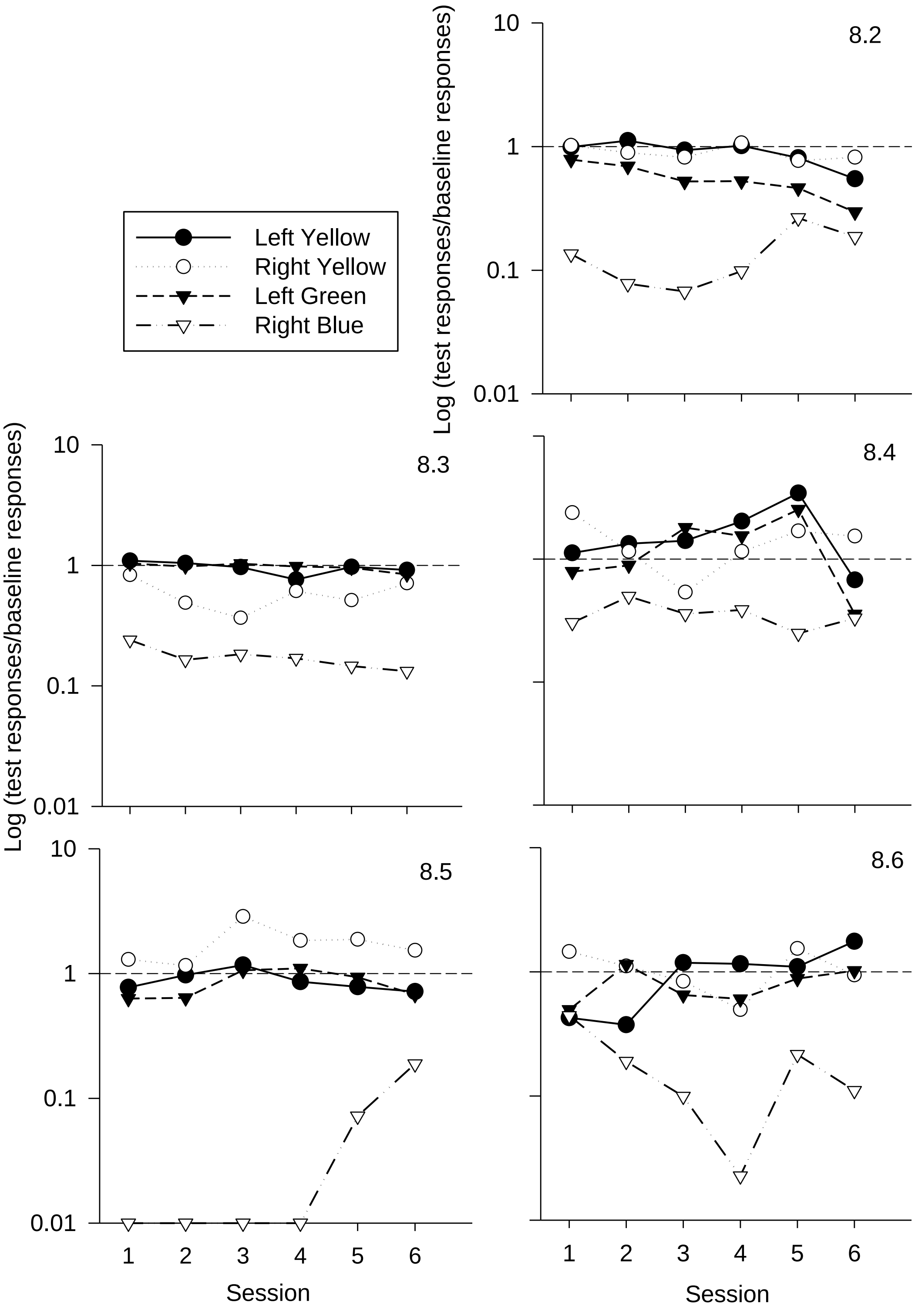


Figure 3.3. Responding plotted as a proportion of baseline for all hens during the first disruptor test. The y-axis is on a log scale and the dashed lines represents baseline levels of responding. Circles represent the Concurrent Component (filled circles = left yellow key, open circles = right yellow key) and triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key). Data points at 0.01 represent zero responses.

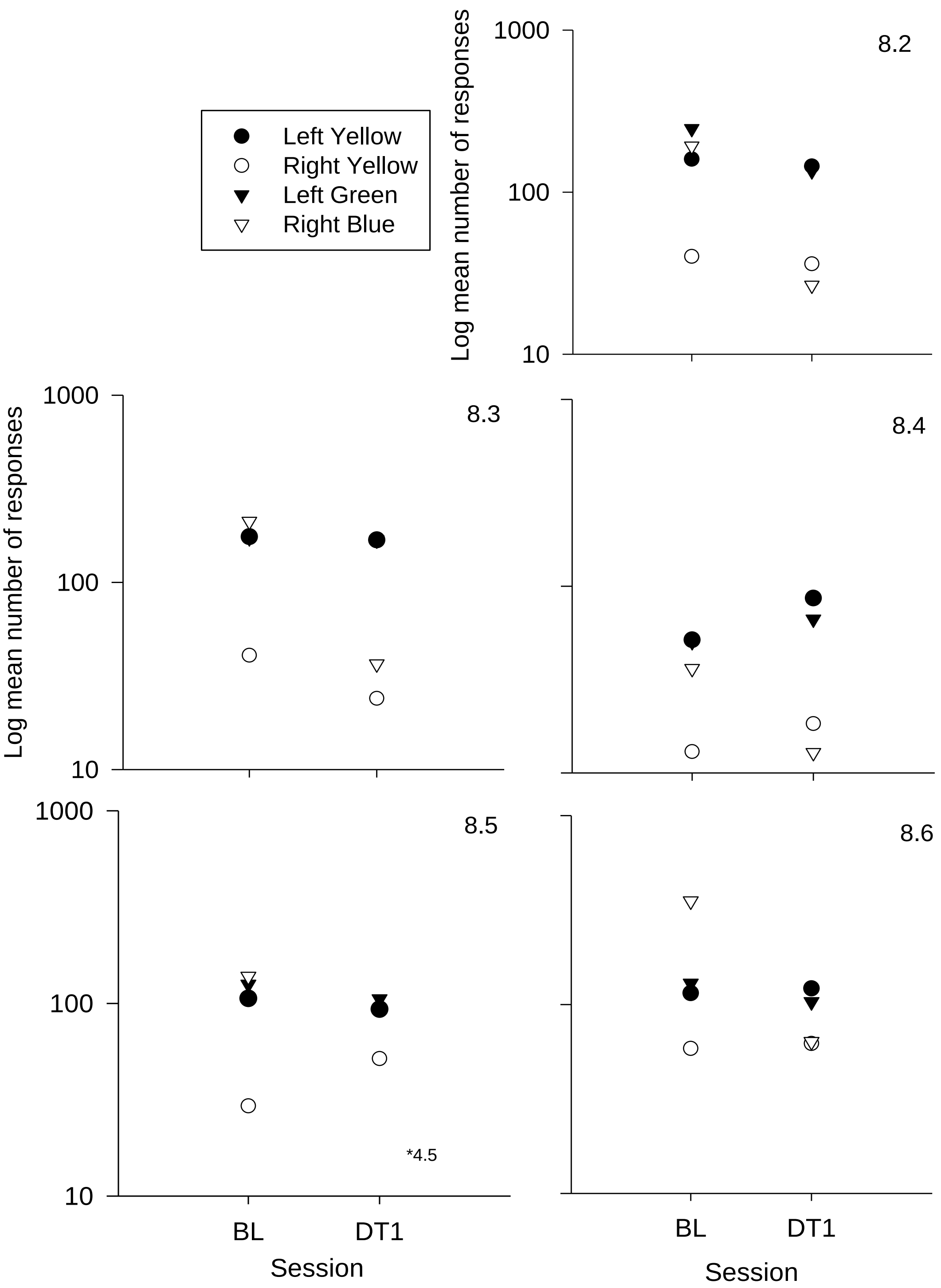


Figure 3.4. Mean number of responses on each key for all six hens during baseline and the first disruptor test. The y-axis is plotted on a log scale. The circles represent the Concurrent Component (filled = left yellow key, open = right yellow key). Triangles represent the stimuli trained separately during baseline, and then presented as the Combined Component in the presence of the white key disruptor (filled = left green key, open = right blue key). White key responses are not shown.

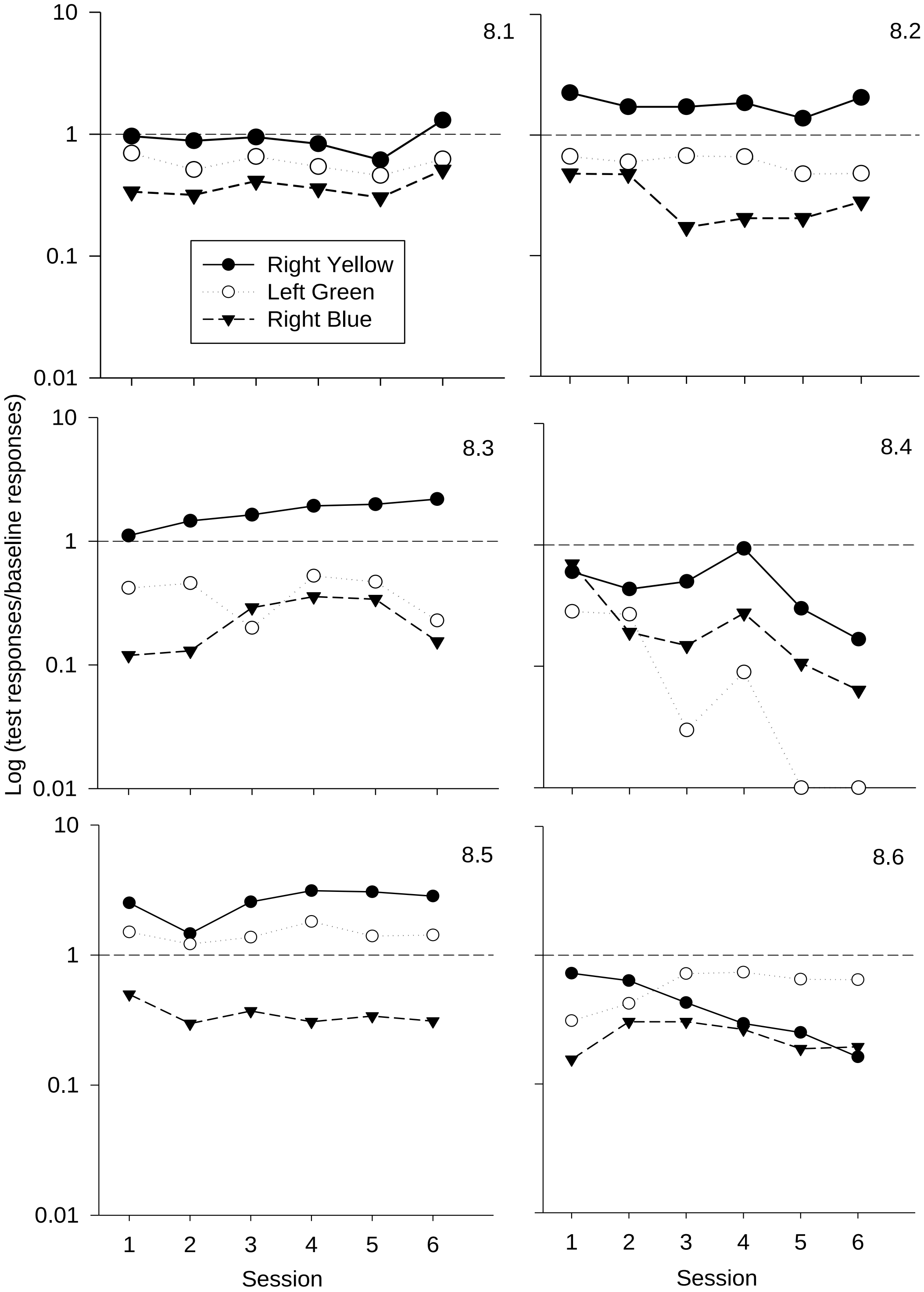


Figure 3.5. Responses plotted as a proportion of baseline responding during the second disruptor test. The right yellow key (filled circles), the left green key (open circles) and the right blue key (filled triangles) were all presented in individual components, paired with the white key disruptor (white key responses not shown on graph). The y-axis is on a log scale and data points at 0.01 represent zero responding.

For the majority of hens, responding dropped in the presence of the white key disruptor, as seen in Figure 3.6 which shows the average number of responses throughout all sessions of the second baseline exposure and the following disruptor test. All hens’ responding on the right blue key dropped considerably when it was paired with the white key disruptor, and this was the same for responses on the left green key too with the exception of Hen 8.6. Responses on the right yellow key, however, did not decrease consistently across hens between baseline and the second disruptor test, with three of the hens showing increases in responding on the right yellow key when it was presented with the white key disruptor.

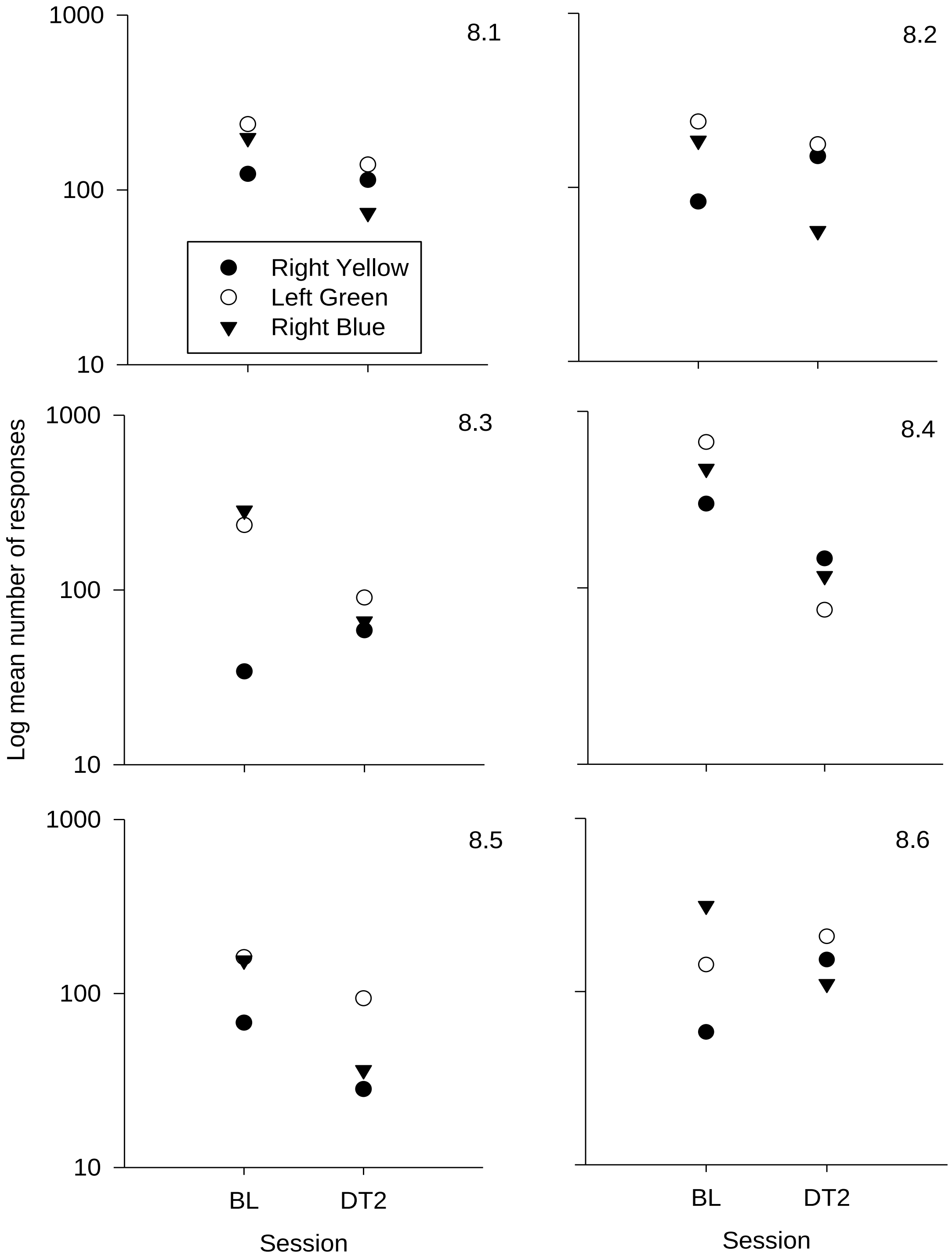


Figure 3.6. Mean number of responses for all hens across all sessions of baseline and the second disruptor test using the white centre key as a disruptor. The y-axis is on a log scale. Filled circles indicate responses on the right yellow key, open circles show responses on the left green key and filled triangles show responses on the right blue key.

Disruptor Test 3

Figure 3.7 shows responses as a proportion of baseline across successive sessions of the third disruptor test. Hens 8.1, 8.2, 8.3 and 8.5 showed lower levels of responding, proportionate to baseline, on the right blue key of the Combined Component. For the remaining two hens, 8.4 had generally variable responding, likely due to deteriorating health that resulted in her receiving a break from experiments. Hen 8.6 showed greater levels of responding proportionate to baseline to the right (leaner) key in both the Concurrent and Combined Components than to the left key in either component. The other notable finding shown in this figure was the responding to the right yellow key of the Concurrent Component. Responding to this key was similar to, if not higher proportionate to baseline, compared with responding on the right blue, left yellow and green keys.

A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key during the disruptor test, with the mean proportion of baseline responding on the right blue key during the disruptor tests, revealed no significant difference between the two types of right key responding, $t(5) = 2.429$, $p = .059$, $d = 1.152$.

Despite the statistically insignificant results with the proportion of baseline responding measure, the actual number of responses within each component during the third disruptor test reduced compared to the number of responses within that component during baseline. Figure 3.8 shows the total number of responses in each component, averaged across the six sessions of both baseline and the third disruptor. Hen 8.4’s data were excluded from this analysis due to her health issues.

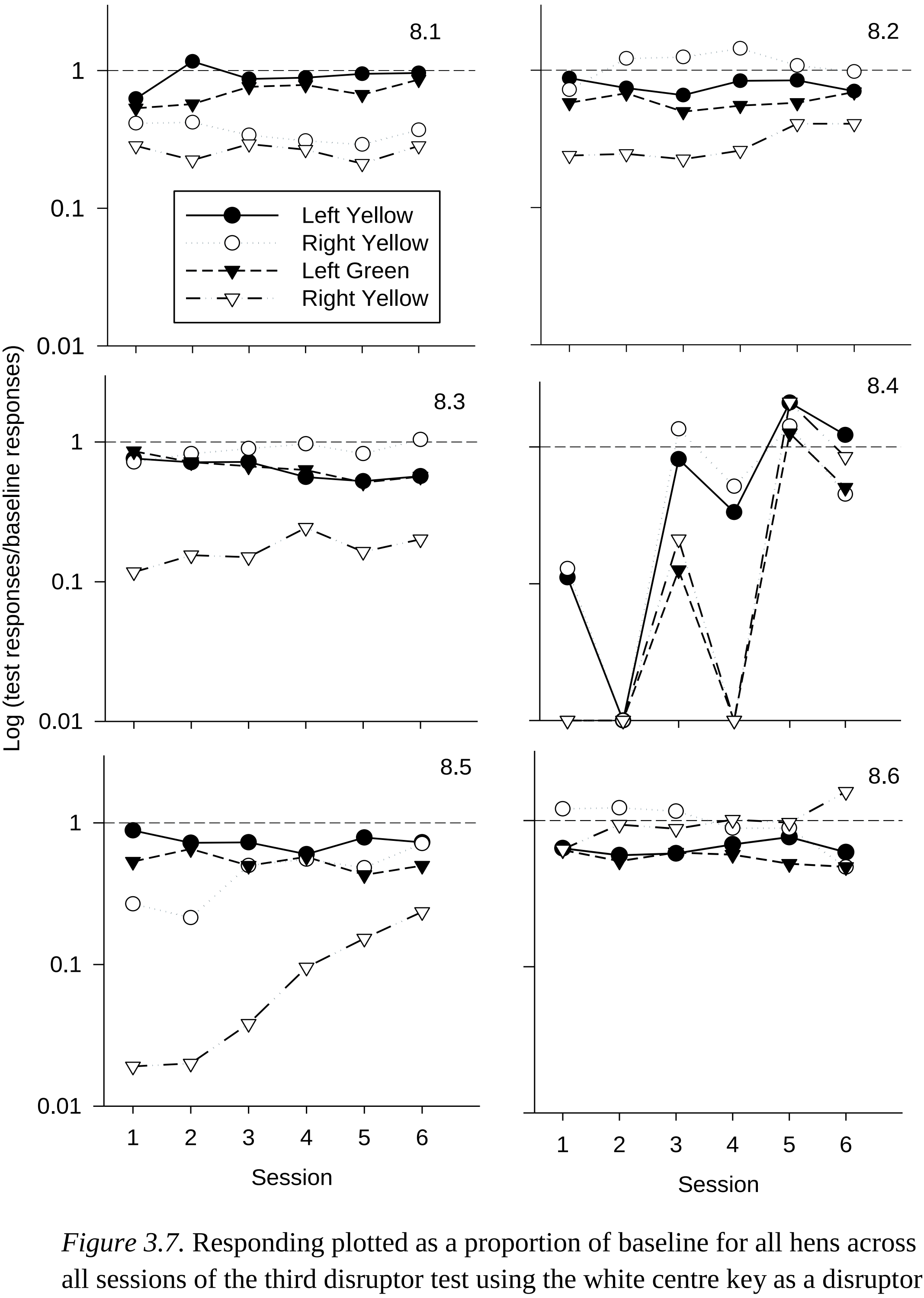


Figure 3.7. Responding plotted as a proportion of baseline for all hens across all sessions of the third disruptor test using the white centre key as a disruptor. The y-axis is plotted on a log scale with data points at 0.01 representing zero responding and the dashed line represented baseline levels of responding. Circles represent the Concurrent Component (filled circles = left yellow key; open circles = right yellow key) and triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key).

The difference in the average number of responses in both components drops from baseline to the disruptor test, consistent with previous findings. In this disruptor test, the average number of responses dropped for all hens on each key of both components in the presence of the disruptor, with the exception of two; Hens 8.2 and 8.5 whose right yellow key responses increased in the presence of the disruptor. A paired-samples t-test comparing the mean number of responses overall in baseline on yellow, green and blue keys with the mean number of responses overall during the disruptor test revealed a statistically significant difference between the number of responses emitted in the presence and the absence of the white key disruptor, $t(4) = 6.892$, $p = .002$.

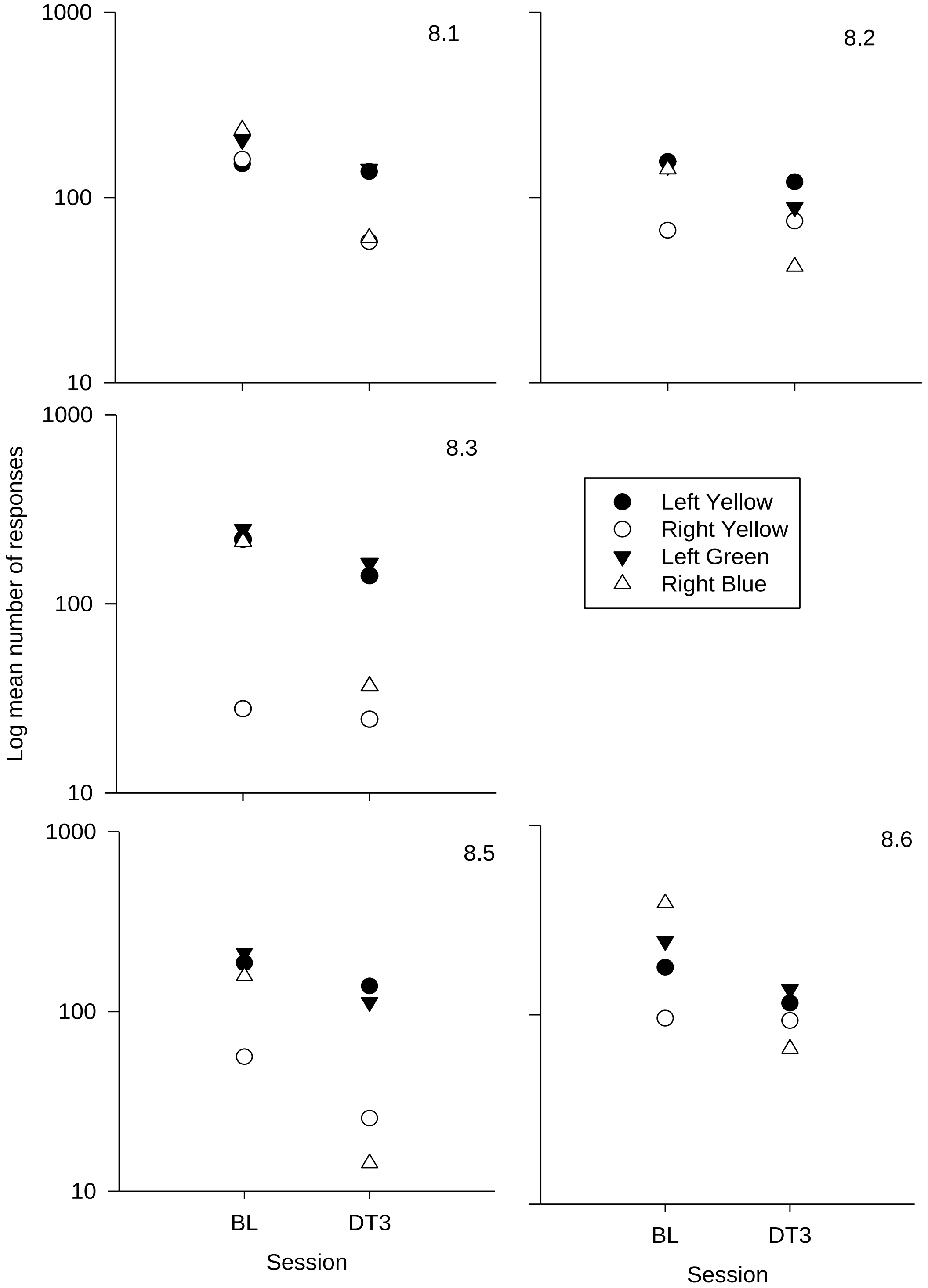


Figure 3.8. Mean number of responses for all hens across the third disruptor test and the baseline sessions that preceded it. The y-axis is on a log scale. Circles represent the Concurrent Component (filled circles = left yellow key; open circles = right yellow key) and triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key).

Centre White Key Responses

Figure 3.9 shows responding on the centre white key, used as the disruptor, for all hens throughout all three disruptor tests. Hen 8.1 did not take part in the first disruptor test and Hen 8.4’s data were excluded from some analysis in the third disruptor test, so their white key responding is not shown for these parts of the experiment on this graph. The first and third columns show the responses when the white key was lit between the two yellow keys (Concurrent Component; filled circles on graph), and between the left green and right blue keys together (Combined Component; open circles on graph). The middle column shows the responses on the white key when it was paired with each of the individual stimuli separately.

During the first disruptor test, responses on the white key increased slowly across sessions for most of the hens, in both of the components in which it was presented. A peak in white key responding occurred during the second disruptor test when it was presented individually with each of the yellow, green and blue keys. For all hens white key responding increased initially here, before dropping off across sessions.

Responses on the white key in this disruptor test had a clear pattern; when the white key was paired with either the right yellow key or the right blue key, responses on the white key were much greater and very similar to each other. There was less responding on the white key when it was presented with the left green key. This was the case for all hens other than 8.1 and 8.4, who’s responding on the white key remained quite similar regardless of the key it was presented with.

During the third and final disruptor test, responding on the white key reduced, to the levels seen during the first disruptor test for most of the hens, the exception being Hen 8.5 who’s responding continued to drop across sessions. Overall, it appears as if there was more responding on the white key when it was presented with the Combined Component during both Disruptor Tests 1 and 3.

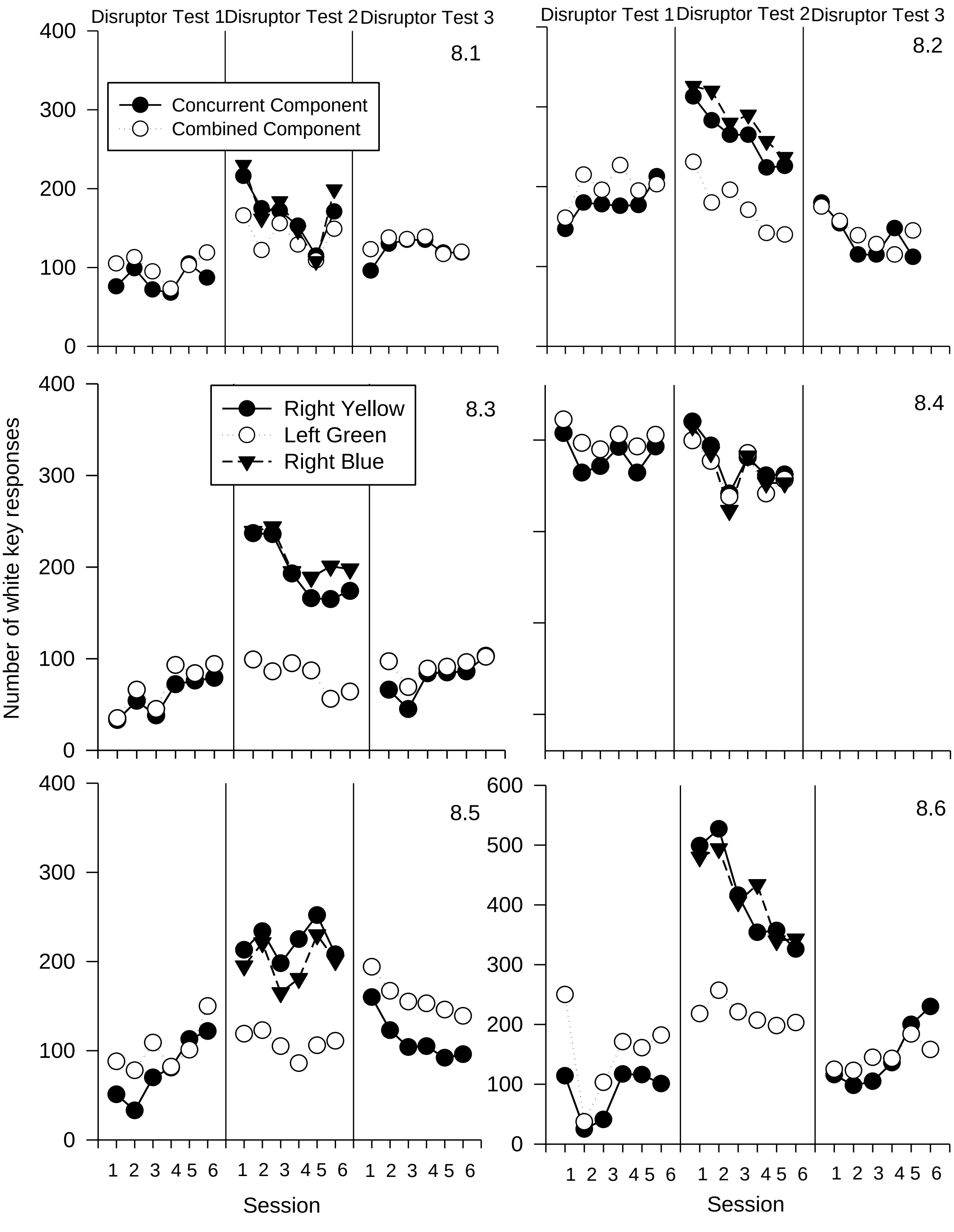


Figure 3.9. Number of responses on the centre white key during each of the three disruptor tests. Note that the y-axis for 8.6 is different due to the larger numbers of responding shown. In the first and third columns of each figure, the filled circles show white key responding when it was presented with the Concurrent Component (both yellow keys), and the open circles show white key responding when it was presented with the Combined Component. The centre column of the figures shows white key responding when it was presented individually with each of the three stimuli; filled circles = right yellow key, open circles = left green key and filled triangles = right blue key.

Experiment 3 Part 2

Baseline

Figure 3.10 shows the mean number of baseline responses across all hens on all keys during each of the baseline exposures prior to the three disruptor tests in the second half of Experiment 3. With the exception of Hen 8.4, all hens responded most to the right blue key presented alone, and all hens responded least to the right yellow key which was paired with the left yellow key throughout all baseline exposures. For the majority of hens, there was little difference in the mean number of responses across sessions on the two left keys, with responding on these keys remaining very similar to each other. Overall, mean baseline responding was fairly stable on each of the keys across all hens and across all sessions.

Disruptor Test 1

Figure 3.11 shows responses during the first pink key disruptor test plotted as a proportion of baseline. For all hens, responding proportionate to baseline dropped in the first session on all keys to below baseline levels. Whilst there was a slight increase in the responding proportionate to baseline on the left yellow key for Hen 8.2, on the right yellow, left green and right blue keys Hens 8.2 and 8.4's responding either continued to drop or remained stable at a lower level throughout the rest of the test. For Hens 8.1, 8.3, and 8.6, responding increased back to baseline levels, and in some cases higher than baseline, after the initial drop during the first session, on both yellow keys and the left green key. Responding on the right blue key of the Combined Component stayed continuously lower proportionate to baseline than responding on both yellow keys and the left green key for Hens 8.1, 8.2, 8.3, and 8.6 throughout the test. There was no consistent difference in responding proportionate to baseline on any key for Hen 8.4. Hens

8.4 and 8.5 are the only two hens whose responding on the right blue key of the Combined Component was not lower proportionate to baseline than the responding on the right yellow key of the Concurrent Component.

Overall, responding on the right blue key of the Combined Component was lower proportionate to baseline than responding on the right yellow key of the Concurrent Component for the majority of hens, but this finding was not supported significantly by a paired-samples t-test, $t(5) = 2.327$, $p = .067$, $d = 1.206$.

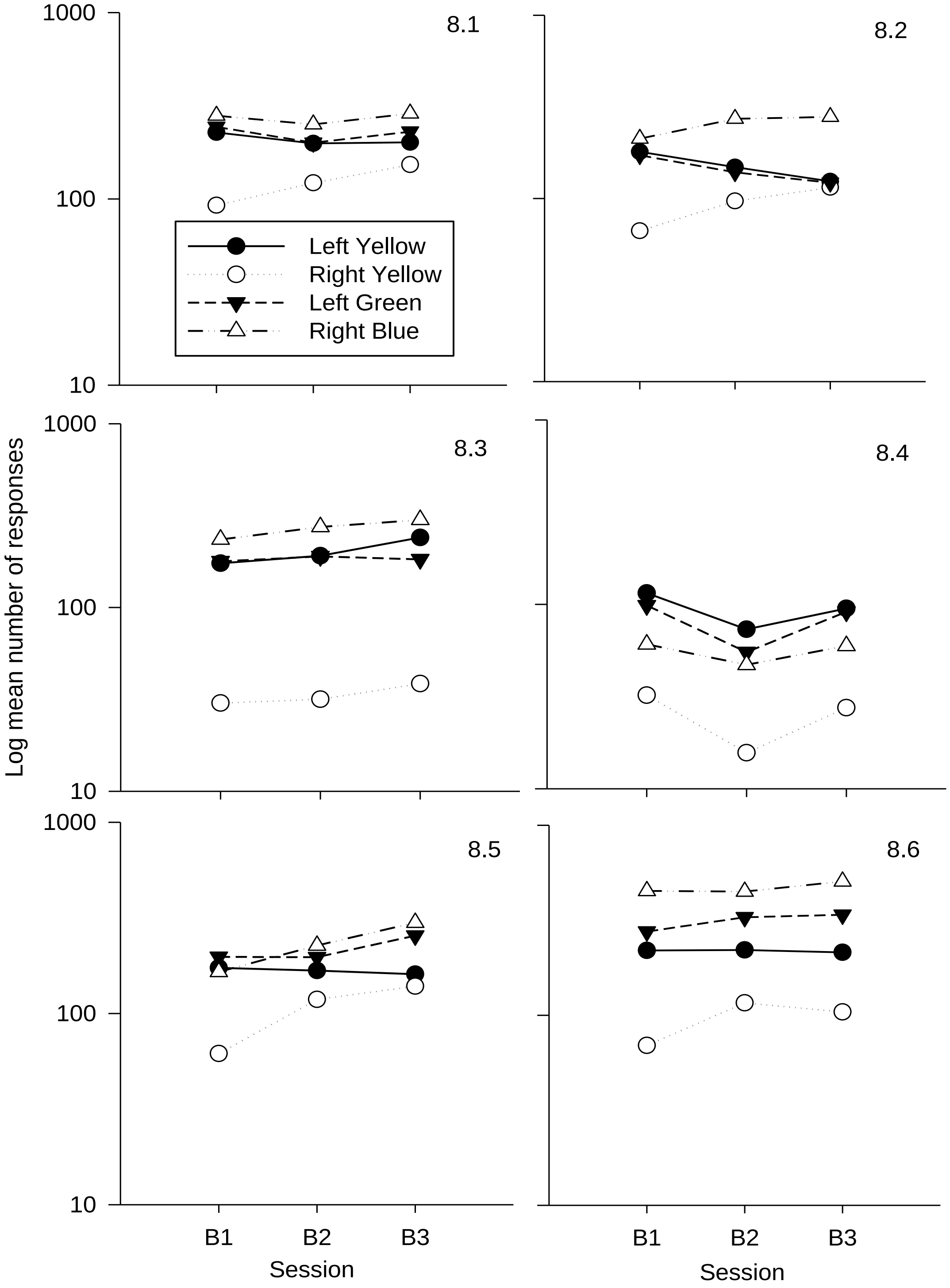


Figure 3.10. Mean number of baseline responses for all hens across all sessions of the baseline exposure prior to the pink key disruptor tests. The y-axis is presented on a log scale, with circles representing the Concurrent Component (filled circles = left yellow key, open circles = right yellow key), and triangles representing the two schedules trained separately (filled triangles = left green key, open triangles = right blue key).

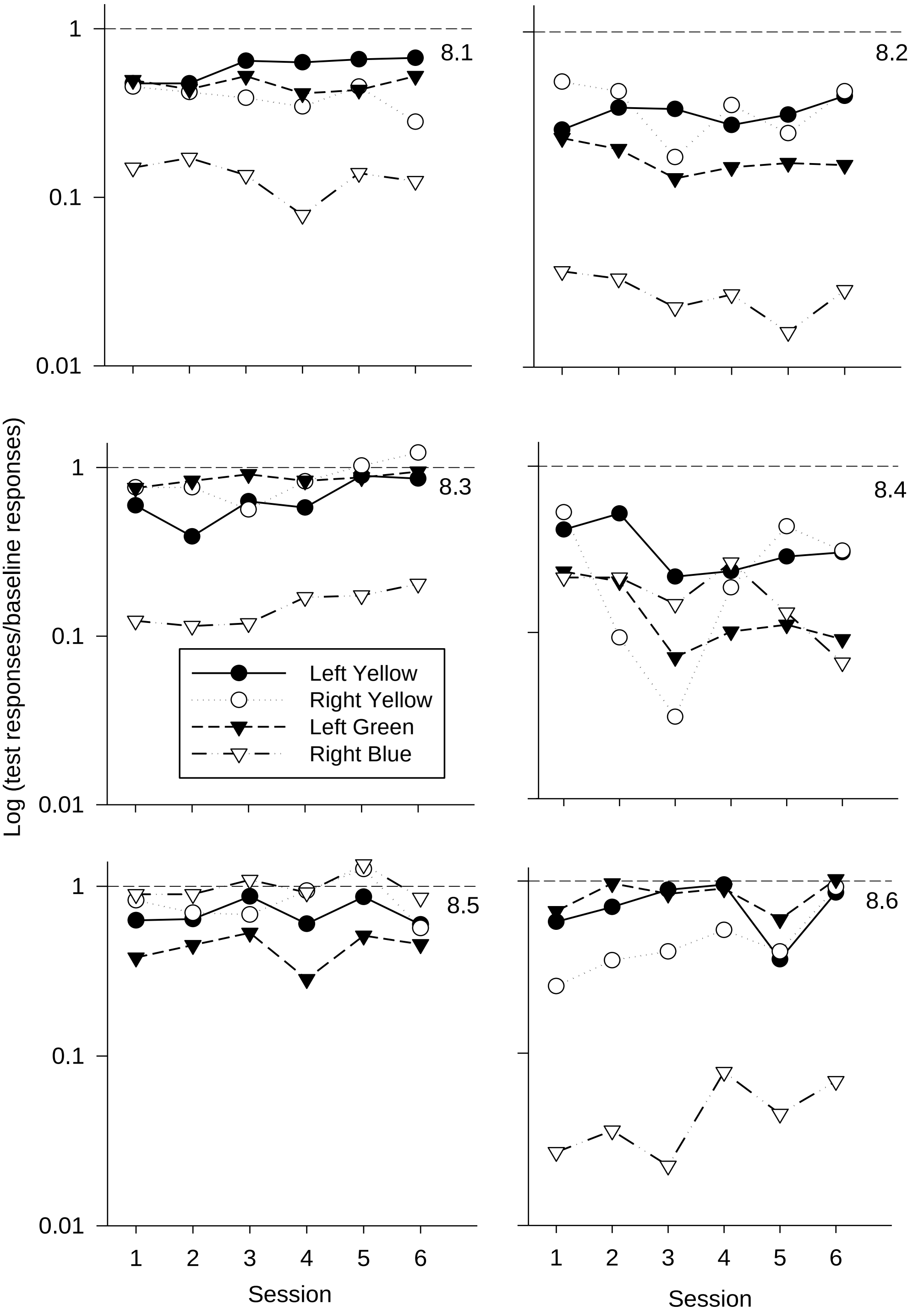


Figure 3.11. Responding plotted as a proportion of baseline for all hens during the first disruptor test using the pink key disruptor (pink key responses not shown on graph). The y-axis is on a log scale, with the dashed line representing baseline levels of responding. Circles represent the Concurrent Component (filled circles = left yellow key, open circles = right yellow key), and triangles represent the Combined Component (filled triangles = left green key, open triangles = right blue key).

Figure 3.12 shows the average number of responses on each key during the first baseline exposure and on the same keys in the first disruptor tests. For all hens, responding decreased overall in the presence of the pink key disruptor. Responding on the right blue key dropped to below the levels of responding on the right yellow key for 4 out of 6 hens, and for the remaining two hens (8.3 and 8.4), responding on the right blue key still decreased comparative to baseline levels. None of the hens showed an increase in responding on any of the keys in the presence of the pink key. A paired samples t-test comparing the mean number of responses during the baseline exposure and the first pink key disruptor test revealed a statistically significant reduction in the number of responses during baseline and the number of responses during the disruptor test; *t*(5) = 6.829, *p* = .001.

Disruptor Test 2

Figure 3.13 presents the responses plotted as a proportion of baseline for all hens during the second pink key disruptor test. In all cases, responding proportionate to baseline was lower on the right blue key when it was presented individually, than on any other key, and importantly, lower than that on the right yellow key, also presented individually. Responding on the left green key, presented individually in the third component of this test, was higher proportionate to baseline for 4 out of the 6 hens than responding on either of the keys/components. For the other 2 hens, 8.1 showed very similar amounts of responding proportionate to baseline on this key and the right yellow key, and Hen 8.6 continued to respond at greater levels proportionate to baseline to the right yellow key throughout the duration of the test. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key during the disruptor test with the mean proportion of baseline responding on the right blue key during the disruptor tests was significant, $t(5) = 3.594$, $p = .016$, $d = 1.532$, showing that there were less responses proportionate to baseline on the right blue key than on the right yellow key.

The average number of responses during the second baseline exposure and second disruptor test is shown in Figure 3.14. Responding decreased in the presence of the disruptor for all hens other than 8.3, whose responding on the right yellow and right blue keys actually increased in the presence of the pink key. Although there was a decrease in left green key responding for most hens, this was only a very slight decrease for Hens 8.1, 8.3 and 8.5. In most cases however, right blue key responding did decrease to below that of right yellow key responding, with Hens 8.1, 8.3 and 8.5’s right key responding very similar on both colours during the disruptor test.

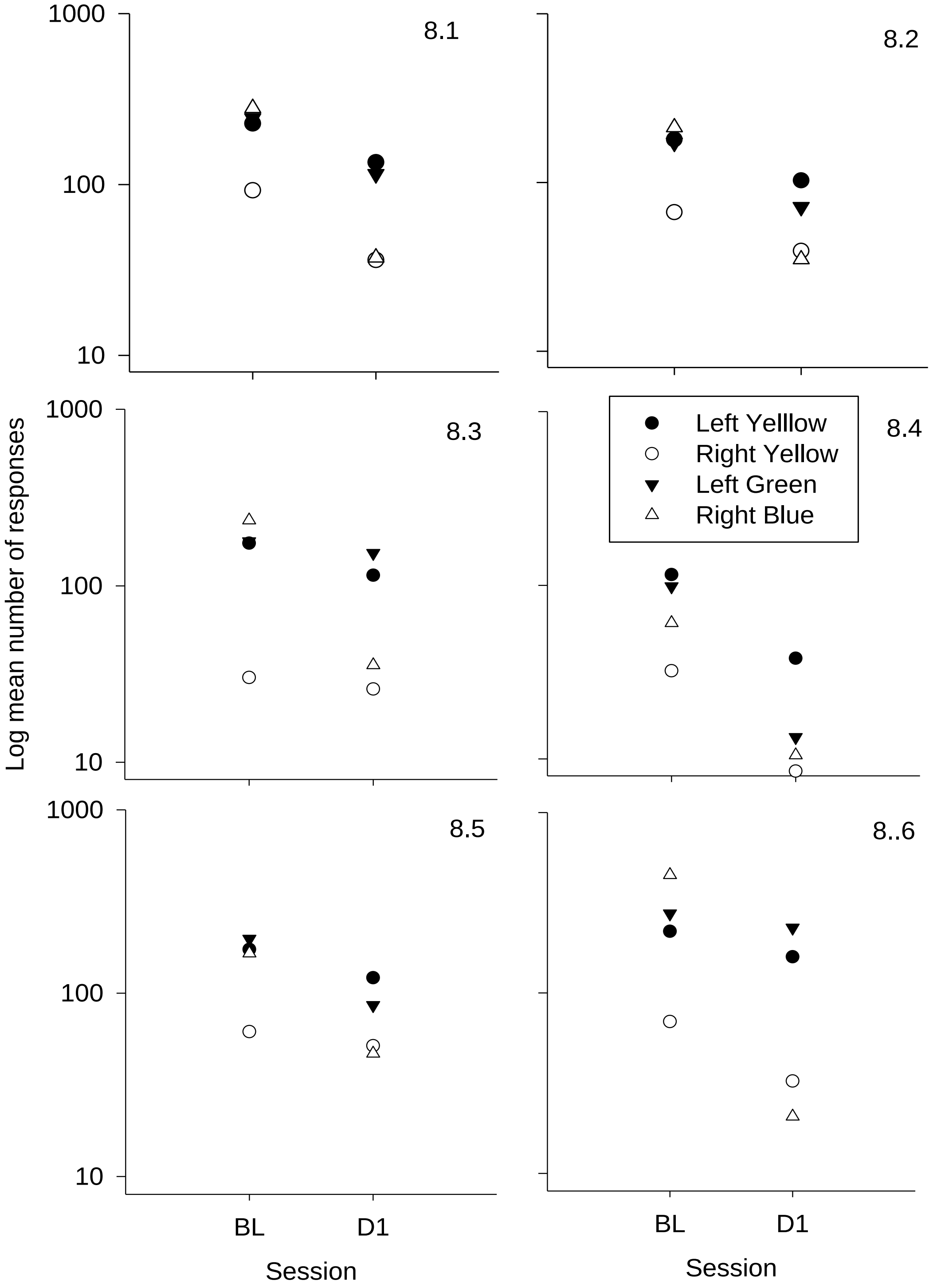


Figure 3.12. Mean number of responses on each key during baseline and the first disruptor test for all six hens. The Concurrent Component is represented by the circles (filled = left yellow key; open = right yellow key) and the triangles represent the stimuli trained separately during baseline (filled = left green key; open = right blue key), and then presented as the Combined Component in the presence of the pink key disruptor (pink key responses not shown). The y-axis is on a log scale.

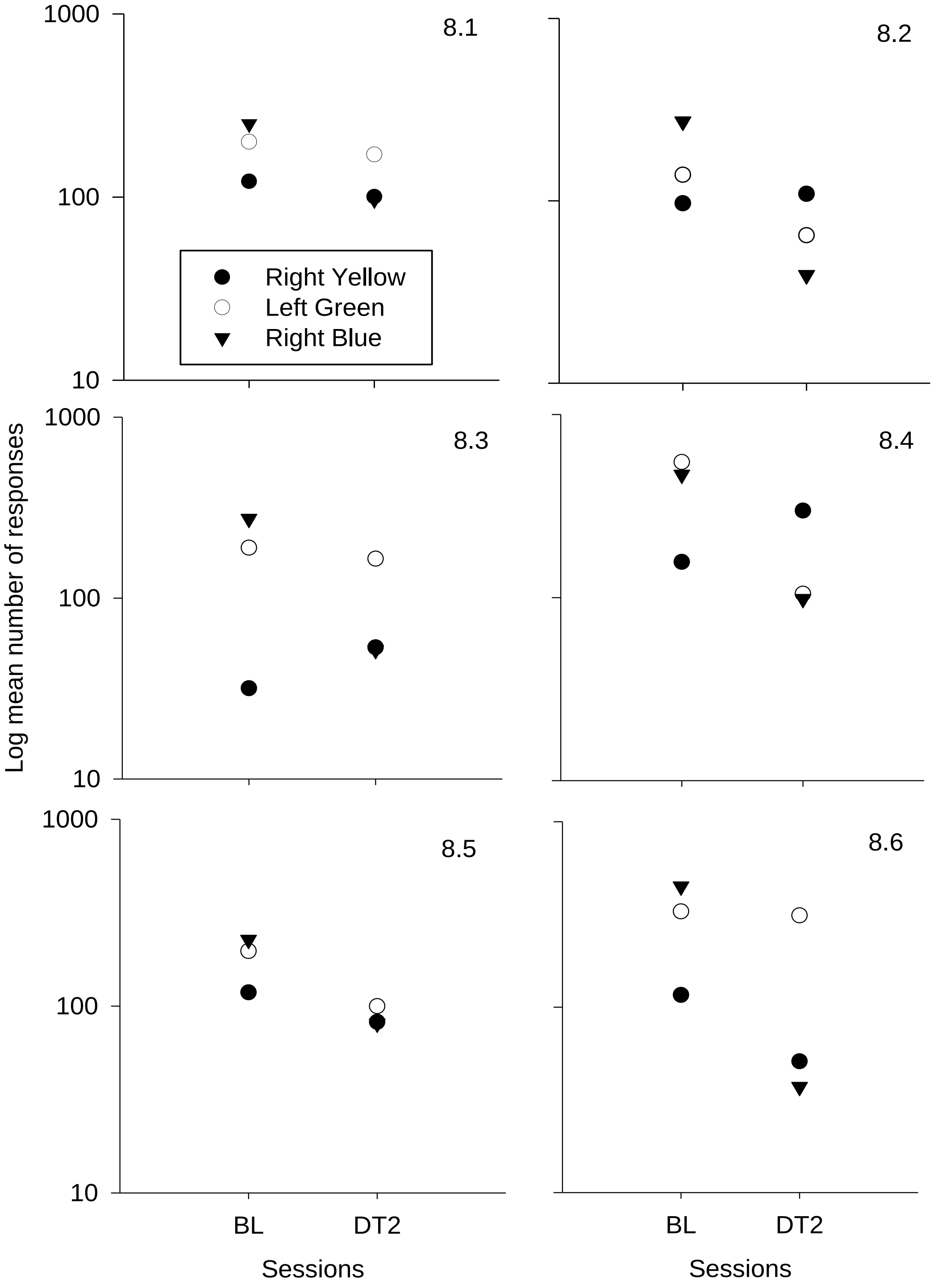


Figure 3.13. Responding plotted as a proportion of baseline for all hens during the second disruptor test, in which the right yellow key (filled circles), left green key (open circles) and right blue key (filled triangles) were all presented individually paired with the pink key disruptor. The y-axis is on a log scale and the dashed line represents baseline levels of responding.

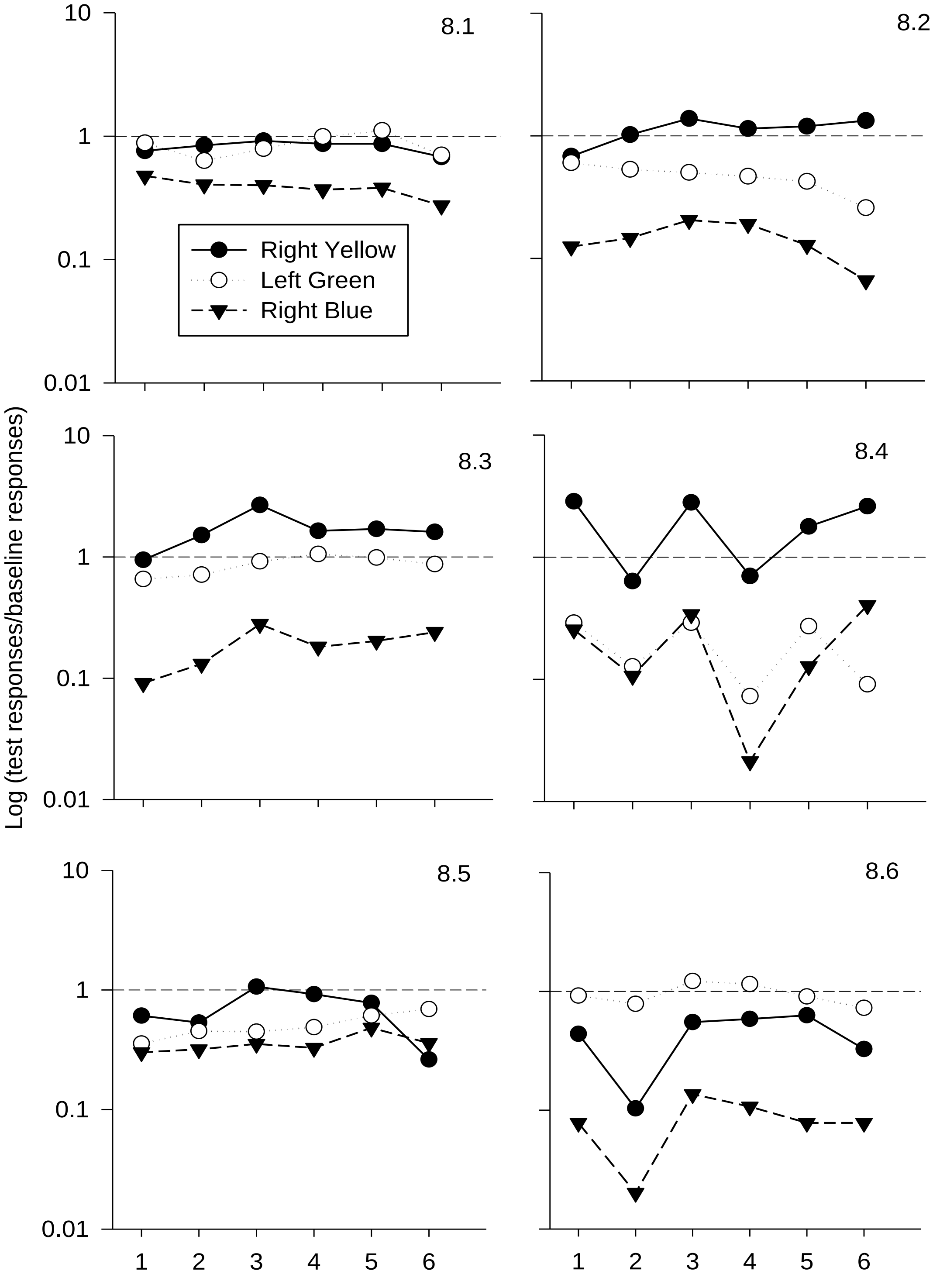


Figure 3.14. Mean number of responses for all hens on each key during the second baseline exposure and the second pink key disruptor test. The y-axis is on a log scale, with filled circles showing right yellow key responses, open circles showing left green key responses and filled triangles showing right blue key responses. Pink key responses are not shown on graph.

Disruptor Test 3

Figure 3.15 shows responses plotted as a proportion of baseline responding across all sessions of the third pink key disruptor test. Hen 8.2's data are missing from the final session of the disruptor test due to a programme error. As with the first disruptor test, responding dropped in the first session, and levels of responding did not rise again to baseline levels or above for most hens until the third or fourth session onwards.

For all hens during this test, responding on the right blue key of the Combined Component was lower proportionate to baseline than responding on any other key, and this was supported with a significant result of a paired-samples t-test, $t(5) = 4.809$, $p = .005$, $d = 17.929$. Responding proportionate to baseline on all other keys was quite similar to one another, with this measure on the right yellow key of the Concurrent Component generally lower than this measure on either of the left keys available, but still higher than responding proportionate to baseline on the right blue key of the Combined Component.

The mean number of responses on each key for all hens during the final baseline exposure and the third pink key disruptor test is shown in Figure 3.16. Once again all hens showed a decrease in responding in the presence of the pink key disruptor. With the exception of Hens 8.2 and 8.3, right blue key responding dropped to below the levels of right yellow key responding for the other hens, and no hens showed an increase in responding on any key between baseline and the disruptor test. A paired samples t-test revealed a statistically significant reduction in the number of responses in baseline and the number of responses in the presence of the pink key; $t(5) = 6.411$, $p = .001$.

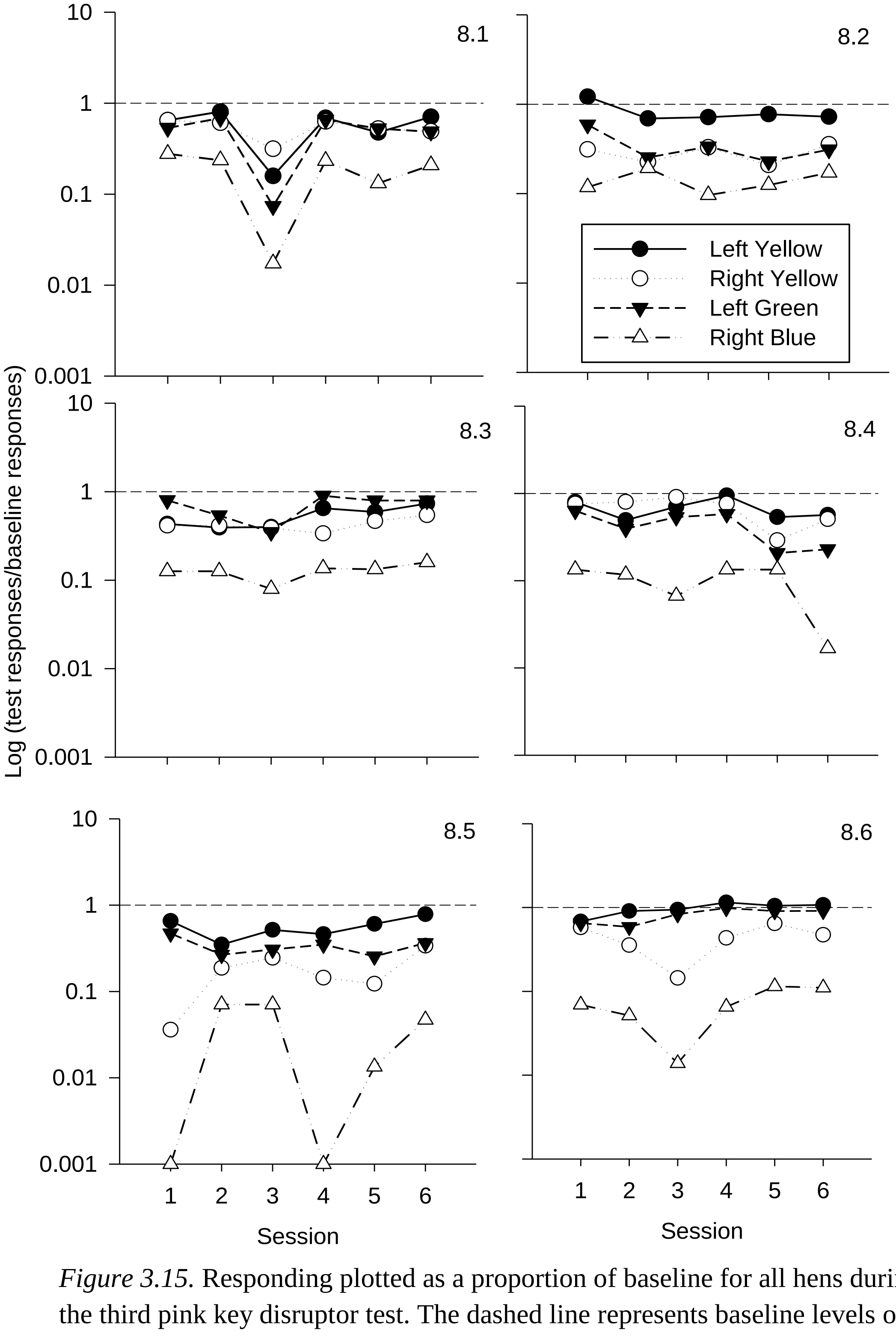


Figure 3.15. Responding plotted as a proportion of baseline for all hens during the third pink key disruptor test. The dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) and triangles represent the Combined Component (filled = left green key, open = right blue key). The y-axis is presented on a log scale and data points at 0.001 represent zero responding.

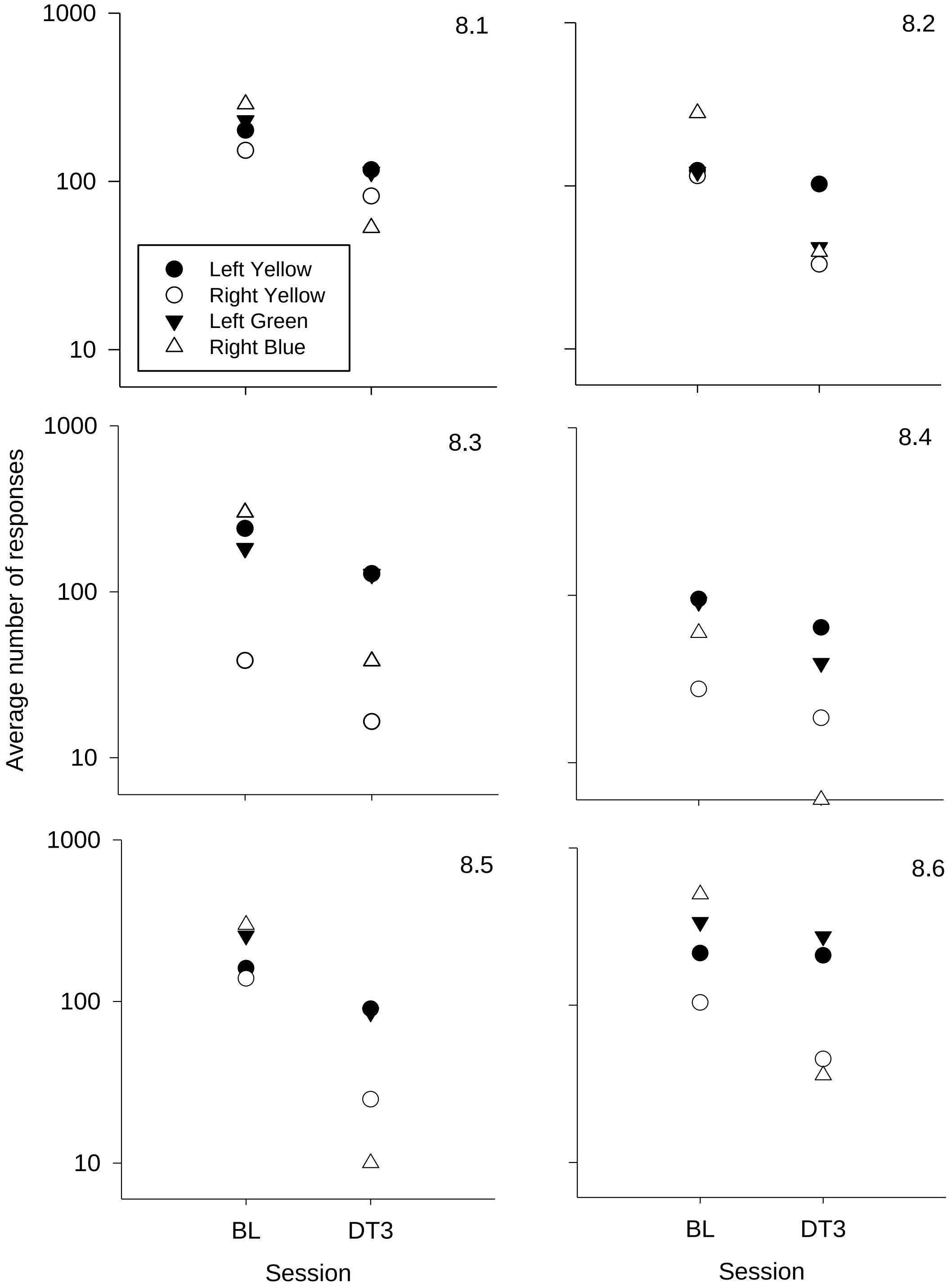


Figure 3.16. Mean number of responses on each key for each hen during baseline and the third pink key disruptor test (pink key responding not shown on graph). The y-axis is on a log scale, with circles representing the Concurrent Component (filled = left yellow key; open = right yellow key), and triangles representing the stimuli trained separately during baseline and paired in the Combined Component during the disruptor test (filled = left green key; open = right blue key).

Centre Pink Key Responses

Figure 3.17 shows the number of responses on the pink key in the three disruptor tests in which it was presented. Circles in the first and third columns of the figures show pink key responding during the Concurrent Component (filled circles) and the Combined Component (open circles). The centre column of the figure shows pink key responding during the second disruptor test in which the pink key was paired individually with each of the three stimuli; right yellow key, left green key and the right blue key.

In the first disruptor test, responses on the pink key were higher when presented between the left green key and the right blue key (Combined Component) for all hens, except 8.5 in selected sessions only, and the first session for Hens 8.1 and 8.6. There was no consistent pattern of responding on this key during this test across hens, with some hens responding on the pink key decreasing as the sessions went on, and other hens responding increasing or varying across the sessions.

The second disruptor test saw pink key responding rise when paired with all individual stimuli for all hens. Responding on this key was highest when paired with the right yellow and the right blue keys, and in all cases, there was considerably less responding on the pink key when it was presented with the left green key.

Responding on the pink key decreased immediately from the first session of the third disruptor during the third disruptor test. Once again, responding was generally greater when it was presented in between the left green and right blue keys of the Combined Component for all hens other than 8.5. Responding on the pink key remained fairly stable for Hens 8.1, 8.2 and 8.3 across sessions, but increased across the test after an initial drop for Hens 8.4 and 8.6 and fell quite steeply for Hen 8.5 in the first few sessions of the test.

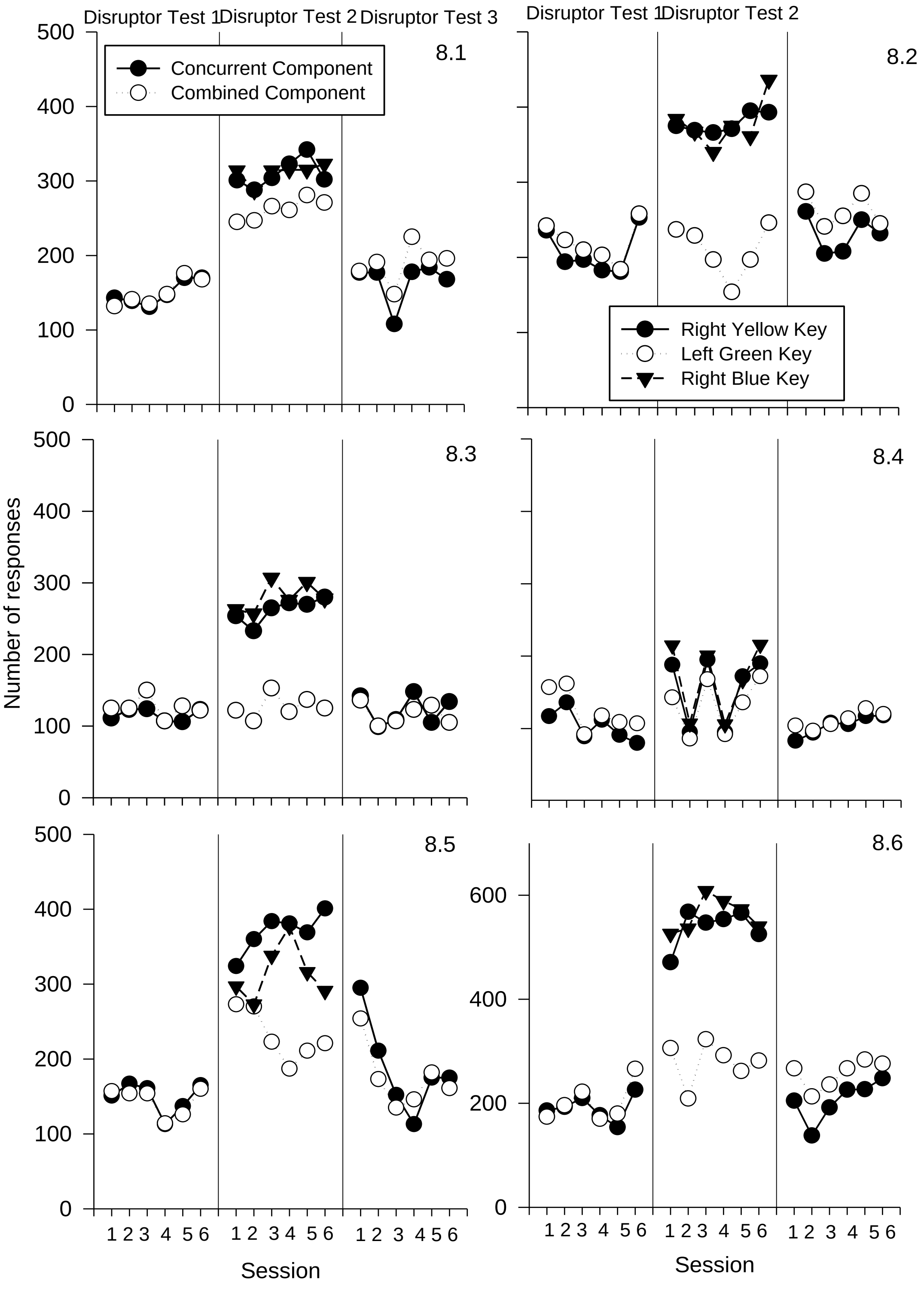


Figure 3.17. Number of responses on the centre pink key during each of the three disruptor tests. The y-axis is on a log scale. In the first and third columns of each figure, the filled circles show pink key responding when it was presented with the Concurrent Component (both yellow keys), and the open circles show pink key responding when it was presented with the Combined Component (left green and right blue keys). The centre column of the figures shows pink key responding when it was presented individually with each of the three stimuli; filled circles = right yellow key, open circles = left green key and filled triangles = right blue key.

Discussion

Experiment 3 replicated Experiment 2 using richer schedules of reinforcement on the centre key, firstly to VI 75-s schedule and then to VI 37.5-s schedule. It aimed to investigate what effect increasing the reinforcement schedules on the centre key had on the persistence of two types of target behaviour, one trained in the same context as an alternative behaviour (Concurrent Component) and one trained in a separate context to the alternative behaviour and combined in the presence of the disruptor (Combined Component).

Data from both parts of Experiment 3 show a reduction in the persistence of responding to the right blue key (target behaviour trained separately to the alternative) for the majority of hens in all of the disruptor tests in which the Concurrent and Combined Components were presented. Furthermore, during the second disruptor tests in both parts of the experiment where the individual stimuli (right yellow, left green, and right blue keys) were presented with the centre key disruptors, right blue key responding was also less persistence than right yellow key responding. Although not all disruptor tests found significant differences between the amount of right blue and right yellow responding proportionate to baseline, the majority of these data continue to show support for training an alternative behaviour in a separate context before combining it with the target behaviour in the presence of a disruptor, in comparison to the traditional DRA method, as a means to reduce persistence.

During baseline conditions throughout both parts of this experiment, response rates on the left green and right blue keys when they were presented independently were generally greater than responding on the Concurrent Component yellow keys. This is to be expected because during the Concurrent

Component the hens had a choice of two keys to respond on, so they allocated their time accordingly between the two keys based on the schedules in effect (see Herrnstein (1970) on the theory of Matching Law). This was usually not the case, however, during the first and third disruptor tests of both parts of the experiment; responding proportionate to baseline during these tests was usually higher on the left yellow or green key, or in some instances, on the right yellow key. It is possible that the increase in responding on the right yellow key was due to the combination of yellow stimuli being treated, and therefore responded to, as one richer context, than either the green or the blue keys independently (see Experiment 1 Discussion for a detailed explanation).

The greater amount of responding on the left keys is also explainable, given that the left key was associated with a richer schedule (VI 37.5 s) across all baseline and disruptor tests in which that key was operational. However, these findings do not support some of the literature, in which baseline response rates are thought to influence responding during disruption. As discussed previously, Podlesnik and DeLeon (2015) state that two separately trained stimuli can produce higher response rates when combined than either stimuli alone. Furthermore, studies investigating both renewal (Sweeney & Shahan, 2013) and reinstatement (Doughty, Reed, & Lattal, 2004), have found that higher response rates during baseline influence the amount of responding that returned, or relapsed, following an extinction phase. In Doughty et al.’s (2004) study with rats and pigeons, greater reinstatement occurred in the component that had been associated with the higher response rates during the baseline/training phase. Instead, the higher rates of left key responding found here are more consistent with the findings of behavioural momentum theory, suggesting that responding associated with a richer schedule during baseline is likely to be more persistent in the face of disruption (Nevin, 1974).

Response rates on the centre keys, however, (both white and pink), with few individual exceptions, were always greater during the Combined Component, rather than the Concurrent Component. One idea is that this increased responding to the disruptor in the Combined Component was related to the increased response rate seen on the individual green and blue keys during baseline, as discussed above. It could be that some previous association with higher response rates on the individual left and blue keys during baseline carried over to the responding during the disruptor test, causing the increased amounts of responding on the disruptor key. It is also possible that this increased responding to the disruptor during the Combined Component supports the idea that both yellow keys in the Concurrent Component were functioning as a richer context overall. As mentioned in Experiment 1, this interpretation is consistent with behavioural momentum theory. As responding to the yellow keys remained more persistent throughout, there would have been increased resistance to the disruptor itself, causing less responding to the centre key in the presence of the Concurrent Components.

Increased centre key responding when it was presented alongside the Combined Component throughout this experiment suggests overall that the Combined Component, and importantly the right blue key, was more susceptible to disruption than the Concurrent Component. In applied terms, these findings could have both positive and negative consequences. Given that right blue key responding still remained less persistent than right yellow key responding, despite higher levels of responding being allocated to the centre key, it could suggest that interventions using the alternative context training procedure might be able to withstand a greater degree of disruption than typical DRA interventions because findings still supported this method even when centre key responding was high. Therefore, in an applied setting, alternative context training could be a successful method to keep reinforcement schedules in place and reduce the persistence of the target behaviour, even if a large amount of other disruption was occurring in the environment. On the other hand, the fact that this component was more susceptible to disruption could be problematic for the same reason, in that responding to disruption in the environment, instead of to the reinforcement maintaining the intervention, could put the effectiveness of the intervention at risk.

In the second disruptor test of both parts of the experiment, in which the individual stimuli were presented with the lit centre keys, responding reduced on both the right yellow and blue key and it was suggested this was because of the richer schedules now available on the centre key. There was, however, still more responding proportionate to baseline on the right yellow key than the right blue key for all hens throughout the experiment, even though both of these keys were on the same reinforcement schedule (VI 150 s). The only difference between them was the colour, and the context in which they were associated with (right blue key alone, right yellow key paired with the left yellow key). This suggests two things, firstly, in keeping with the idea above, that responding on the right blue key was more susceptible to disruption and so responding on it reduced when it was placed alongside a richer alternative. Secondly, it suggests that responding on the right yellow key was more persistent because it had a history of reinforcement with a richer context (both yellow keys paired together during training).

A common finding across both parts of Experiment 3 was the reduction in responding on all keys, more often than not, in the presence of both the centre white and centre pink keys. Whilst this highlights the potential effects of using a centre key providing additional reinforcement as a disruptor, it also supports previous literature that has found that the use of alternative reinforcement will reduce response rates (Nevin et al., 1990), possibly due to changes in the association between the stimuli trained and paired with reinforcement during baseline (see Experiment 2 Discussion). As the reinforcer rate on the centre key increased across this experiment, response rates on other keys reduced to the rate associated with the new source of additional reinforcement.

Experiment 3 found that a centre key disruptor, associated with both a VI 75-s schedule and a VI 37.5-s schedule, reduced the persistence of the Combined Target (right blue key) responding, compared to that of the DRA/Concurrent Target (right yellow key) responding. Not only that, but responding on all keys in the majority of cases also decreased in the presence of the centre key. It was not clear however which process caused this, whether it was due to the additional reinforcement available, or due to the disruption of contingencies associated with the reinforcement and key colours presented during baseline training. Responding to the centre key directly increased as the schedule increased, and was greater when paired with the individual stimuli presented during the second disruptor tests during each part of the experiment. Findings from this experiment continue to support the idea that training a target behaviour associated with a particular stimulus context in one setting, before combining it with another stimulus associated with an alternative behaviour in the presence of a disruptor, can reduce the persistence of that target behaviour when compared to a target behaviour trained in the same context as the richer alternative.

Chapter 3: Summary

Experiments 2 and 3 aimed to investigate training an alternative behaviour in a separate context to a target behaviour before combining them in the presence of a disruptor. Persistence of target responding was then compared to the persistence of responding of a target behaviour trained in the same context as the alternative behaviour, such as in a traditional DRA intervention. Three disruptors, were used, a centre key that provided an additional source of reinforcement on three different schedules; a VI 150-s (red key), a VI 75-s (white key) and a VI 37.5-s (pink key).

Overall, there was no consistent effect of increasing the rate of reinforcement on the centre key across the different experiments. There were two general ideas for patterns of responding across each of the different reinforcement rates; firstly, that responding would be greater on the left and right keys when the lower reinforcement schedule was active on the centre key because there was less reinforcement to be gained from responding to it. This would suggest that left and right key responding would decrease as the centre key schedules increased. Secondly, the opposite of this was also a possibility, that responding across all keys would increase as the schedule on the centre key increased because there is an increased amount of both responding, and reinforcement, in the overall component context. Whilst both of these patterns were seen for individual hens and individual disruptors, they did not continue across reinforcement rates presented and the majority of hens did not display any consistent pattern of responding on the left or right keys as the centre key reinforcement rate increased.

The following figures show the average number of responses on each of the keys (excluding the centre key) for the three disruptor tests used when the three different reinforcement schedules were in effect. Note that some disruptor tests used in the presence of the red key (VI 150-s), have been excluded from this analysis as they were not comparable to the other two centre key experiments carried out. On all of the figures, there are three disruptor columns, representing responding during that disruptor test for the VI 150-s, VI 75-s and VI 37.5-s schedule centre key reinforcement rates. The first set of data points in each of the disruptor columns shows the average number of responses during the baseline presentation that preceded the disruptor test, and the second set of data points show the average number of responses when the disruptor was in effect.

Figure 3.18 shows the average number of responses on each of the keys (excluding the centre key) for the first disruptor test of each of the three different reinforcement schedules used. In this disruptor test, one component presented both yellow keys with the centre key disruptor in between them, and in a separate component both the left green and right blue keys were presented with the centre key disruptor in between. Note that Hen 8.1’s data was removed from this analysis as she was not the same hen across both experiments.

When response rates on the individual keys were analysed, responding on all keys varied across each of the centre key reinforcement rates they were paired with, and there was no consistent pattern across hens or reinforcement rates. As shown in Figure 3.18, Hen 8.2 was the only hen who’s responding decreased as the centre key reinforcement rate increased, and who continued to show consistently higher rates of responding during baseline, before a reduction in responding when the centre key disruptor was present. Some hens, for example 8.3 and 8.6, showed consistently higher responding on some keys and not others, but there is no clear pattern. Right key responding was slightly more stable than left key responding, and generally lower than left key responding, as would be expected, but even this was not the case for Hens 8.3 and 8.6 during the VI 75-s and the VI 37.5-s centre key disruptors. Right blue key responding, however, was lower in each of the disruptor tests for all hens and across all centre key reinforcement schedules with the exception being Hen 8.3 during the VI 75-s and the VI 37.5-s centre key disruptors.

Figure 3.19 shows the average number of responses on each of the keys (excluding the centre key) for the second disruptor test of each of the three different reinforcement rates used. During this disruptor test, the right yellow, left green, and right blue keys were all presented individually in components each paired with the centre key. Once again, Hen 8.2 showed a general reduction in responding on all keys as the centre key reinforcement rate increased, and this time Hen 8.4's data also followed a similar pattern. Hens 8.5 and 8.6 however showed the opposite effect, with responding generally increasing as the reinforcement schedules on the centre key increased, especially on the right blue key. In all but two cases (Hen 8.3 VI 75-s and Hen 8.5 VI 150-s), right blue key responding was lower than responding on any other key across all hens and the three centre key reinforcement rates used.

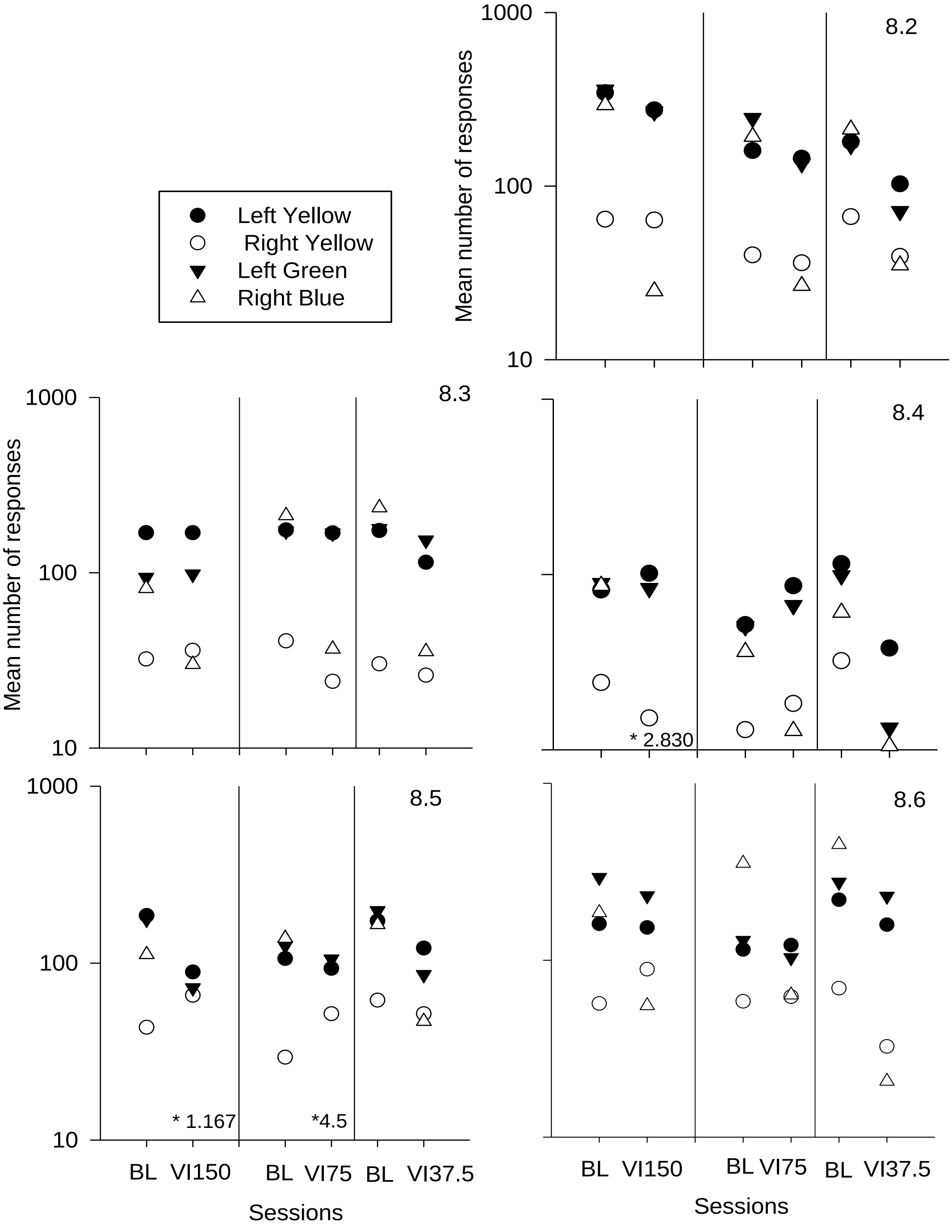


Figure 3.18. Average number of responses for each hen on each of the keys (excluding the centre key) for the first disruptor test and preceding baseline sessions of each of the three different reinforcement schedules used. The y-axis is on a log scale, and circles represent responding on the yellow keys trained in the same context (filled = left yellow, open = right yellow), while triangles represent responding on the green and blue keys trained in separate contexts (filled = left green, open = right blue).

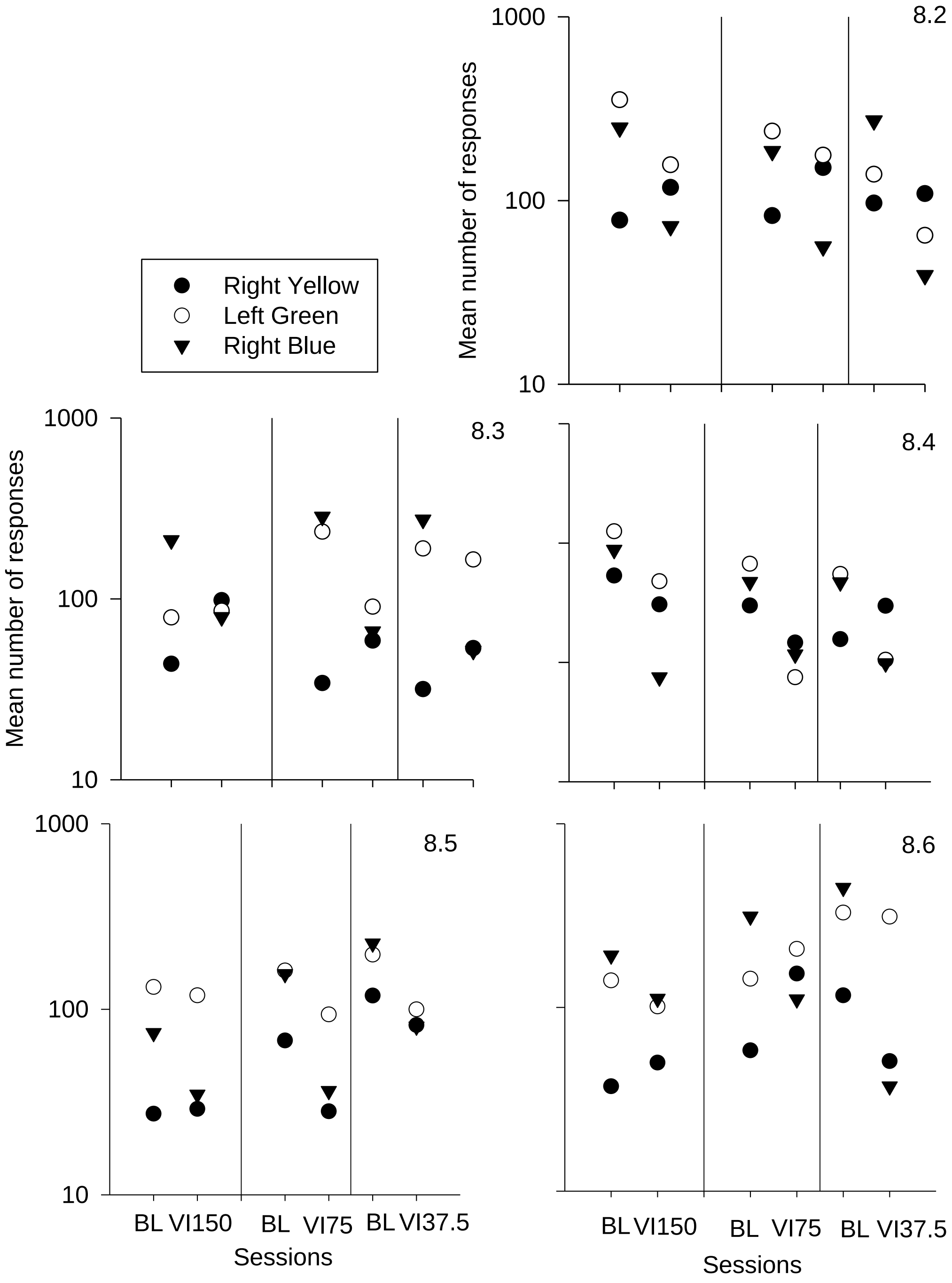


Figure 3.19. Average number of responses for each hen on each of the keys (excluding the centre key) for the second disruptor test and preceding baseline sessions of each of the three different reinforcement schedules used. The y-axis is on a log scale, with filled circles representing responding on the right yellow key, open circles representing responding on the left green key and filled triangles representing responding on the right blue key.

Figure 3.20 displays the average number of responses on each of the keys (excluding the centre key) for the third and final disruptor test of each of the three reinforcement rates used. This disruptor test was a repeat of the first disruptor test run with each of the different reinforcement schedules. Note that Hen 8.4's data was excluded from part of this analysis.

Interestingly, responding did change from the first disruptor test, although these changes were not consistent across hens. Overall, responding on both left and right keys was lower here in the presence of the centre key compared to the first disruptor test, and whilst Hen 8.2 had demonstrated patterns of responding in line with predictions during the first disruptor test, there was no clear pattern of responding during this disruptor test. In general, responding during this disruptor test was inconsistent, and in several cases during baseline, right key responding was higher than left key responding, particular when presented with the higher rates of reinforcement on the centre key. With the exception of Hen 8.2 during the VI 37.5-s centre key reinforcement rate, and Hen 8.3 during the VI 75-s reinforcement rate, responding on the right blue key was lower than all other responding (including the right yellow key) across all hens and all of the centre key reinforcement rates used.

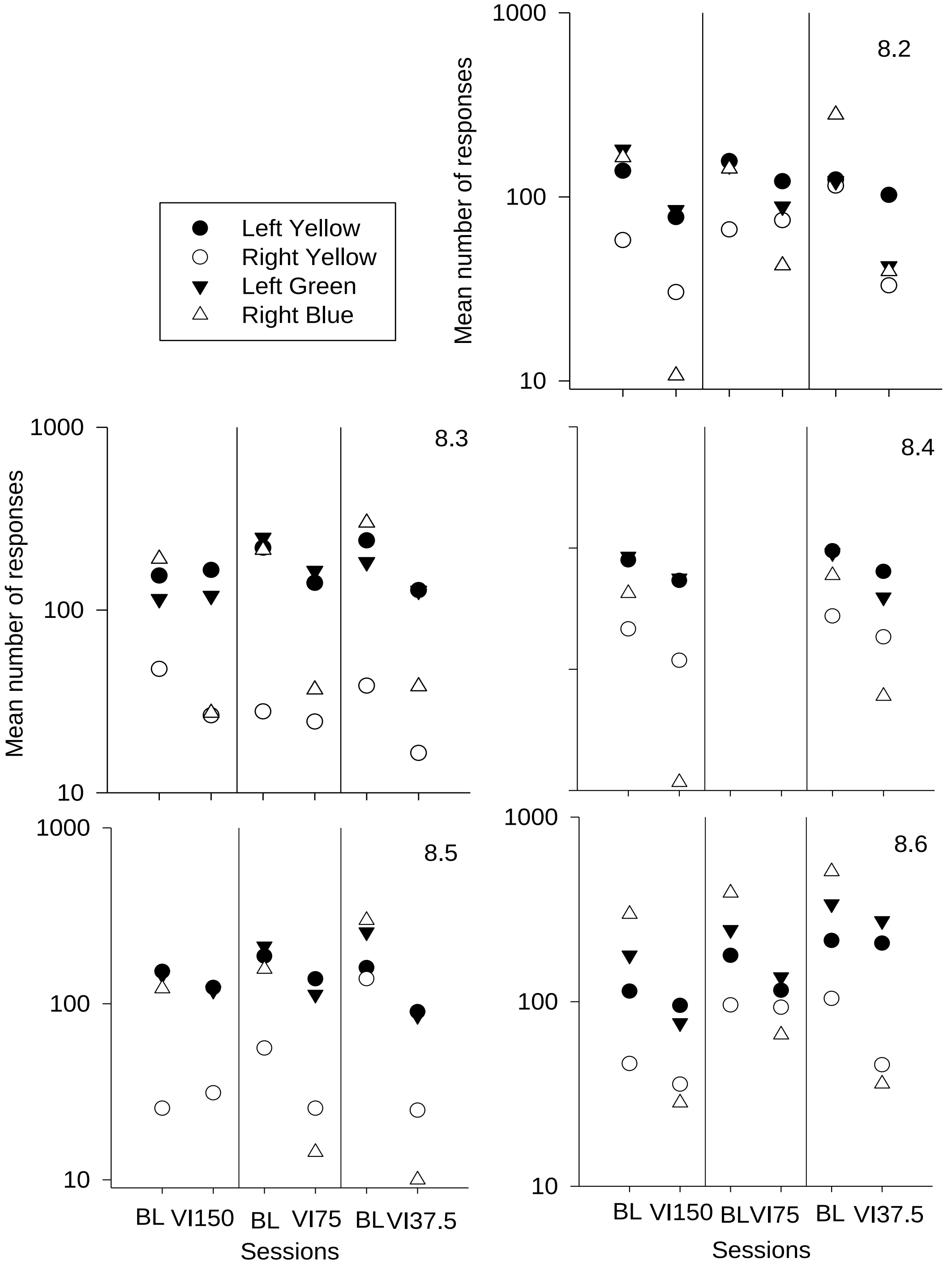


Figure 3.20. Average number of responses for each hen on each of the keys (excluding the centre key) for the third and final disruptor test and preceding baseline sessions of each of the three different reinforcement schedules used. The y-axis is on a log scale, and circles represent responding on the yellow keys trained in the same context (filled = left yellow, open = right yellow), while triangles represent responding on the green and blue keys trained in separate contexts (filled = left green, open = right blue).

The average number of responses across all baseline sessions preceding each of the disruptor tests using the different rates of reinforcement on the centre key was quite variable across the experiments, as shown in Figures 3.18-3.20. This was especially true for the first and second disruptor tests with all of the reinforcement rates, however, hens showed individual differences here. This instability in baselines across the experiments highlights the importance of returning to baseline after each disruptor test, and using the averages of baseline responding that occur immediately before the disruptor test to calculate proportion of baseline measures. One might expect changes in responding to the green and blue keys across repeated baselines, because the contingencies associated with each of the keys changed as soon as they were presented in the same context for the first time during the first disruptor tests. The contingencies associated with the yellow keys however remained more stable because there are fewer changes made to the context during the disruptor tests. In general, baseline responding was more stable on the left keys across experiments than on the right keys, regardless of colour.

The only other notable finding shown in Figures 3.18-3.20, and consistent across centre key reinforcement schedules, is the reduction in responding overall in the presence of the disruptor, regardless of reinforcement schedule or disruptor test in effect. This is clear from the differences in the average number of baseline responses columns to the average number of disruptor responses for the majority of hens. This reduction in responding in the presence of the disruptor was supported by paired samples t-tests as presented and discussed in the results sections above.

Responses on the centre key also changed as the reinforcement schedules associated with that centre key increased. Figure 3.21 presents the number of responses on the centre key during the three disruptor tests of Experiment 2 (VI 150-s red centre key). These are re-presented here for clarity and comparison, as all five disruptor tests are presented together during the results section of Experiment 2. Figure 3.9, in the Results of Experiment 2, shows the number of responses on the centre key during the three disruptor tests of the VI 75-s white centre key, and Figure 3.17, in the Results of Experiment 3, and shows the number of responses on the centre key during the disruptor tests of the VI 37.5-s pink centre key. Although there were few clear patterns of responding on the left and right keys across centre key reinforcement rates, there were some clear patterns of centre key responding as the reinforcement rate on this key increased.

As expected, the number of responses on this key increased as the reinforcement schedule increased, with more responding from all hens on the centre key with the VI 37.5-s. All three centre key reinforcement schedules had disrupting effects on left and right responding, even though only some reduction in responding on the left and right keys was observed as the centre key schedule increased. Centre key responses, however, increased greatly as the reinforcement schedules increased, which over time could have changed responding on the left and right keys even more. This, along with the fact that the red key on a lower reinforcement rate still produced disrupting effects, led to the red key being considered for future experiments, rather than the white or pink keys on the richer schedules. In addition, it seemed unlikely that in an applied setting, an additional reinforcement at a very high rate would be purposefully added to the environment as a disruptor, and so the red key was chosen for use again in Experiments 8, 9 and 10.

The common finding across centre key reinforcement rates was the increase of responding on the centre key during Disruptor Test 2 for all reinforcement rates. When the centre key was paired with the individual keys in Disruptor Test 2, rather than in between the Concurrent Components (both yellow keys) or Combined Components (left green and right blue keys), centre key responding increased considerably across all of the reinforcement rates it was paired with.

It is not exactly clear why this increase in responding occurred, especially when centre key responding then reduced again during the disruptor test. However, it is possible that having only two keys to choose from instead of three reduced the response competition, in turn increasing responding on the centre key as the only other available alternative regardless of the reinforcement schedule in effect.

The other common finding on the centre key across experiments was the increased amount of centre key responding when it was presented in between the left green and right blue keys (Combined Component) during Disruptor Tests 1 and 3. In almost all cases, centre key responding was higher here than when the centre key was presented between the yellow keys in the Concurrent Component. As discussed previously, this finding could be problematic if behaviour trained in two separate contexts was more easily disrupted than behaviour trained in the same context. Used in applied settings, this could put the effectiveness of an intervention at risk.

There were several findings from these experiments that are significant for applied settings. Firstly, training a target behaviour in one setting, before combining it with an alternative behaviour in the presence of a disruptor, can reduce the persistence of that target behaviour when compared to a target behaviour trained in the same context as the richer alternative, such as during a traditional DRA intervention. This was shown not just through the more commonly used measure of persistence, proportion of baseline, but also with average response rates, that showed, in most cases, a greater number of responses on the DRA Target (right yellow) key than the Combined Target (right blue) key. Although discussed in more detail later, the implications of the use of proportion of baseline for applied settings are worth noting now, because in interventions, frequency of responses or response rate are more likely measures than proportion of baseline to determine how behaviour is continuing. Frequency of responding as an absolute measure is essential when aiming to reduce problem behaviours that have detrimental effects to an individual. For example, a 60% reduction in responding compared to baseline may sound like a successful reduction, but if the behaviour is a child hitting a classmate to the point of injury only four times an hour instead of the 10 times previously, it is still a cause for concern.

Another important finding across the experiments so far is the consistently higher proportion of baseline responses during disruptor tests on the right yellow (DRA Target) key. Potential reasons for this are outlined in the relevant experiment discussions, but it seems quite likely that as the right yellow key is always paired with the left (and richer) yellow key during baseline, both yellow stimuli are associated with a greater availability of reinforcement. This would account for the higher proportion of baseline responding on this key in the presence of a disruptor, and for the potential increased persistence of responding to the right yellow key because it is trained and associated with the richer reinforcement schedule occurring on the left yellow key.

This has strong applied implications for those implementing DRA procedures, because it suggests not only that the DRA Target behaviour will remain more persistent in the face of disruption, but that target responding could actually increase when the richer alternative reinforcement schedule is no longer available. This also suggests that training an alternative behaviour on a richer reinforcement schedule (the left green key in the experiment) in a separate context to the problem behaviour (right blue key in the experiment), will reduce the persistence of the target behaviour when compared to target behaviour trained in the same context as the alternative.

These findings were shown using a disruptor that allowed reinforcement to be maintained for all responses in the context. Although previous studies have investigated maintaining responding to examine the effects of persistence and behavioural momentum theory (Harper & McLean, 1992; Nevin et al., 1981) there were no known laboratory studies investigating the persistence of a target behaviour in either DRA, or an alternative context training procedure without the use of extinction. Given that the use of extinction, as already discussed, can be problematic, the present findings suggest it is possible to investigate the persistence-strengthening effects of DRA procedures without using extinction.

There are limitations to the conclusion from these experiments; one being that the same group of hens was used throughout. Whilst this allowed useful comparison measures within-subjects across procedures, it affects the amount of time that the hens were exposed to the same conditions repeatedly. This can be concerning from both a basic research point of view and an applied point of view. It is possible that the outcomes of the later experiments are impacted because the hens had prior exposure to the contingencies associated with the left and right keys in both components, and had experienced these keys associated with extinction (see Experiment 1). Furthermore, although the key colour and reinforcement schedule changed on the centre key, by the time this was increased to its final rate in the second part of Experiment 3, the hens had still been exposed to a lit centre key several times, potentially reducing the disrupting effects the centre key might have.

It is also unlikely in an applied setting that participants are exposed so many times to the same conditions. Dube et al. (2009) highlight the differences between baseline exposures in laboratory settings, which are often greater in number and greater in frequency, than baseline exposures in applied settings. This has the potential to change the strength of the rich and lean components of the experiments (Dube et al., 2009). These changes happen over time, because repeated exposure to the richer conditions continually strengthen the behaviour associated with the richer component of an experiment, leading to potentially differing (and stronger) reinforcing effects in the later exposures.

Although these experiments go some way to providing a solution to the persistence-strengthening effects of DRA procedures, questions still remain. Using a centre key as a disruptor with an associated reinforcement schedule provided a useful disruptor that allowed reinforcement to continue for alternative (left key) and target (right key) responses, but it also meant that more reinforcement was added to both the DRA/Concurrent and Combined Contexts as well. As this reinforcement was added equally, across all components and disruptor tests, this is still a useful measure, but it does mean that there is more reinforcement added to the environment, and in applied settings, this could be problematic especially if there are challenging behaviours occurring. Furthermore, it is a well-researched finding that concurrent reinforcement can reduce responding even if relatively little time is spent working towards and collecting that reinforcement (Dube et al., 2009; Nevin et al., 1981; Nevin et al., 1990). It is a possibility then that the reduction of alternative and target responding in the presence of the centre key, observed in Experiments 2 and 3 above, was simply due to the presence of an additional source of reinforcement.

It seems, therefore, that is a need to investigate the persistence-strengthening effects of DRA procedures in settings that allow alternative and target reinforcement to remain in effect, but do not add any further reinforcement to the context. This would allow investigation into whether disruptors that did not provide any additional reinforcement still reduced responding overall as the disruptors that provided additional reinforcement did. It would also allow a further analogy between an experimental setting, and an applied setting, in which alternative and target reinforcement is likely to continue without adding anything further to the environment.

Chapter 4: Experiments 4-7

Previous research indicated that training an alternative behaviour in a separate context before pairing it with a target behaviour makes the target behaviour less persistent than training both behaviours within the same context. This has been found with both extinction as a disruptor, (for example, Experiment 1 in the present study, and Mace et al. (2010); Podlesnik and Bai (2015); Podlesnik et al. (2012)), and with other disruptors, such as other sources of reinforcement available on an additional key (e.g., Experiments 2 and 3).

The next series of experiments explored the effects of different disruptive conditions, other than extinction and an alternative reinforcement source, using the same baseline condition as in the previous experiments, on the persistence of the target behaviour. Experiment 4 explored the effects of combining the alternative and target behaviour following training in separate contexts with no added disruptor. This was to uncover any effects of this procedure alone. Following that experiment, flashing light and sound were used as disruptors (Experiments 5 and 6 respectively). In these experiments, no further reinforcement was added to the context. Experiment 7 investigated the effects of changing the physical context. In this experiment, the effects of moving the hens to a transparent (Perspex) operant chamber (where general lab activity could be observed), on the persistence of target behaviour that had been trained in an enclosed chamber were examined.

Experiment 4: No Disruptor

Despite apparent success at reducing the persistence of the target behaviour when it was trained in a separate context to an alternative behaviour, questions remain as to what exactly is causing that effect. One possibility, supported by behavioural momentum theory (Nevin, 1974), is that fewer reinforcers are added to the context overall by training the two behaviours separately. By not introducing additional reinforcement into the target behaviour environment while the alternative response is being trained, the development of persistence of the target response is prevented. This has important implications for applied uses of DRA interventions, where the alternative behaviour is typically introduced and frequently reinforced in the same context in which the target behaviour is already being reinforced, unintentionally strengthening the target behaviour with potentially damaging consequences (Mace et al., 2010). It is important to understand how these persistence-strengthening effects might be avoided, and, as has been pointed out previously, one way to do this would be to examine the effects of training the alternative and target behaviours separately before combining them without the addition of a disruptor to see if the target behaviour remained less persistent.

As previously mentioned, one could argue that the combination of the separate training contexts during the disruptor tests is in itself a disruptor, because changes the context from that associated with the training or baseline procedure. Findings from Podlesnik et al. (2012), discussed in Podlesnik & DeLeon (2015), suggest that in the experimental setting, the combination of the alternative and target keys, after training in separate contexts, has disrupting effects. They suggest that this is because adding the alternative key to the target context disrupts the stimulus-response contingencies presented and learned during baseline training, i.e., the association between the right blue key and the VI 150 s reinforcement schedule. It is unknown, however, to what degree this change in stimulus contexts alone might disrupt responding, or, if the effects found in previous experiments, resulted from the presence of a disruptor or from this combination of stimuli.

In addition to the possibility that combining the two stimuli is itself a disruptor, it is also possible that this very procedure alone has persistence-reducing effects. As the alternative and target responses are both trained in separate contexts, before being combined, one might predict fewer responses (relative to training levels) when the keys are made concurrently available. It is difficult to quantify then if a reduction in responses compared to baseline levels after the two stimuli were combined was due to the effects of the disruptor, or to the effects of combining the two separately trained stimuli.

Thus, the next experiment investigated combining an alternative behaviour with a target behaviour trained in separate contexts, without the addition of a disruptor. Not only did this allow for the reinforcement schedules to remain in effect (see Introduction for further discussion) it also allowed for the examination of whether the target behaviour trained in a separate context to the alternative behaviour was less persistent, when compared to the alternative and target behaviours trained in the same context, without the presence of a specific additional disruptor.

During this experiment, there were some changes made to the disruptor tests. Namely, the second and third disruptor tests from previous experiments, in which the stimuli had been presented individually with a disruptor, and then combined again with the disruptor, were not used. This was because the focus was on the effects of combining the alternative and target stimuli on the persistence of behaviour, and so indicative data could be examined from the use of the first disruptor test alone.

Method

Subjects

The subjects were five of the six hens from Experiment 3, and a replacement hen numbered 8.4. Unfortunately, this hen's health also deteriorated during this experiment, so her data during the second part of the experiment was removed.

Apparatus

The same experimental chamber as used and described in Experiments 1-3 was used for the duration of this experiment.

Procedure

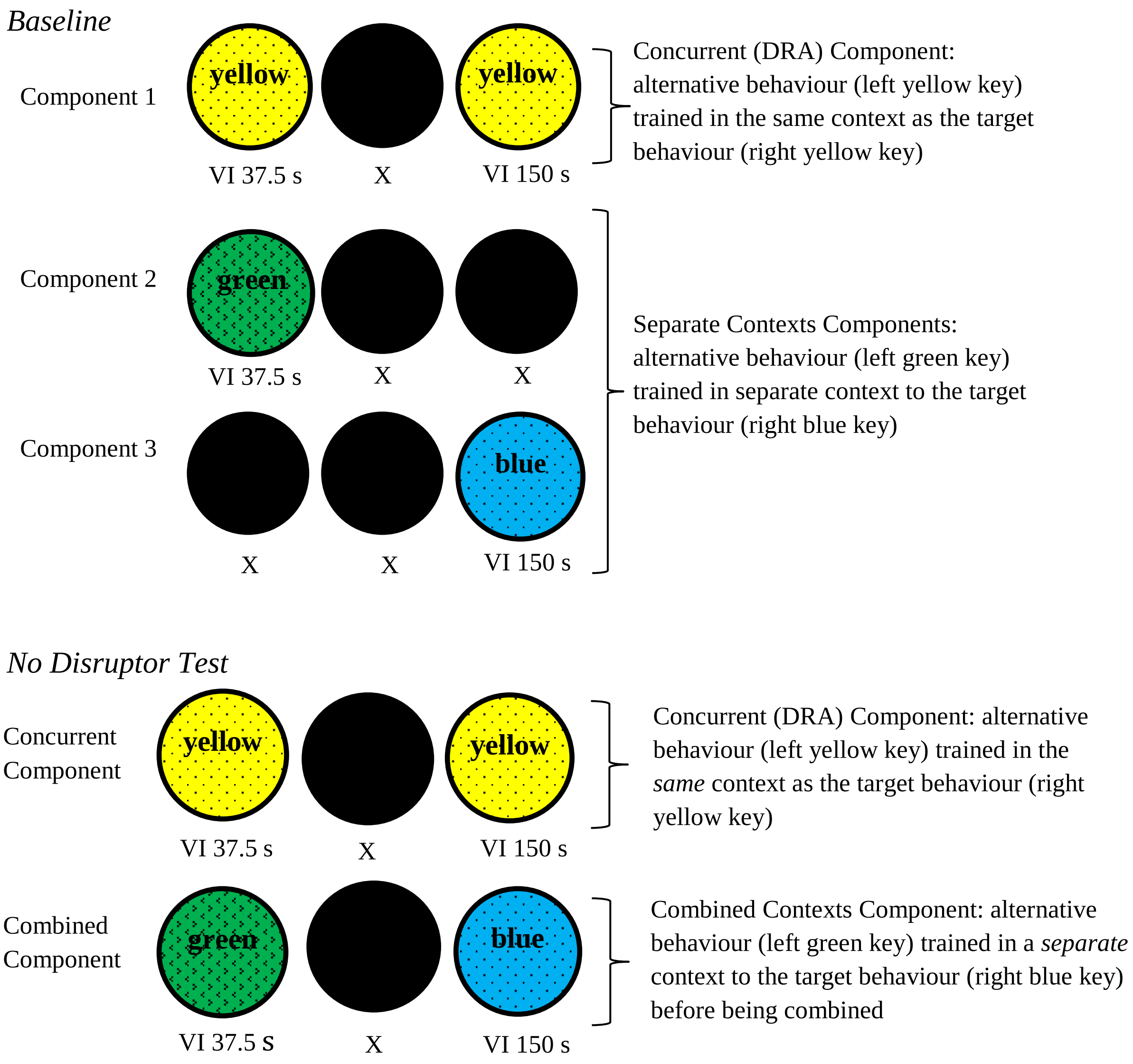
Baseline Training

The baseline procedure was the same presentation of components as previously used in all experiments so far, as shown in Figure 4.1. As the hens had previously experienced this baseline condition several times already, they were only returned to the baseline condition for six sessions prior to the test outlined below.

No Disruptor Test

The hens continued to be placed in the same experimental chamber as baseline. In one component, the hens were presented with the left and right yellow keys from baseline Component 1, hereafter referred to as the Concurrent Component. In a second component, the left green key from baseline Component 2 and the right blue key from baseline Component 3 were combined into one component, referred to as the Combined Component. No changeover delays were used in either component. The key colours and reinforcement schedules were kept the same as the baseline condition and are displayed in Figure 4.1.

These two components were presented 12 times each, totalling 24 component presentations per session. Components were presented in random order and were separated by a 20-s inter-component-interval (ICI). The sessions started and ended with an ICI, and 3-s access to wheat was provided for reinforcement. Total session length was 32.5 minutes, and, in keeping with baseline presentations, there were six sessions.



Concurrent (DRA) Component: alternative behaviour (left yellow key) trained in the same context as the target behaviour (right yellow key)

Separate Contexts Components: alternative behaviour (left green key) trained in separate context to the target behaviour (right blue key)

Concurrent (DRA) Component: alternative behaviour (left yellow key) trained in the *same* context as the target behaviour (right yellow key)

Combined Contexts Component: alternative behaviour (left green key) trained in a *separate* context to the target behaviour (right blue key) before being combined

Figure 4.1. Key colours and schedules as presented during baseline (upper panel) and the No Disruptor Test (lower panel).

Results

The number of responses during each session of baseline, and during the No Disruptor Test are shown in Figure 4.2. Due to illness, Hen 8.4's data were not included. Hens 8.1, 8.3 and 8.5's responding during baseline was generally greater on the two left keys, associated with the richer (VI 37.5-s) schedules. Hens 8.2 and 8.4 on the other hand responded much more to the right blue key, presented alone and associated with the leaner schedule (VI 150-s).

Figure 4.2 compares the number of responses during baseline with the number of responses during the No Disruptor Test. There were only two cases (Hens 8.1 and 8.6) where responding on the right blue key was lower than on the right yellow key. Responding between these two keys was comparable for Hens 8.2 and 8.5, and inconsistently lower at times on one or the other. There was no statistically difference in responding on these two keys, with a two-way repeated measures ANOVA comparing the number of right yellow and right blue key responses across sessions showing no main effect of session $F(5,20) = 1.401$, $p > .05$, $\eta_p^2 = .259$, or of response type $F(1,4) = .362$, $p > .05$, $\eta_p^2 = .083$. There was a significant interaction between sessions and response type; $F(5,20) = 3.068$, $p < .05$, $\eta_p^2 = .434$.

Hen 8.5 was the only hen who's responding on the right blue key remained similar to baseline levels, all other hen's response rates on the right blue key reduced comparative to baseline, but not compared to the right yellow key. A reduction of responding overall between baseline and no disruptor test sessions was not observed for any hen other than 8.2. Responding on both left keys remained quite similar to each other and relatively stable across all sessions.

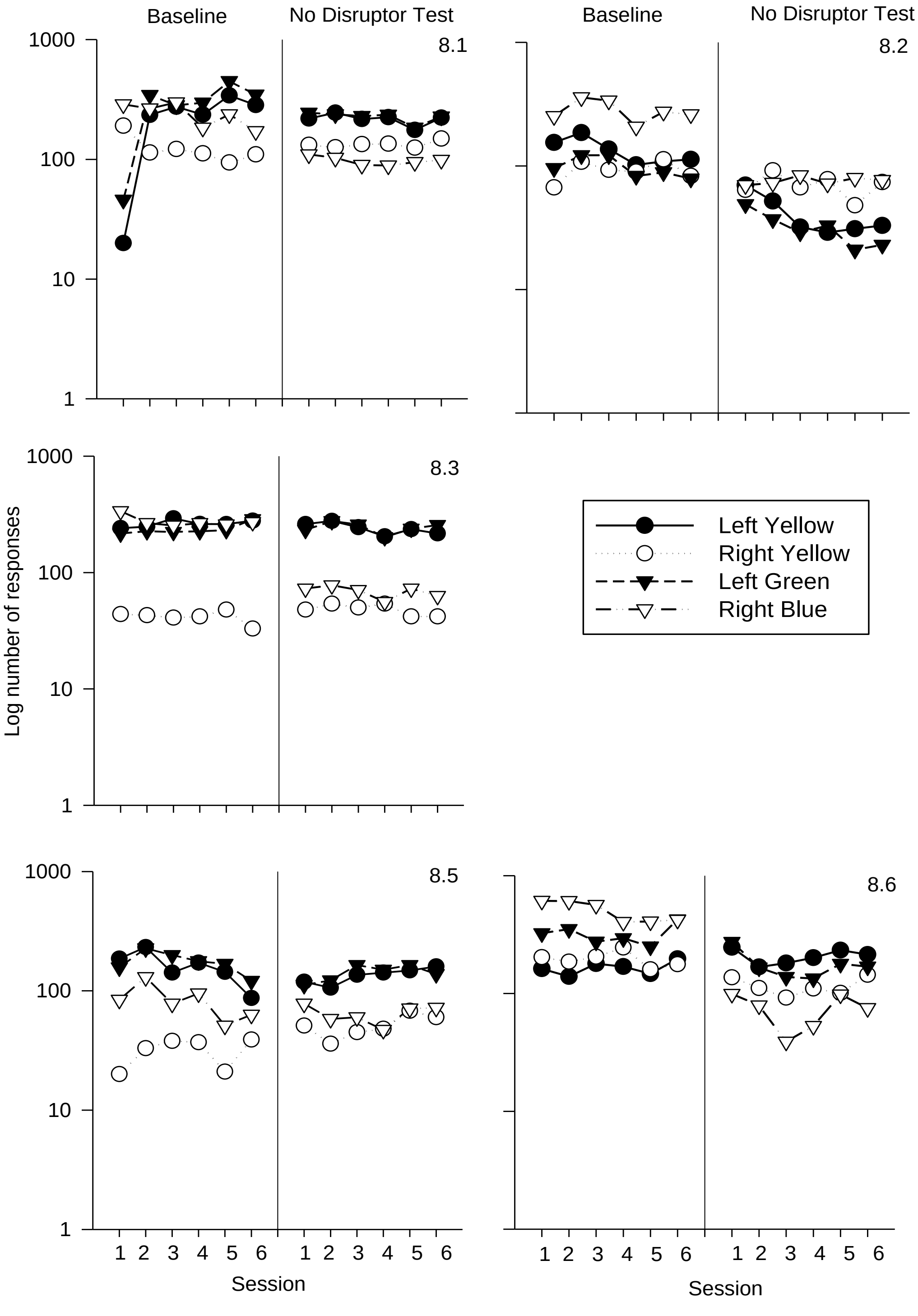


Figure 4.2. Response rates for all hens during the six sessions of baseline that preceded the No Disruptor Test, and response rates during the six sessions of the No Disruptor Test. The y-axis is on a log scale, and circles represent the Concurrent Component (filled = left yellow, open = right yellow). Triangles represent the two stimuli trained separately during baseline (filled = left green, open = right blue) before they were combined during the No Disruptor Test.

Whilst proportion of baseline is generally regarded as the measure of persistence in the presence of disruption, the response rates during the No Disruptor Test described above were included to compare to baseline as there was no actual physical disruption applied during the test. Despite this, proportion of baseline measures were still needed to compare the data to previous experiments. Therefore, Figure 4.3 shows responding plotted as a proportion of baseline on all keys during the No Disruptor Test. For all hens, responding was lower proportionate to baseline on the right blue key, than it was on the right yellow key. A paired-samples t-test comparing the average proportion of baseline responses on the right yellow key with the average proportion of baseline responses on the right blue key was significant; $t(4) = 7.216$, $p = .002$, $d = 1.655$. Furthermore, proportion of baseline responding was lower on the right blue key than any other key for three out of five hens. Overall, proportion of baseline responding throughout the course of this test remained very stable, and for Hens 8.1, 8.3 and 8.5, similar to baseline levels of responding. Both Hens 8.2 and 8.6 showed slight decreases in responding proportionate to baseline on all keys except the right yellow key (Hen 8.2) and the left yellow key (Hen 8.6).

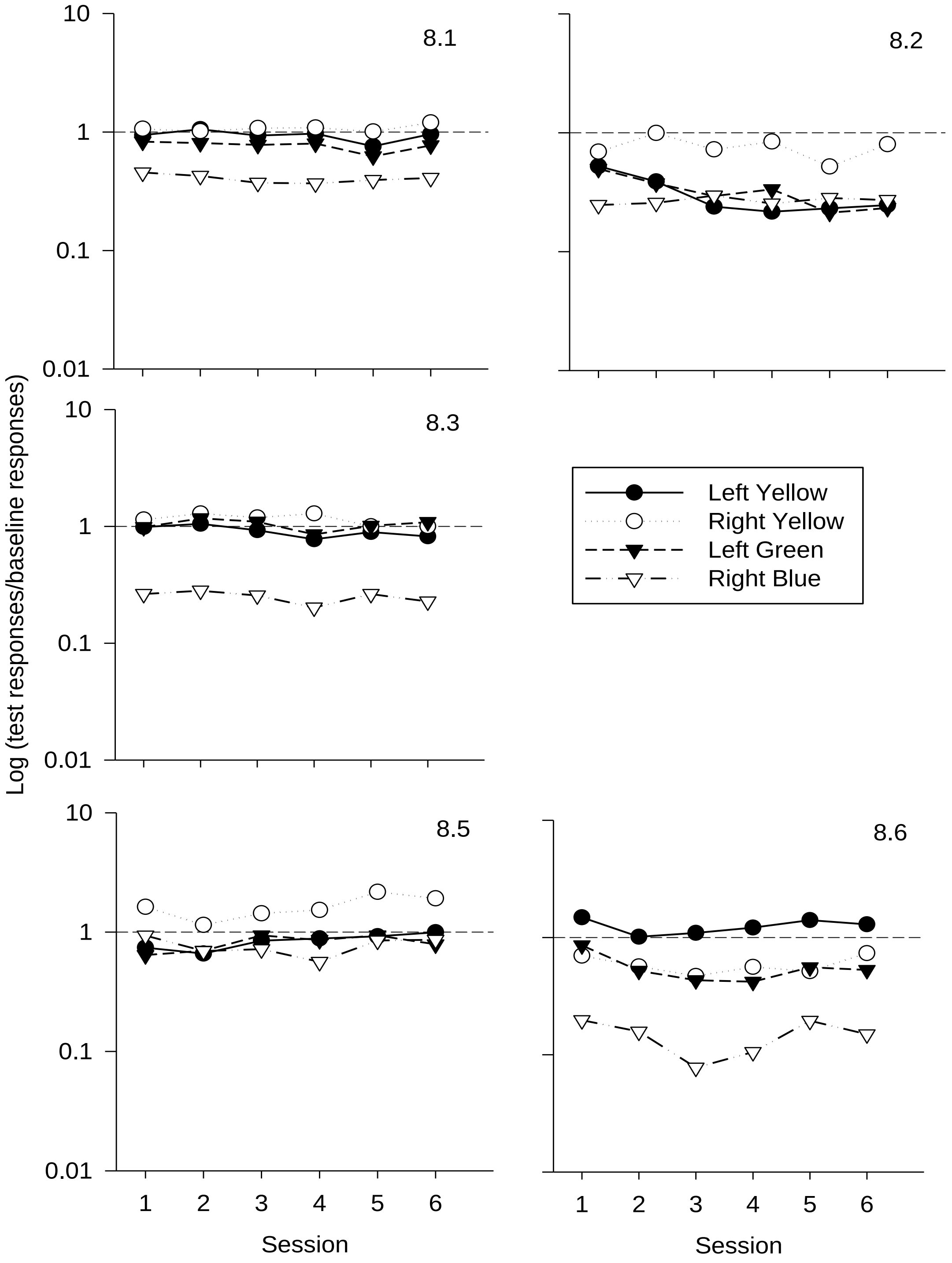


Figure 4.3. Responding plotted as a proportion of baseline during the No Disruptor Test. The y-axis is presented on a log scale and the dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the Combined Component (filled = left green key, open = right blue key).

Discussion

The present experiment aimed to investigate combining an alternative behaviour with a target behaviour trained in separate contexts (Combined Component), without the addition of a specific disruptor. In keeping with previous findings it was thought that the target behaviour trained in that separate context (right blue key) would be less persistent when compared to the target behaviour trained in the same context (right yellow key) as the alternative behaviour (Concurrent Component).

The proportion of baseline data (see Figure 4.3) suggest, as per previous experiments, that responding on the right blue (Combined Target) key is less persistent than responding on the right yellow (Concurrent/DRA Target) key and this finding was supported statistically. These findings support that of other research, and suggest that combining two stimuli trained in separate environments is effective at reducing the persistence of the target behaviour.

Generally, persistence has been measured as a proportion of baseline responding (Nevin, 1974). However, in an applied setting it may be that the actual difference in response rates between the two types of target responding, the right yellow (Concurrent/DRA Target) key and right blue (Combined Target) key is more important. Therefore, the initial set of data presented (Figure 4.2) examined the response rates during the No Disruptor Test, comparing them to baseline levels of responding directly. Responding on the right blue key overall was similar to responding on the right yellow key, in fact for three out of the five hens, right yellow key responding was actually lower than that of the right blue key. These data raise the question of whether persistence, as measured by the proportion of baseline data, or the response rates are of more relevant to the applied setting, especially as there was more responses on the right yellow key than there were on the right blue key.

The average response rate data showed that responding overall during the no disruptor test also did not reduce comparative to baseline levels. Although one would expect a reduction on the right blue key when it was combined with the left green key because it is now competing with another response type, responding on the left green and both left and right yellow keys did not reduce compared to baseline. This suggests that some other external force might have been necessary to act as a disruptor and change responding, other than the combination of the left green and right blue keys alone. Perhaps greater exposure to these contingencies, beyond the six sessions implemented here, are necessary to fully understand the differing results between the response rate and proportion of baseline data.

A limitation to this experiment included how the No Disruptor Test was implemented across both components. When there was no disruptor used, there was no change to both components (i.e., the left green and right blue key were presented together, representing a change in baseline, but the two yellow keys were presented exactly as they were in baseline). Being able to apply something equally to both components was one of the key criteria for a disruptor (Craig et al., 2014).

This experiment did, however, have implications for the applied significance of this methodology, similar to that of previous findings from an unpublished study discussed by (Podlesnik & DeLeon, 2015). During that study, six pigeons were trained to respond to an alternative (left) key and a target (right) key of the same colour in the same component, just like a traditional DRA situation. They trained responding to an alternative (left) key of one colour and a target (right) key of another colour in two separate components. The alternative and target keys were then combined and reinforcement was maintained for 21 days, so the pigeons were exposed to both the DRA Component (same colours) and the Combined Component (different colours) in alternation. When persistence was tested following pre-session feeding, there was no difference between the persistence of the two types of target responding, regardless of whether it was trained as part of the DRA or the Combined Component. This was the case despite the differences in key colour signalling the different reinforcement rates in the Combined Component (Podlesnik & DeLeon, 2015).

Whilst similar to the present study in terms of the stimuli presented, the unpublished data still used pre-session feeding as a disruptor to measure the persistence of the target behaviours, which the present study did not. However, the data discussed by Podlesnik and DeLeon (2015) provide two possibilities in relation to the present study; firstly, that longer term exposure to the Combined Component without a disruptor essentially results in the same situation as the Concurrent Component in terms of the reinforcement available in that context. Translating that into an applied situation, it suggests that such long-term exposure to Combined-Context DRA as an intervention may not actually be beneficial to reducing persistence. Secondly, the key colour in the Combined Component of the unpublished study made no difference after the pigeons were exposed to the two colours in the same context for a period of time following training; thus suggesting that the key colour alone was not discriminative enough to signal two separate contexts (Podlesnik & DeLeon, 2015).

Bai et al. (2016) conducted an experiment with pigeons, using a similar procedure to that outlined in the present experiment. Their procedure differed from the present one in that pigeons were exposed to two different baseline conditions, one resembling the present experiment's baseline procedure, and one featuring the lean and rich schedule combinations, as found only in the DRA Component of the present experiment. Additionally, when the individually trained stimuli were combined, reinforcement was withheld (Bai et al., 2016), using extinction as a disruptor.

Their results suggest that during extinction tests, although the target responses reduced faster when trained in the presence of the alternative response, there was greater persistence and relapse of the target response following this type of training (Bai et al., 2016). Findings from the present experiment support those of Bai et al. (2016), because the Combined Target (right blue) responding, did reduce proportionate to baseline during the No Disruptor Test. Furthermore, they strengthen the findings of Bai et al. (2016) by enabling reinforcement to be maintained, rather than having to discontinue it during extinction conditions. However, as discussed above, long term exposure to the Combined Component whilst maintaining reinforcement may cause persistence-strengthening effects no different from those found in the DRA Component, so further investigation into this procedure is still warranted.

The current set of data, and the findings discussed by Podlesnik and DeLeon (2015), do not adequately answer the question of whether combining the stimuli alone without a disruptor do reduce the persistence of target responding on the Combined Target (right blue) key. This is because of the differing results from the proportion of baseline, and response data, and the questions arising from that about the measurement of persistence. It is also unclear if combining the two stimuli accurately defined a disruptor, due to the lack of reduction in responding overall between the baseline and No Disruptor Test. Combining the stimuli did provide some change in the experimental conditions (Nevin & Wacker, 2013), and it did present a change in the behaviour learned during the baseline condition (Craig et al., 2014). If, however, disruption requires some external force to be applied to the environment, or reduction in responding after the disruption has been applied (Nevin, 2015), then it cannot be concluded that combining the stimuli alone is a disruptor. What it does do, however, is change the stimuli associated with that particular context, which could reduce the responding to both of the keys within that context.

Experiment 5: Flashing Key Light

Training an alternative behaviour in a separate context to a target behaviour before combining them in the presence of a disruptor seemed to be a possible solution to the persistence-strengthening effects of DRA, where the two behaviours are trained in the same context. Persistence of the target behaviour was reduced with the previously used disruptors (extinction and a key associated with reinforcement), but the effects were less clear when no disruptor was used (Experiment 4). Thus an added disruptor might be a necessary part of the procedure to see this reduction in the persistence of target responding. Previously used disruptors altered the available reinforcement in the context, so the intention here was to investigate disruptors that did not affect the reinforcement rates i.e., did not change, add or withhold access to reinforcement in any way.

A disruptor that does not alter reinforcement in the experimental context is more analogous to many applied situations, where reinforcement may not be easily discontinued, which is often the case in classroom settings. Problem (or target) behaviour in the classroom may be maintained by many variables, but is most likely to provide access to a form of tangible reinforcement (Dube et al., 2009). This reinforcement may be escape or avoidance of task completion, peers or teacher attention, and more, all of which is difficult to remove completely, for all instances of behaviour. Typical classroom disruption may not affect some of these reinforcers; casual observations showed that excessive noise, activities outside the classroom window and distraction from peers were the most commonly observed ‘disruptors’ to classroom tasks. Therefore, keeping reinforcement ongoing throughout the experimental process allows investigation into disruptors and persistence, similar to an applied setting.

The aim of this experiment was to see if the method of combining alternative and target stimuli after training behaviours associated with them in separate contexts was still effective at producing less persistent target behaviour than training the two behaviours in the same context, when tested with other potential disruptors.

The two disruptors used in these next experiments were a flashing light and sound, and naïve hens were used to avoid any potential history effects from the previous experiments. The same basic experimental procedure as used for Experiments 1-3 was used in this experiment. For the flashing light disruptor, the centre key situated between the two active keys of each component flashed white at a rate of 0.1s on/off, whenever the active keys were lit. No known studies had used the flash of a key light as a form of disruption to measure the persistence of behaviour.

Method

Subjects

The subjects were six domestic Brown Shaver hens, numbered 11.1 to 11.6, and all under a year old at the start of the study. The hens were housed in individual cages in the same room with a 12-hour light and dark cycle. The hens had free access to water at all times, were weighed daily and kept at a body weight of 85% (+/- 5%) of their free-feeding body weight by supplemented feeding after each experimental session. In the home cage, the hens were fed using a commercial laying pellet. During the experiment, wheat was used as a reinforcer. In addition, the hens received grit weekly and vitamins when necessary as part of their usual feeding routine.

Apparatus

Three keys were situated at one end of an experimental chamber, approximately 370 mm off the floor of the chamber. Multi-colour LED light panels allowed a number of different key colours to light each key. The chamber was 1120 mm long, made of plywood and divided into two parts, separated with a mesh wire divider, so that the back section could accommodate the speakers for the sound disruptor. The part of the chamber where the hens were placed during experimental sessions was 650 mm long by 680 mm wide. The walls inside the chamber were painted white and a black rubber mat was situated on the floor of the chamber to enable easy removal for cleaning. Figure 5.1 shows a photograph of the inside of the experimental chamber. A 120 mm wide rectangular hole below the keys allowed the hen’s access to wheat in the magazine when the hopper was raised and lit. The magazine was operated automatically and situated outside of the chamber. A nearby computer running MED-PC software programmed and recorded all experimental conditions and data.

Figure 5.1. A photograph of inside the chamber that was used for Experiments 5 and 6, showing the front section of the chamber where the hens stood on the mat, and the rear section of the chamber in which the speakers were placed for the sound disruptor.

Procedure

Part 1. Shaping and Training

All six hens had been subjects in an undergraduate psychology laboratory, in which they were hand-shaped to eat from the magazine and to peck a key (coloured red, to avoid any possible biases to particular key colours used in the present study). Following that, they had experienced four sessions each with a manually operated progressive-ratio (PR) schedule using wheat or puffed wheat as a reinforcer.

For the present experiment, training started by presenting both the left and right key concurrently during three different components, as per the shaping and training procedure used during Experiment 1. After 26 days, all hens were responding steadily to both keys in each component at which point the initial baseline period began, as outlined below.

Part 2. Experimental Procedure

Baseline

The same baseline procedure as previously used in Experiments 1-4 was used for the duration of this experiment. The combinations of key colours and schedules presented during baseline are shown in Figure 5.2. For this group of hens, there were a total of 35 baseline sessions initially, to establish stable baseline responding. Subsequent baseline exposures between disruptor tests ran for six sessions.

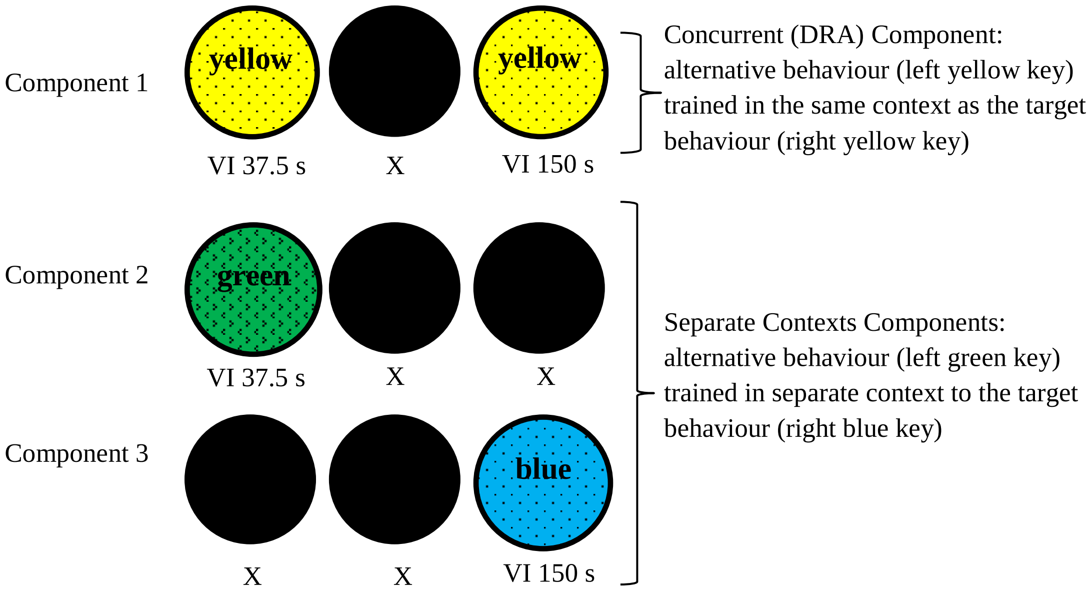


Figure 5.2. The key colours and schedules associated with each key in each of the three components presented during all baseline sessions.

Disruptor Tests

The Concurrent Component, featuring the left yellow and right yellow keys, and the reinforcement schedules associated with them, remained as in the baseline procedure throughout the disruptor tests. The left green key and the right blue key, however, were combined into one component, with the same reinforcement schedules as also used in baseline. The disruptor situated between the left and right keys of both components was a flashing key light. The centre key, situated between the left and right keys of the components, flashed white at a rate of 0.1s on, and 0.1s off. There was nothing preventing the hens from pecking this key, however there were no programmed consequences for pecking this key. The flashing key light was turned off when other keys were turned off; during the ICI’s and when the magazine was raised for reinforcement. Disruptor tests were six sessions in length and followed the schedule outlined in Table 5.1.

Table 5.1. The component combinations, key colours and schedules as presented during the disruptor tests. The numbers indicate the schedules active on each of the keys with ‘FLASH’ indicating the flashing centre key.

Disruptor Test	Components	Key Colours and Schedules		
1	comp. 1	🟨 37.5	FLASH	🟨 150
	comp. 2	🟩 37.5	FLASH	🟦 150
2	comp. 1	▨	FLASH	🟨 150
	comp. 2	🟩 37.5	FLASH	▨
	comp. 3	▨	FLASH	🟦 150
3	comp. 1	🟨 37.5	FLASH	🟨 150
	comp. 2	🟩 37.5	FLASH	🟦 150

Results

Baseline

The mean number of responses for each hen on each key across all repeated baselines is shown in Figure 5.3. For all hens there were some individual differences in the number of baseline responses within each baseline exposure, but there were few major changes across baselines overall. Responding rose slightly across baselines for Hens 11.1 and 11.2, and decreased slightly for 11.3, but all other hens’ responding remained fairly stable across sessions. Responding for all hens was most variable on the right blue key presented alone. A two-way repeated measures ANOVA showed no significant interaction across baseline sessions and the mean number of responding on all keys; $F(6,30) = .507$, $p > .05$, $\eta_p^2 = .092$, no significant effect across baselines, $F(2,10) = .871$, $p > .05$, $\eta_p^2 = .148$ but a significant effect of key colour presented $F(3,15) = 25.303$, $p < .05$, $\eta_p^2 = .835$.

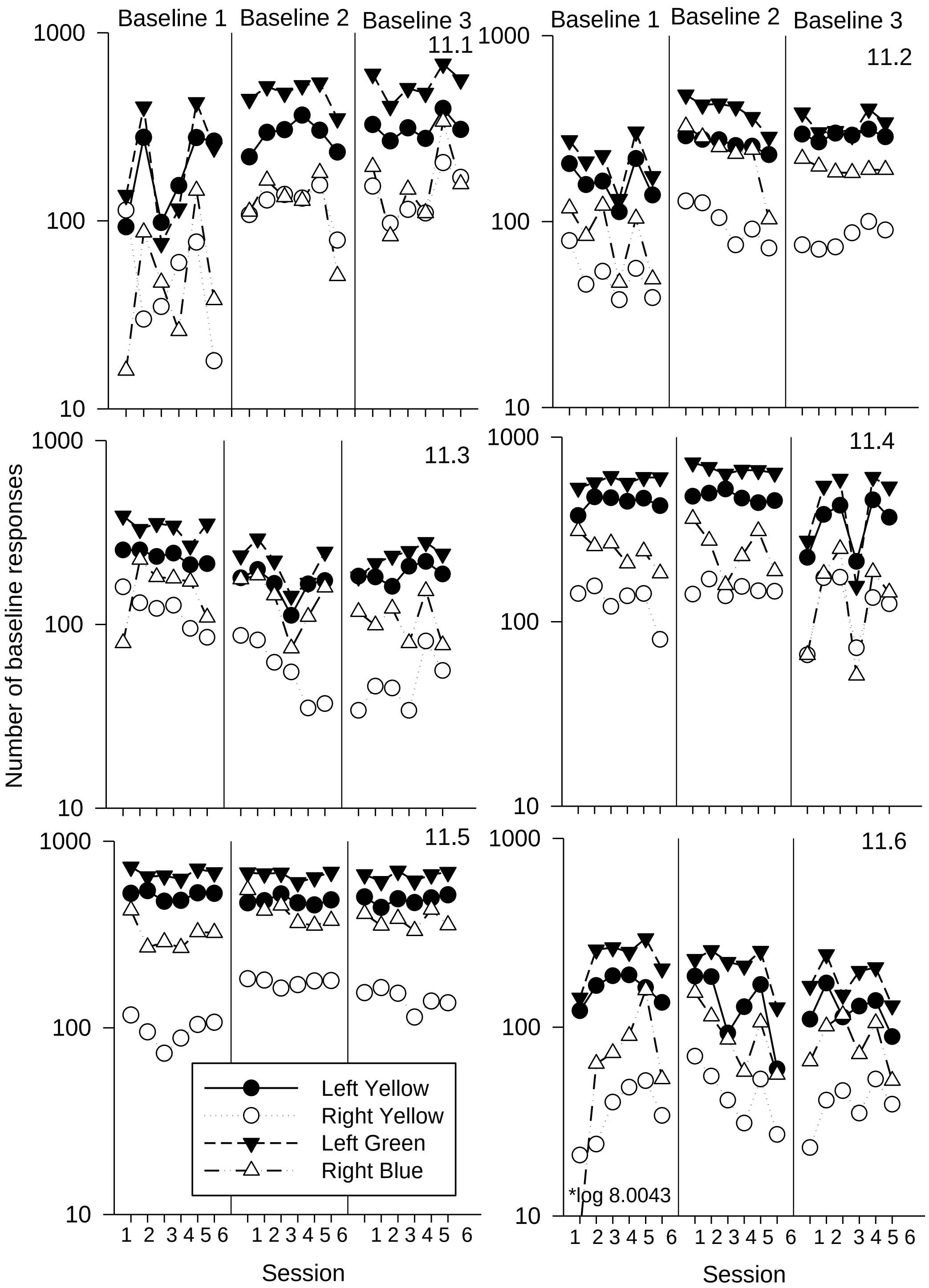


Figure 5.3. Number of responses for each hen on each key across all baseline sessions of Experiment 5. The Y-axis is presented on a log scale, and circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the two stimuli trained separately (filled = left green key, open = right blue key).

Disruptor Test 1 (Combined Stimuli)

Responses on each key of each component during the first flashing light disruptor test are plotted as a proportion of baseline in Figure 5.4. Responses during this first disruptor test were quite unstable, there was an initial drop in responding by most hens on most keys during the first session of the test, responding rose again to above baseline lines for all hens by the second or third session. The only exception to this was responding on the right blue key of the Combined Component, which remained lower, proportionate to baseline, than responding on all other keys.

Overall, responding proportionate to baseline was less persistent to the right blue key of the Combined Component. A paired-samples t-test comparing the mean number of responses on the right blue and right yellow keys, taken as a proportion of baseline rates, showed this difference to be significant, $t(5) = 8.820$, $p = .000$, $d = 2.889$.

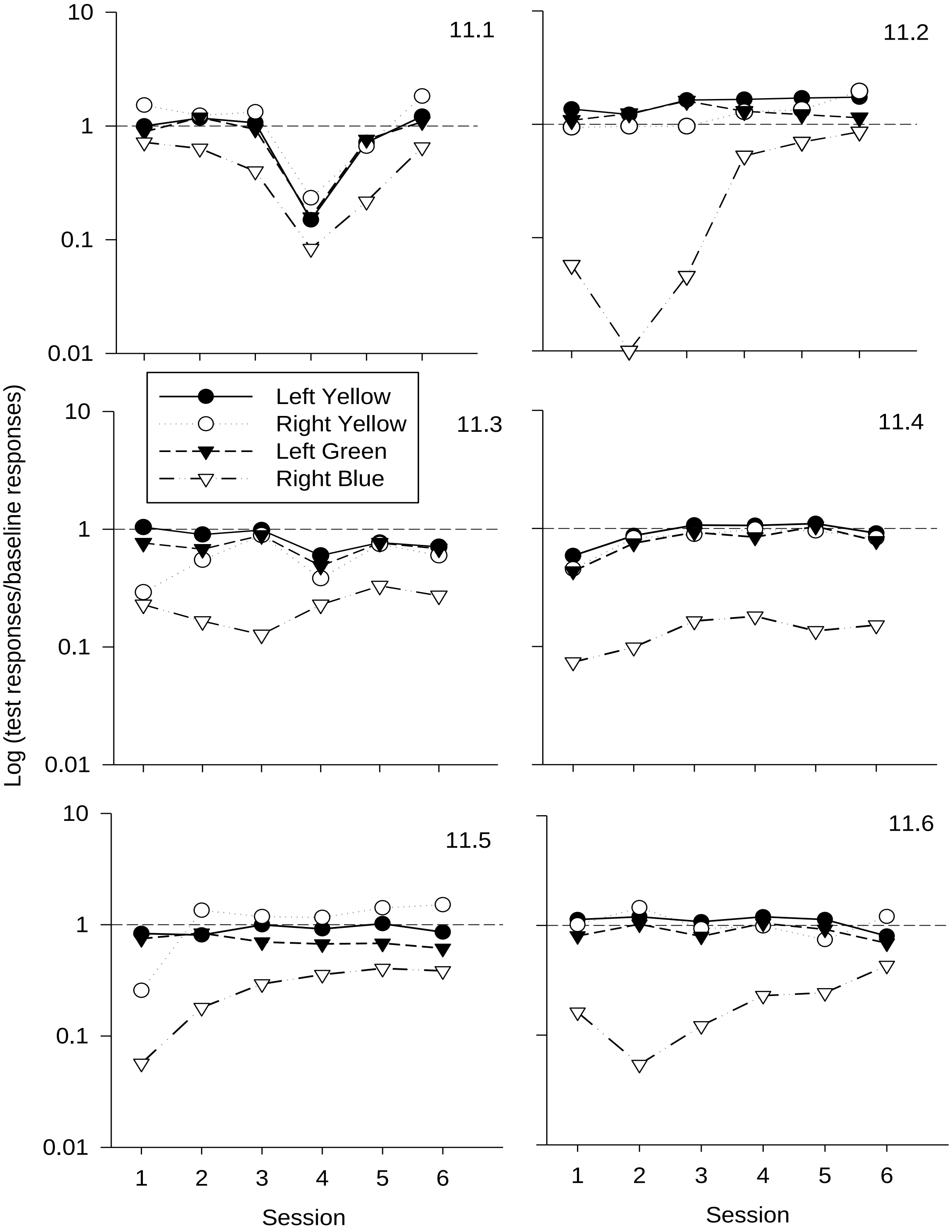


Figure 5.4. Responding plotted as a proportion of baseline during the first flashing centre key disruptor test. The y-axis is presented on a log scale, and the dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the Combined Component (filled = left green key, open = right blue key). Data points at 0.01 represent zero responding.

Disruptor Test 2 (Individual Stimuli)

Responses for the second flashing key disruptor test are presented in Figure 5.5 plotted as a proportion of baseline responding. Responding as a proportion of baseline during this test was much higher than baseline on the right yellow key, and whilst there was some reduction in responding proportionate to baseline on occasional sessions for Hens 11.1 and 11.4, overall responding remained high throughout the test.

For five of the hens, responding proportionate to baseline on the right blue key remained similar to that of the left green key, with the exception of Hen 11.1, who's responding proportionate to baseline on the right blue key was much higher than the left green key. In addition, for Hens 11.1, 11.5 and 11.6, responding on the right blue key actually rose slightly proportionate to baseline throughout the test in the presence of the flashing light disruptor, and whilst this effect was also seen for their responding on the left green key, responses on that key generally remained lower throughout. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key with the mean proportion of baseline responding on the right blue key was significant; $t(5) = 8.955$, $p = .000$, $d = 3.618$, showing lower persistence of responding on the right blue key than on the right yellow key.

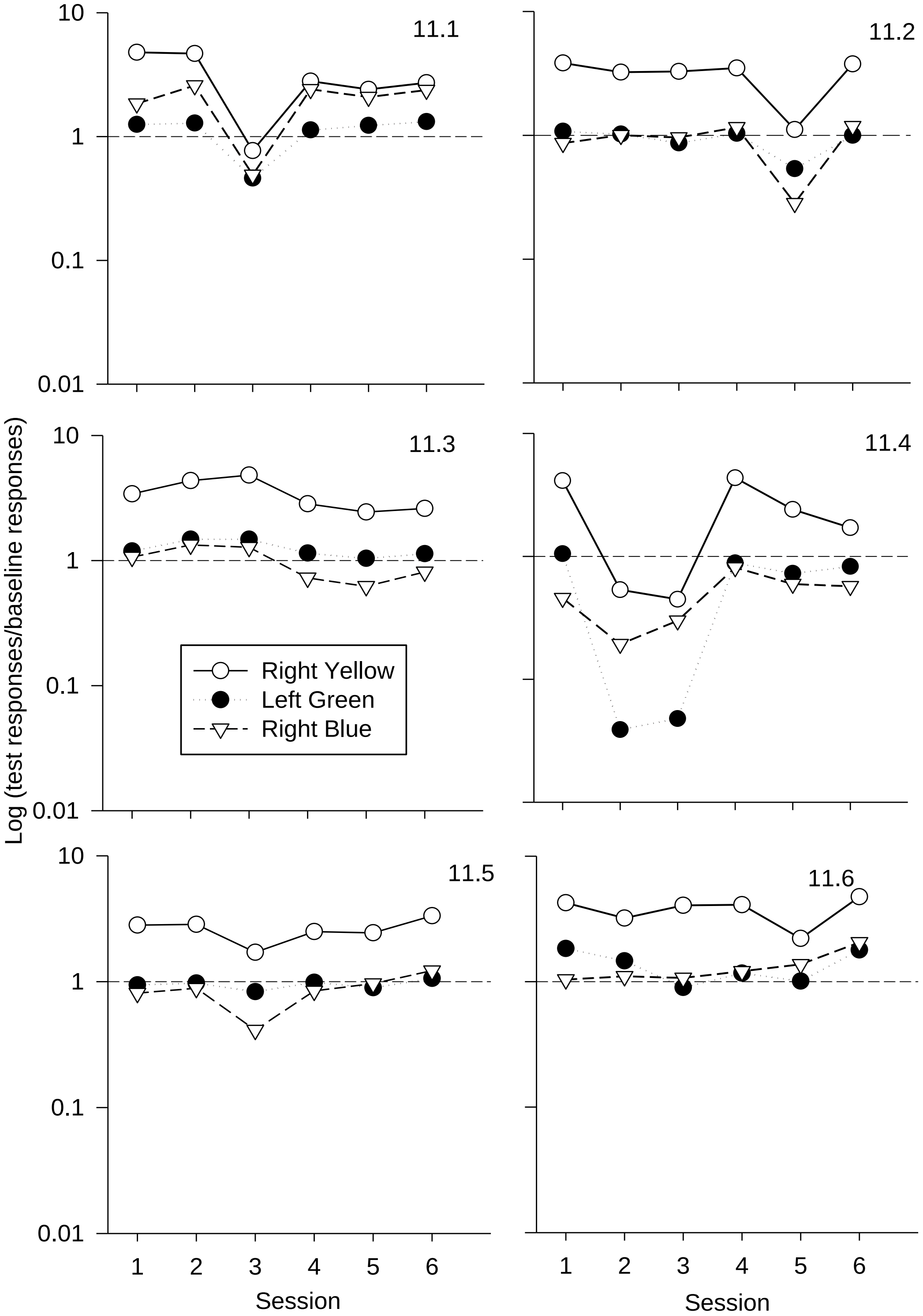


Figure 5.5. Responding plotted as a proportion of baseline during the second disruptor test when each of the individual stimuli were presented alongside the flashing centre key disruptor. The y-axis is on a log scale and the dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the Combined Component (filled = left green key, open = right blue key).

Disruptor Test 3 (Combined Stimuli)

Figure 5.6 presents the responses on each key of both components during the third and final flashing light disruptor test. For all hens, responding on the right blue key of the Combined Component was lower proportionate to baseline than responding on all other keys. For Hens 11.1 and 11.5, responding on all keys dropped below baseline levels initially and only increased again from the third disruptor session onwards. For all other hens, responding increased on all other keys proportionate to baseline during the first session. For all hens other than 11.2 and 11.5, responding on all keys was fairly unstable across all sessions of the disruptor test.

Overall, responding on the left yellow key of the Concurrent Component was the most persistent, for all hens other than 11.2 and 11.3, who's right yellow key responding was greater proportionate to baseline. Right blue key responding, proportionate to baseline, was less persistent then right yellow key responding and a paired-samples t-test on the mean of these data was significant, $t(5) = 6.296$, $p = .001$, $d = 1.764$.

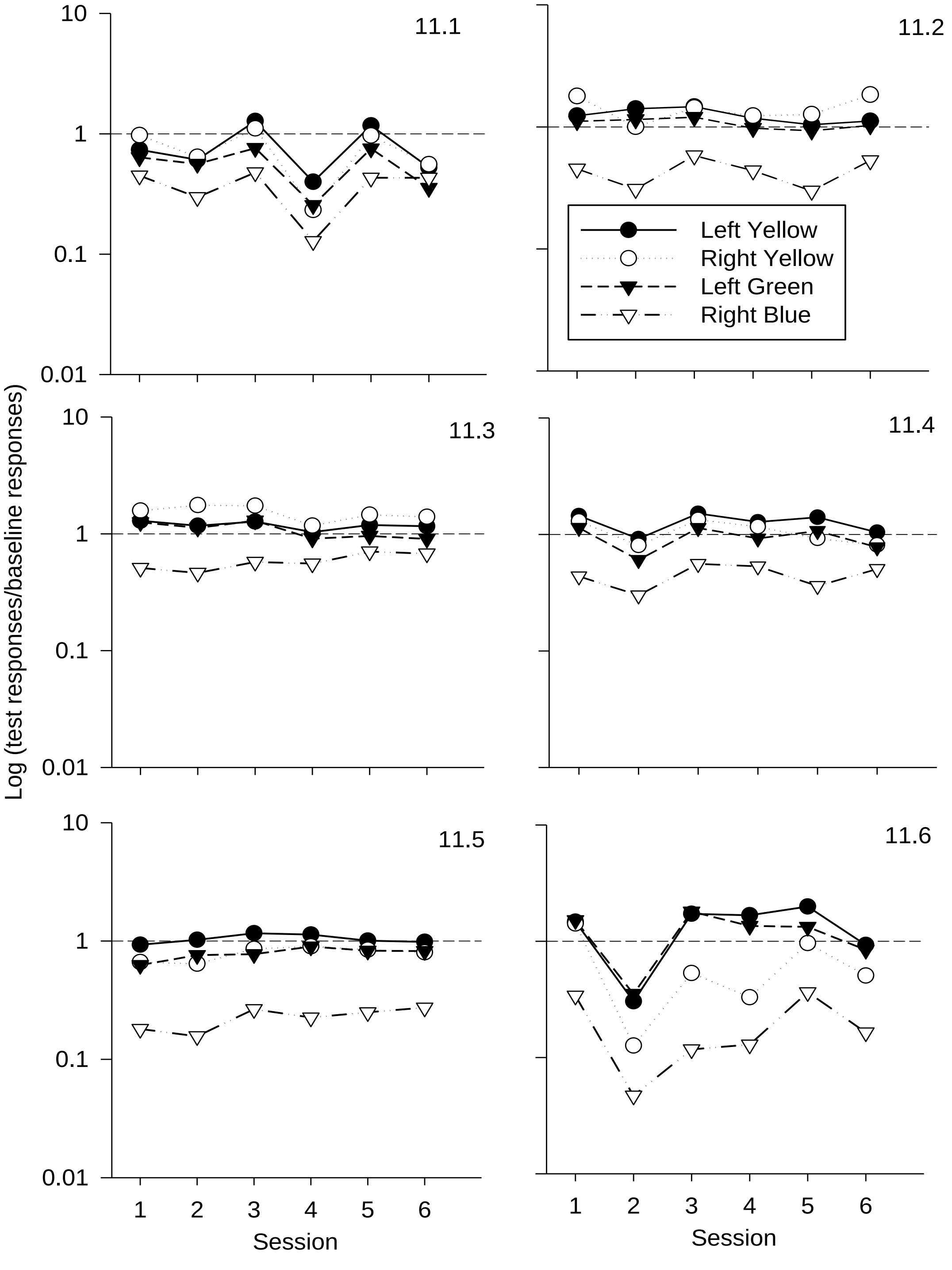


Figure 5.6. Responding plotted as a proportion of baseline during the third flashing centre key disruptor test. The y-axis is presented on a log scale and the dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the Combined Component (filled = left green key, open = right blue key).

Flashing (Centre) Key Responses

Figure 5.7 presents the number of responses on the flashing centre key across all three disruptor tests. When the flashing centre key was first turned on, all hens immediately began responding to it, even though the key was not associated with any reinforcement schedule. Responding on this key though reduced over sessions of the first disruptor test.

During the second disruptor test, when the flashing centre key was paired with the individual stimuli, responding on the flashing centre key increased enormously. This is also shown in Figure 5.7. For all hens, when the flashing key was paired with the left green key (richer schedule, white circle in the graph), responding on it was minimal. When the flashing key was paired with either the right yellow key or the right blue key, however, responding on it was consistently greater for all hens. This was particularly the cases for responding on the flashing key when paired with the right blue key, as shown by the black triangles on the graph. For most of the hens on the first session of the disruptor test, responses on the centre key when paired with the right blue key were over 500 during the total time that component was present for (12 minutes), and in the case of Hen 11.4, she responded a total of 2808 times during the first session. Despite the large number of responses on the flashing centre key, all available reinforcement was still being collected via responding on the right blue key.

Responding on the flashing centre key during the third and final disruptor test reduced dramatically from the previous disruptor test. With the exception of Hen 11.3 throughout, and the first session for Hen 11.4, responding on this key was zero for all other hens across the entire disruptor test.

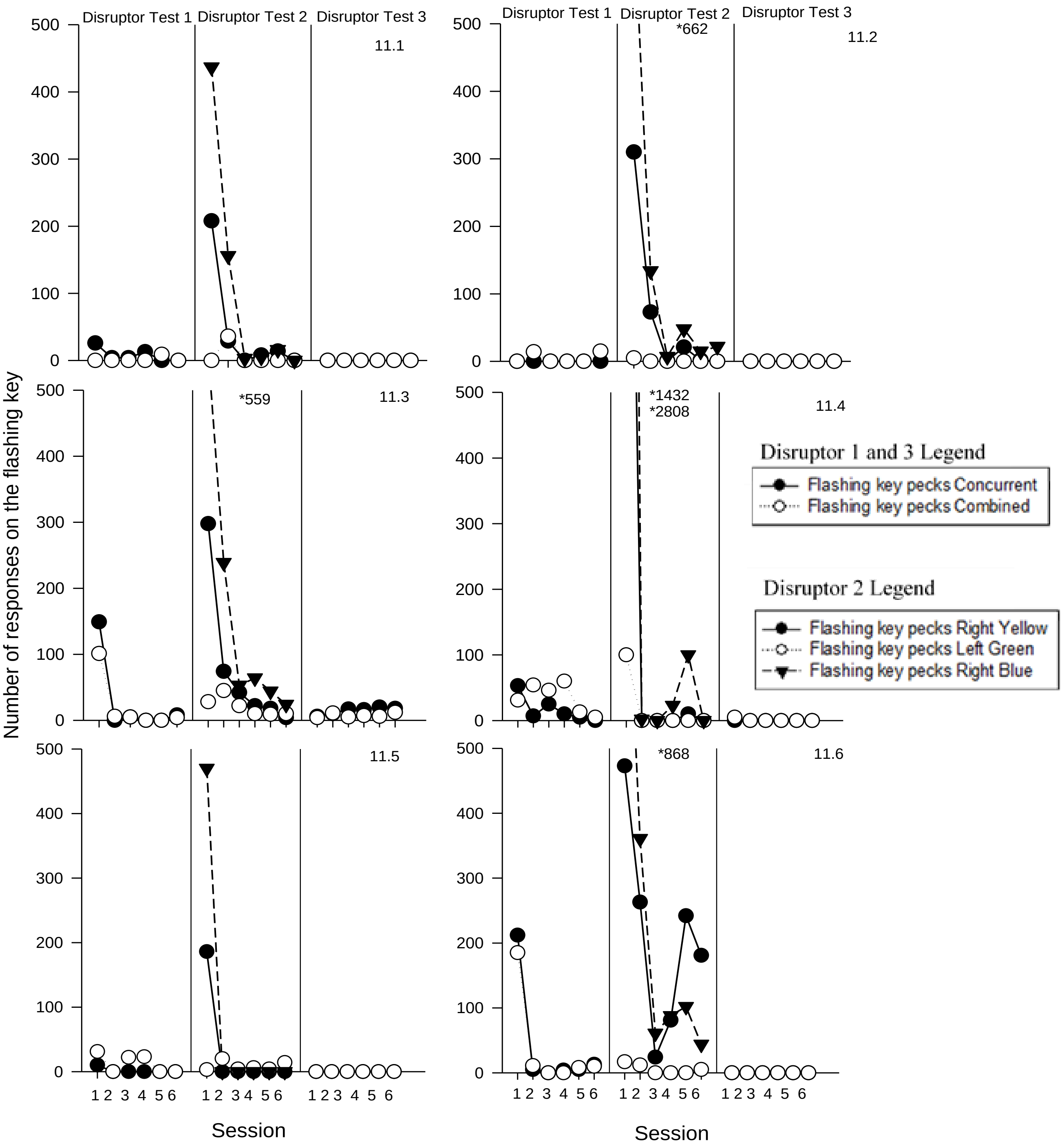


Figure 5.7. Number of responses on the flashing centre key during each of the three disruptor tests. The first and third column show responding on the flashing centre key when paired with the Concurrent Component (left and right yellow keys; filled circles) and the Combined Component (left green and right blue keys; open circles). The centre column shows responding on the flashing centre key when paired with each of the individual stimuli within that disruptor test; right yellow key (filled circles), left green key (open circles) and the right blue key (filled triangles).

Discussion

Experiment 5 investigated the effect of the presence of a disruptor on alternative behaviour trained in a separate context to that of the target behaviour before they were combined. The persistence of that target behaviour, (i.e., responding relative to baseline levels) was compared to the persistence of a target behaviour trained in the same context as the alternative behaviour and then paired with the same disruptor. In this experiment, the disruptor was a flashing centre key light, a disruptor that did not change anything about the reinforcement available to the hen.

Overall, responding was generally less persistent, assessed as proportionate to baseline responding, to the right blue key of the Combined Component than it was, not only to the right yellow key of the Concurrent Component, but to all other keys as well. This was the case for both the first and third disruptor tests. These findings support the notion of training an alternative behaviour in a separate context to the target behaviour before combining them in the presence of a disruptor. In terms of problem behaviour, the findings suggest that should an alternative behaviour (e.g. left green key) be trained in a separate context to that in which the problem behaviour (e.g. right blue key) is occurring, then the problem behaviour will be less persistent in the face of disruption than when the behaviours are trained in the same context (e.g. both yellow keys). Although additional evidence from applied research is required, these findings still have important implications for practitioners trying to understand how to reduce the persistence of problem behaviours whilst using DRA.

During the second disruptor test, when the stimuli were presented individually and paired with the centre flashing key, responding on the left green key was very similar, and in some cases lower, than that on the right yellow and right blue key. Although responding was generally less persistent to the stimulus associated with lower reinforcement during baseline, the present finding shows the direct opposite of this. This is because in this case, persistence was greater for both of the target (problem) behaviours associated with the leaner reinforcement schedule than for the alternative behaviour associated with the richer reinforcement schedule. In an applied setting, this could be concerning because during an intervention, persistence of the richer alternative, and a reduction in persistence of the leaner target, or problem behaviour, would be the intended result. Further investigation into this, beyond the six sessions measured here, would be useful.

Responding on all keys, proportionate to baseline, did not reduce in the presence of the centre flashing key, in fact in some cases (especially disruptor tests 1 and 2), responses actually rose compared to the baseline levels. In previous research (see Experiments 2 and 3, and Nevin et al. (1981)), a lit centre key associated with a reinforcement schedule reduced the responding on other active keys, which was not observed here. One possibility is that the present findings did not withhold reinforcement, so responding is less likely to reduce overall, unlike in previous research (Nevin et al., 1981), where a reduction was seen in the presence of the centre key.

In this experiment there were greater amounts of responding on the flashing key itself, especially in the second disruptor test. There are several possible reasons as to why this might have been the case. Firstly, it could be that having the additional centre key stimulus presented, regardless of it not being associated with a reinforcement schedule or changing reinforcement rates, is enough to alter the environment previously associated with baseline stimuli and reinforcement rates on the left and right keys in both components, and so produce responding to that additional stimulus (Nevin et al., 1981). Additionally, even though these hens had not been exposed to an active centre key previously, the training and baseline phases of this experiment provided them with experience of responding to, and earning reinforcement from, a lit key. Therefore, it is possible that stimulus generalisation towards a lit key could have generated higher response rates. That said, this increase in responding towards the centre key when it was lit, but not flashing, was not observed with the group of hens used in Experiments 1-3.

Secondly, responding was greater on the flashing centre key when it was paired with the right yellow or right blue keys. Both of the right keys were associated with active VI 150-s reinforcement schedules, and on average, produced five reinforcers across the 12 minutes for which they were active. The difference between responding on the centre key during these presentations, compared to when it was presented with the left green key (associated with a VI 37.5-s schedule), may be to do with the leaner schedules in effect on the right keys, causing additional responding to the centre flashing key during the wait for reinforcement to be received. One possible way to avoid this additional responding might be to have the flashing key, or a flashing light, positioned in such a way that the hens were unable to peck at it. Alternatively, another stimulus, such as a noise, could be arranged so the hens are physically unable to interact with it. Whilst other behaviour during the wait for reinforcement would of course be possible, the large number of pecks on the flashing key itself would be avoided.

Thirdly, responding on this centre flashing key typically started off with a large amount of responses to the key over the first few sessions of the disruptor test, before decreasing over time as the test went on. It is possible that the simple presence of the flashing key was treated by the hens as a novel stimulus, and as time went on, they began to generalise responding towards it, as they had to other lit keys in the past. Repeated testing of exposures to the centre flashing key, or to other novel stimuli in the environment, may provide a way of testing if this was the case or not.

The other notable finding during this experiment was, once again, the large number of responses proportionate to baseline to the right yellow key, particularly during the second disruptor test, and shown by individual hens throughout the first and third disruptor tests. Whilst these results do not support behavioural momentum theory due to the greater number of responses towards the leaner option of the two reinforcement schedules (see Experiment 1 Discussion), they could support the idea that both yellow keys are being viewed as one richer stimulus context. This is compared to the left green or right blue keys individually, resulting in responding during the disruptor tests being greater to the right yellow key, proportionate to baseline. It could also be due to the more frequent association with both yellow keys in one overall richer context (due to the combination of both reinforcement schedules), causing increased levels of responding there.

Finally, the similarity in levels of responding between the right blue and left green keys during the second disruptor test were also a surprising result. Reinforcement rates on these two keys differed greatly, the rate associated with the left green key was three times that of the right blue key. As all of these hens were naïve, they had no previous experience of having the green and blue key presented together in one stimulus context with the exception being the six sessions of the first disruptor test. It is possible that there was some history effects from that first disruptor test, and future research might consider changing the order in which these tests are presented, or re-presenting the individual stimulus disruptor test to examine this possibility.

In summary, a flashing centre key as a disruptor resulted in mixed findings. Responses across all keys did not reduce greatly compared to the baseline levels of responding, suggesting that the flashing centre key did not disrupt responding in the way that previous disruptors did, by causing a reduction of responding in their presence. The reduction in responding overall compared to baseline was still not seen here, however, responding on the target key trained separately to the alternative did reduce, despite large numbers of responses on the flashing centre key at times.

These findings are in line with previous findings, suggesting that alternate context training could be a successful method to reducing the unwanted persistence-strengthening effects of DRA interventions. This is because the data showed that responding was less persistent to the target behaviour trained in the separate context to that of the alternative behaviour, even though the amount of responding overall comparative to baseline levels was not reduced in the presence of the disruptor.

Experiment 6: Sound

As with Experiment 5, the aim of this experiment was to continue to investigate if the method of combining alternative and target stimuli after training behaviours associated with them in separate contexts was still effective at producing less persistent target behaviour than training the two behaviours in the same context, when tested with other potential disruptors.

One of the major findings from the use of the flashing centre key disruptor (Experiment 5), was that responding on each of the keys did not reduce greatly compared to baseline levels of responding, even though there was a large number of pecks on the flashing centre key itself. Although responses to the flashing centre key were redundant, responses to it were very frequent, particularly during the individual stimulus disruptor test (Disruptor Test 2). This raised the question of what would happen to responding on the other keys compared to baseline levels of responding if there was a disruptor in place that could not be interacted with. Using sound that came from speakers situated at the rear of the chamber, separate from the hens, meant that they could not turn around and peck at any visual stimuli, or the speakers themselves, and allowed investigation into the effects of a disruptor that could not be manipulated by the hens at all.

Sound has been used as a disruptor before where the aim was to interfere with responding in some way. For example, sound has been used to assess the disruption to recall and memory in humans (Jones & Beaman, 1998; Tremblay, MacKen, & Jones, 2001), auditory and visual processing differences in chimpanzees (Martinez & Matsuzawa, 2009), and temporal discrimination in a variety of different procedures and species. As with the flashing key light, sound had not been used to examine the persistence of behaviour in its presence. A sound was chosen that the hens were reasonably familiar with in order to avoid an aversive or distressing situation. Many of the disrupting sounds heard during classroom observations were sounds such as lawnmowers, sports games or music lessons, so whilst the sounds were not necessarily aversive to the students, they were distracting. In keeping with the classroom analogy, a sound that might have similar distracting properties to the hens was used in this experiment. Previous research in the University of Waikato Learning and Animal Welfare laboratory had investigated hens preference and aversions to certain sounds, and, using this as a guide, a sound that was the least aversive to hens was selected (Jones, 2011), as an analogy to a non-aversive, but distracting sound, in the classroom. The sound chosen was a hen room recorded during feeding time.

Method

Subjects

The subjects were the same six hens from Experiment 5, housed and fed in the same conditions as previously described.

Apparatus

The same experimental chamber as Experiment 5 was used throughout this experiment. This time, the back section of the chamber, separated from the hen with mesh wire, held speakers that played the sound described below. These were separated from the hens so that they could not approach the sound and to avoid damage to the speakers. All other aspects of the apparatus remained the same, including the key panel and the magazine that gave access to wheat as a reinforcer.

Procedure

Baseline

The same baseline procedure as outlined in Experiment 5 was used throughout this experiment. Six sessions of baseline ran before the first disruptor test, and the hens were returned to six sessions of baseline in between each of the disruptor tests.

Disruptor Tests

Disruptor tests were the same as Experiment 4 in terms of the components and active keys, however during this experiment, the disruptor used was exposure to the sound of a hen room recorded during feeding time. Feeding time was chosen because it was generally when the hen room was at its noisiest. The sound was recorded on an iPhone 5c recording application and edited to turn on for 5 seconds and off for 5 seconds for 1-min, which was the duration of the components. No sound was played during the ICI, and the sound also switched off if reinforcement was earned during the active component time and resumed playing after reinforcement. The average volume (dB level) of the sound disruptor was 83.9dB across all disruptor tests, as measured by a standard decibel meter. The volume was measured at the start of every experimental session during testing of equipment, and remained the same for all hens run during that session. The exact dB levels and average for each disruptor are displayed in Table 6.1. An average dB rating of 85dB was aimed for based on previous research (Jones, 2011; McAdie, Foster, Temple, & Matthews, 1993). The centre key, still situated between the left and right keys of the components, was turned off during this experiment. Disruptor tests were again six sessions in length and followed the same active key and VI schedule as Experiment 4. At no time during this experiment was reinforcement withheld.

Table 6.1. The dB level recorded at the start of each session for all disruptors and the average dB level for each disruptor test.

	Disruptor Test 1	Disruptor Test 2	Disruptor Test 3
Session 1	81.3 dB	87.6 dB	86.3 dB
Session 2	81.3 dB	88.2 dB	83.4 dB
Session 3	87.6 dB	87.2 dB	85.4 dB
Session 4	81.2 dB	86.5 dB	74.5 dB
Session 5	80.6 dB	82.2 dB	89.4 dB
Session 6	82.3 dB	86.1 dB	79.1 dB
Average	82.4 dB	86.3 dB	83 dB

Results

Baseline

Figure 6.1 presents the number of responses on each key for all hens across all baseline sessions. Baseline responding remained fairly stable across baseline exposures for most hens, with the exception of Hen 11.4 whose responding gradually decreased across all sessions of the second and third baseline. Within the individual baselines, responding was less stable, with Hen 11.1’s responding dropping and then gradually increasing again during the third baseline presentation. Hen 11.6’s responding also changed quite variably throughout all baselines. A two-way repeated measures ANOVA found there was a significant interaction across baseline sessions and responding on each of the different response types; F6,30) = 2.144, p <.05, η_p^2 = .300, a significant effect across the response types, F(3,15) = 22.888, p <.05, η_p^2 = .821 but no significant effect across baseline conditions, F(2,10) = 2.659, p > .05, η_p^2 = .347.

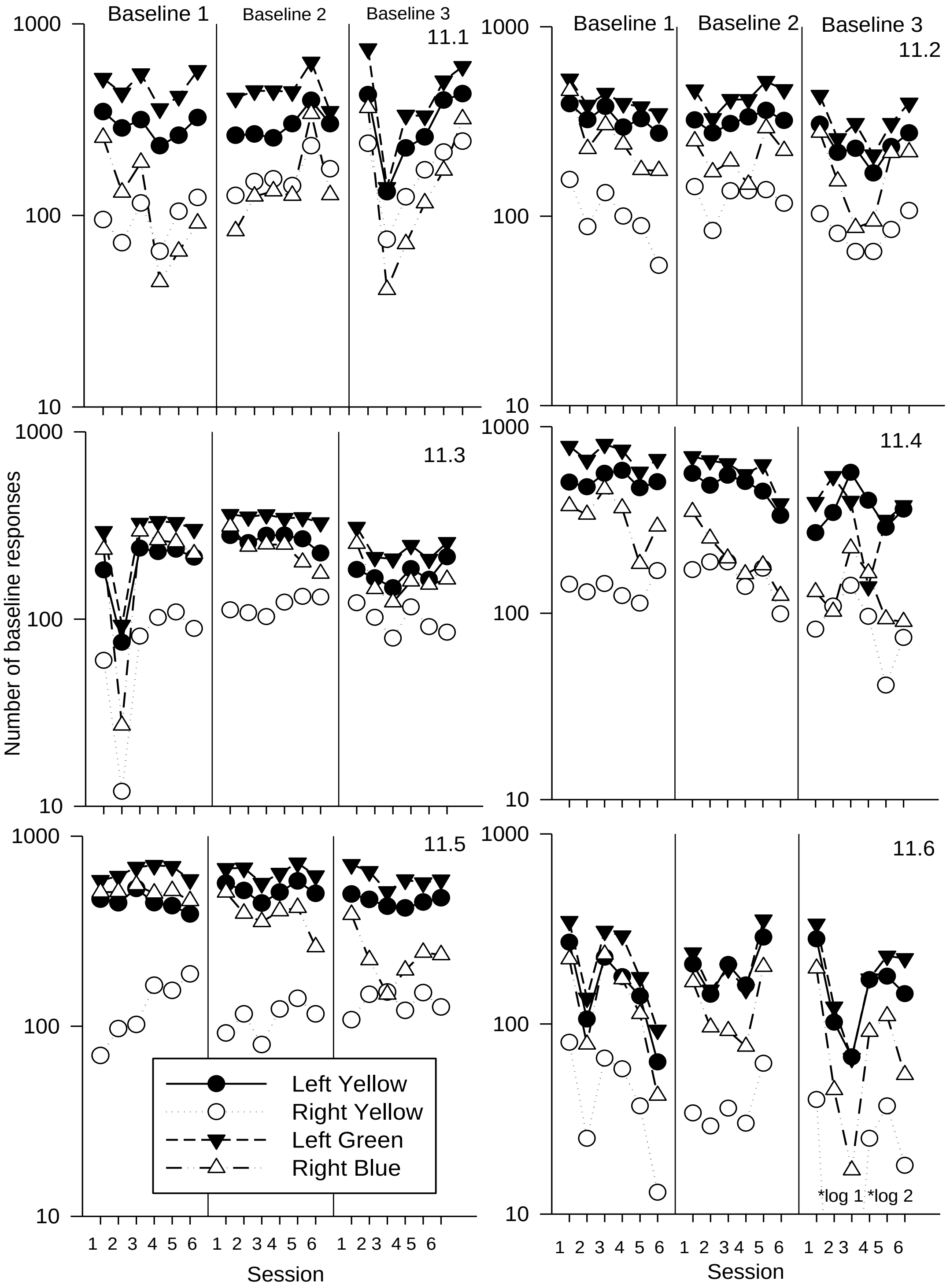


Figure 6.1. Number of responses for each hen on each key across all baseline sessions of Experiment 6. The y-axis is presented on a log scale, and circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the two stimuli trained separately (filled = left green key, open = right blue key).

Disruptor Test 1 (Combined Stimuli)

Figure 6.2 displays the responses during the first sound disruptor test (5s on, 5s off) plotted as a proportion of baseline responding. All hens responded less to the right blue key, proportionate to baseline, than to the right yellow key. Five out of the six hens responded to the right blue key less, as a proportion of baseline, than to other available keys. Only Hen 11.1 responded less to the left green key than the right blue key, as a proportion of baseline, an opposite finding to that which was expected.

For all hens in the first session of the test, responding on the left green and the right blue key (both keys of the Combined Component) dropped to below baseline levels. This was also the case for Hens 11.2 and 11.4 for the left and right yellow keys (Concurrent Component), and for Hen 11.6 on the right yellow key only, while for Hens 11.1, 11.3 and 11.5, responding on both yellow keys increased above baseline levels from the first session. Responding overall remained quite stable for the duration of this test.

For five out of the six hens, responding proportionate to baseline on the right blue key was less persistent during disruption than responding proportionate to baseline on the right yellow key, and this finding was significant when a paired-samples t-test compared mean responding proportionate to baseline on the right yellow and right blue keys; $t(5) = 9.111$, $p = .000$, $d = 1.913$.

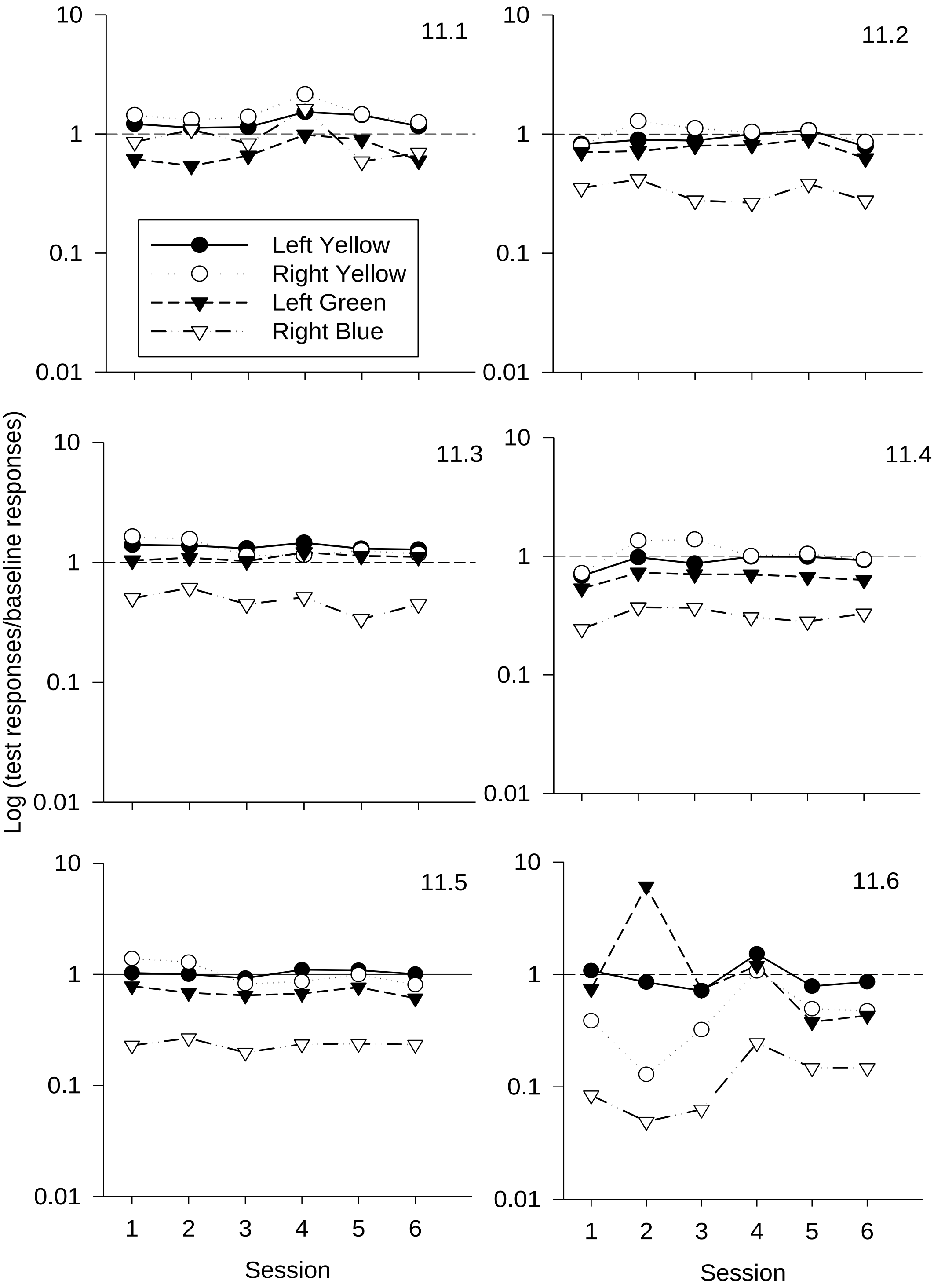


Figure 6.2. Responses plotted as a proportion of baseline on all keys during the first sound disruptor test. The y-axis is presented on a log scale and the dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the Combined Component (filled = left green key, open = right blue key).

Disruptor Test 2 (Individual Stimuli)

Responses plotted as a proportion of baseline for the second disruptor test using sound are shown in Figure 6.3. For all hens, responding was less persistent on the right blue key than on the right yellow key. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key during the disruptor test with the mean proportion of baseline responding on the right blue key during the disruptor tests was significant, $t(5) = 3.526$, $p = .017$, $d = 1.676$.

With the exception of Hen 11.1, responding on the right blue key remained similar to baseline levels of responding for the duration of the disruptor test. However, responding on the right yellow key rose well above baseline levels, and most hens continued to respond to it at higher rates for much of the test. Responses proportionate to baseline on the left green key in many cases were similar to responding proportionate to baseline on the right blue key throughout, and also similar to baseline levels of responding, shown at 1 on the figures.

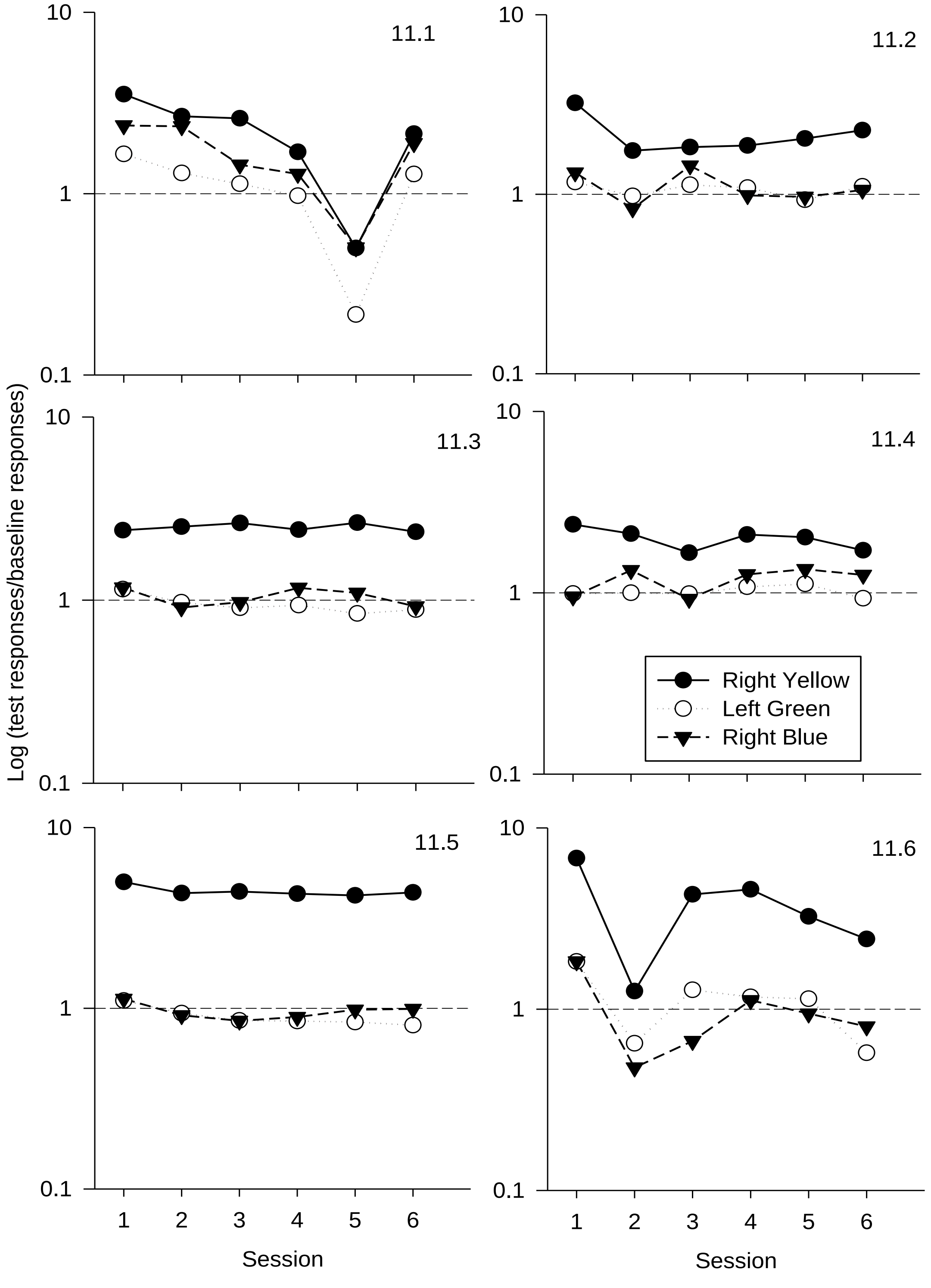


Figure 6.3. Responses plotted as a proportion of baseline during the second sound disruptor test. The y-axis is presented on a log scale and the dashed line represents levels of baseline responding. Filled circles represent the right yellow key, open circles represent the left green key, while triangles represent the right blue key.

Disruptor Test 3 (Combined Stimuli)

Figure 6.4 displays the responses during the third and final disruptor test plotted as a proportion of baseline responding. For all hens, responding on the right blue key of the Combined Component was lower, proportionate to baseline, than responding on the right yellow key of the Concurrent Component. For all hens other than the second to last session for Hens 11.5, responding was lower proportionate to baseline on the right blue key than on any other key.

Responding on the other keys remained quite stable for most of the hens throughout this disruptor test, with occasional drops or increases in responses on both yellow (Concurrent Component) keys and the left green key. For most of the sessions, responding on all keys other than the right blue key remained at, or higher than, baseline levels.

Figure 6.4 shows that responding was less persistent on the right blue key compared to the right yellow key, and this was supported by a paired-samples t-test comparing the mean proportion of baseline responding on the right blue key with the mean proportion of baseline responding on the right yellow key; $t(5) = 6.233$, $p = .002$, $d = 3.008$.

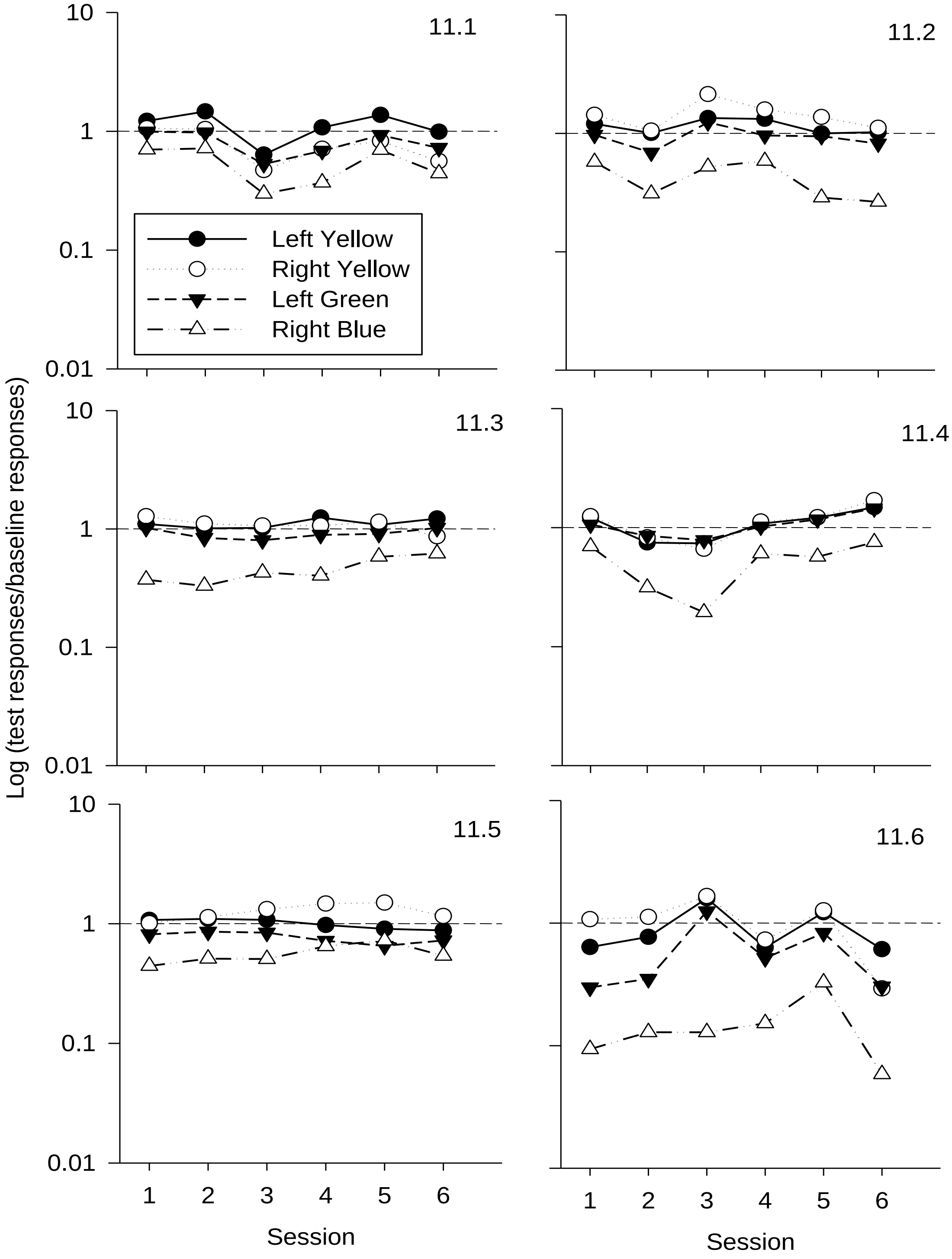


Figure 6.4. Responding plotted as a proportion of baseline during the third sound disruptor test. The y-axis is presented on a log scale and the dashed line represents baseline levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles represent the Combined Component (filled = left green key, open = right blue key).

Discussion

This experiment aimed to investigate the effect of sound as a disruptor on the persistence of an alternative behaviour trained in a separate context to that of a target behaviour before combining them (Combined Component). The persistence of that target behaviour was then compared to the persistence of a target behaviour trained in the same context as the alternative behaviour (Concurrent Component) and then paired with the same disruptor. The disruptor used was the sound of a hen room at feeding time, playing for 5s and switching off for 5s continuously during test sessions.

The present findings show that target behaviour trained in a separate context to the alternative behaviour was less persistent than the two behaviours trained in the same context. These findings further support the clinical implications of potentially reducing the persistence-strengthening effects of DRA interventions. Furthermore, the present findings provide an initial investigation into the use of sound as a potential disruptor in measuring the persistence of behaviour, however responding in the presence of the sound did not reduce across sessions on all keys compared to baseline levels of responding without the sound.

There are several aspects to note in the present findings. Firstly, the right blue and left green key responses proportionate to baseline were very similar to each other during the individual stimulus disruptor test, despite being associated with very different reinforcement schedules and response rates during baseline. This was also found during the same disruptor test using a flashing centre key, although it is possible that some history effects from the first disruptor test are in place. Moreover, it also suggests that perhaps neither the sound nor the flashing light were significantly disrupting responding, as there was little shift in proportion of baseline responding on either of these keys away from baseline levels. Secondly, it makes sense to see higher levels of responding on the right yellow key during this disruptor test, because during baseline, and in other disruptor tests, this key is paired with the left yellow key associated with a richer reinforcement schedule, and the hens have associated responding to both of these keys at a certain rate.

The use of sound as a disruptor differed in many ways to the other potential disruptors previously investigated. Unlike previous potential disruptors, the hens could not interact directly with the sound and therefore, no relevant data (such as rate of pecking on the flashing key in the previous experiment) were collected. The location of the speaker in a separate part of the rear of the chamber precluded pecking of the speaker. Therefore, looking at the effects of sound as a disruptor could rely only on the difference of responding to each of the keys during the presence of the sound compared to baseline levels of responding, rather than being able to measures the responses towards the disruptor as previous experiments have allowed.

When the sound first started, there was a slight drop in proportion of baseline responding on at least two keys for all hens other than Hen 11.3, in the first session of the first disruptor test, but that did not continue as time went on. On all keys besides the target behaviour trained in a separate context (right blue key), responding returned to approximate levels of baseline responding after the first one or two sessions. In all other disruptor tests, this initial reduction in responding during the first sound sessions was not seen, and hens continued to respond near baseline levels to each of the keys other than the right blue (target) key. It is possible that the hens adapted to the noise after its initial presentation during the first disruptor tests, and that subsequent sound on the disruptor tests did not disrupt them enough to reduce their response rates.

There were also some limitations to the present experimental methodology. First, it was impossible to keep the dB level the same throughout the individual sessions and hens, because other noises in the laboratory environment could not be controlled. Even though the dB reading was taken from inside a closed operant chamber, situated away from much of the noise of the laboratory, the chamber was not completely sound proof so other noises could have added to the dB readings on certain days. This could also have been impacted by the time of day in which sessions were run (for example, the laboratory setting tended to be busier and, therefore, noisier mid-morning). Future experiments could consider controlling for this variation in external noise.

Another potential limitation was the choice of sound. Although the sound of a hen room at feeding time was chosen because it was a sound that the hens were all familiar with and was previously demonstrated to be minimally aversive, these reasons could also have contribution to some degree of habituation of this particular sound, minimising the potential disrupting effects. Previous research suggests that certain sounds can and do impact hens’ responding (Jones, 2011; McAdie et al., 1993), so investigations into the use of other sounds as disruptors would be beneficial to see if greater disrupting effects are possible. Whilst this could impact the persistence of responding in the face of disruption, an aversive sound would not provide the same analogy to the disrupting sounds likely outside a classroom.

Furthermore, the order in which the disruptor tests were presented could potentially impact findings. It is possible that pairing the left green with the right blue key throughout creates a stimulus context that is associated with certain levels or reinforcement and response rates. It is also possible that the second exposure to the combined stimuli (green and blue) during the third disruptor test is impacted by the exposure to the stimuli in the first disruptor test, as findings between these two tests remain quite similar.

To conclude, the use of sound as a general disruptor was not as effective because responding overall did not reduce greatly in its presence. However it was successful as a disruptor to measure persistence of the two types of target behaviour, right yellow and right blue key responding. The findings from this experiment added to previous findings, suggesting that persistence of target behaviour trained in a separate context to the alternative behaviour, was lower than persistence of target responding trained in the same context as the alternative behaviour. Furthermore, the use of sound as a potential disruptor allowed investigation into a disruptor that could not be pecked or tampered with, and maintained reinforcement for the alternative and target behaviours.

Discussion of Experiment 5 and 6

When both the flashing light and sound disruptors were in effect, across all disruptor tests, reduced persistence of responding to the Combined Target (right blue) key was evident compared to responding on the DRA Target (right yellow) key, and these findings were supported statistically.

In addition to the proportion of baseline data, the average number of responses during baseline, and in the disruptor tests that followed, were compared across both experiments. Figure 6.5 shows the average number of responses on each of the keys during the first and third disruptor tests using both the flashing light and sound disruptors, and the baseline sessions that preceded each of these tests. The commonality was the decrease in the average number of right blue key responses in the presence of all disruptors and for all hens with one exception (Hen 11.3 on the first sound disruptor test). Not only did the average number of responses on this key reduce from baseline to the corresponding disruptor tests, but the average number of responses also reduced to below that of right yellow key responses.

Two-way repeated measures ANOVA’s examined the difference between the number of responses on the right yellow key and right blue key during Disruptor Tests 1 and 3 of both the flashing light and sound experiments. Findings were fairly consistent across the disruptor tests, with the first flashing light disruptor test showing a significant difference between the two types of right key responding (yellow and blue), $F(1,5) = 22.894$, $p < .05$, $\eta_p^2 = .821$, but no significant difference across sessions, $F(5,25) = 2.542$, $p > .05$, $\eta_p^2 = .337$, and no significant interaction between session and right key responding $F(5,25) = 2.815$, $p < .05$, $\eta_p^2 = .360$.

During the third flashing light disruptor test, there was a significant difference in the two types right key responding, $F(1,5) = 13.673$, $p < .05$, $\eta_p^2 = .732$, and across sessions, $F(5,25) = 2.747$, $p < .05$, $\eta_p^2 = .355$, but there was no significant interaction between sessions and right key responding $F(5,25) = 2.408$, $p > .05$, $\eta_p^2 = .325$.

Right blue key responding was also lower than right yellow key responding during both of the sound disruptor tests. A two way repeated measures ANOVA on right key responding during the first sound disruptor test revealed a significant difference between the two types of right key responding $F(1,5) = 6.891$, $p < .05$, $\eta_p^2 = .580$, but no significant effect across sessions $F(5,25) = 1.436$, $p > .05$, $\eta_p^2 = .223$ and no significant interaction between sessions and right key responding $F(5,25) = .713$, $p > .05$, $\eta_p^2 = .125$. During the third sound disruptor test, there was also a significant differences between the two types of right key responses, $F(1,5) = 35.220$, $p < .05$, $\eta_{\frac{2}{p}} = .876$, but no significant effect of session $F(5,25) = .602$, $p > .05$, $\eta_{\frac{2}{p}} = .108$, and no significant interaction between sessions and right key responding ; $F(5,25) = .972$, $p > .05$, $\eta_{\frac{2}{p}} = .163$.

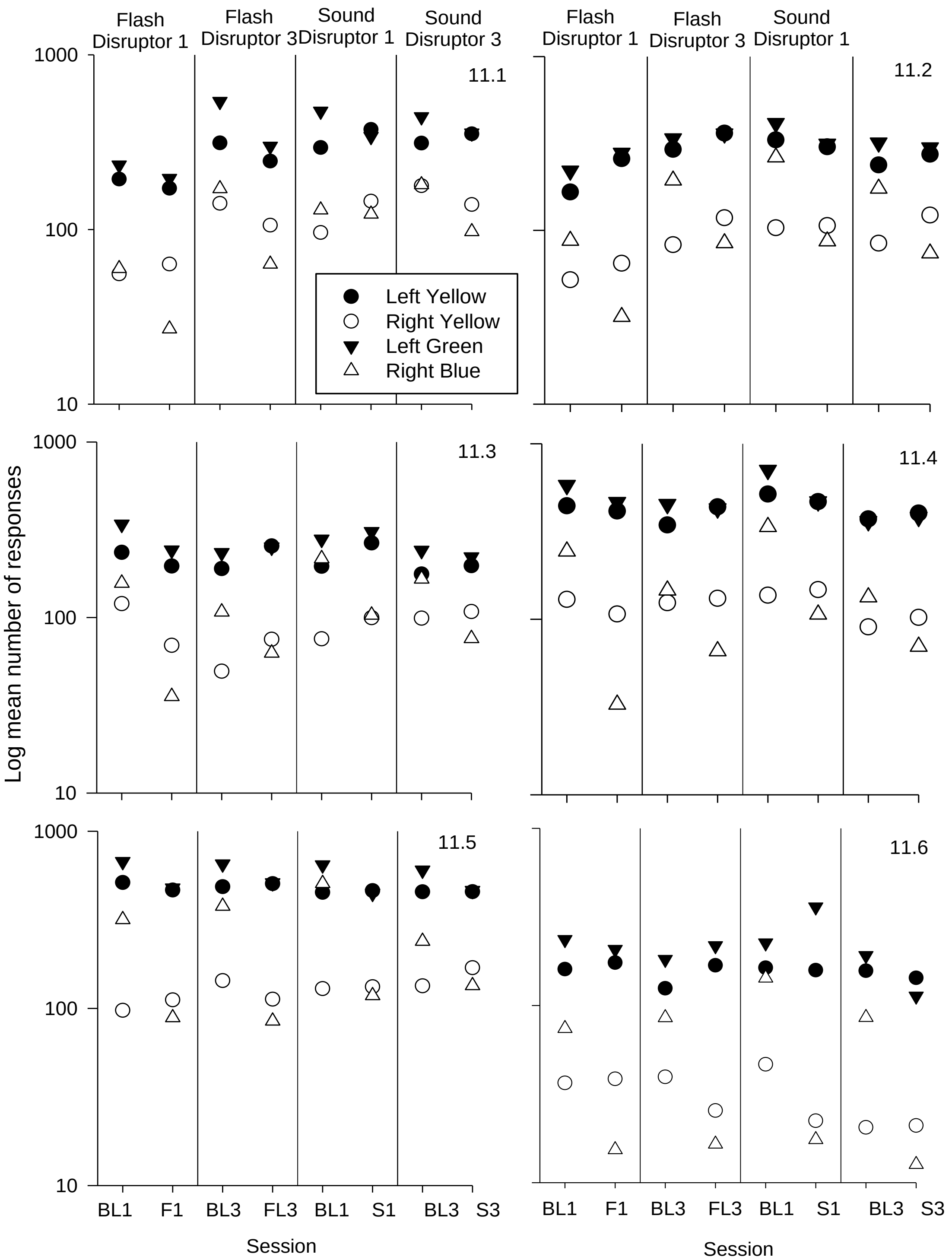


Figure 6.5. Mean number of responses across all sessions of the first and third baseline exposures, and all sessions of the disruptor tests of the flashing light and sound experiments. The y-axis is presented on a log scale. Circles represent responding on the yellow keys (filled = left yellow, open = right yellow) and triangles represent responding on the green and blue keys (filled = left green key, open = right blue key).

These results support all of the findings shown through the proportion of baseline data; that training a target behaviour (right blue key) in a separate context to the alternative can reduce the persistence of that target behaviour in comparison to a context in which both the alternative and target behaviours (right yellow key) are trained together.

There were some differences shown in Figure 6.5 in how left key responding changed between each of the baseline and disruptor tests, with some hens average responding reducing in the presence of the disruptors, and other hens responding increasing in the presence of the disruptors. However these were not consistent across hens or disruptors, with, for example, Hen 11.3 showing a decrease in average responding between the first baseline and the first flashing disruptor test, but then an increase in average responding between the third baseline and third flashing disruptor test, and Hen 11.2 showing a similar pattern for the two sound disruptor tests.

A more common finding across hens and disruptor tests however was the rise in the average number of responses on the right yellow key in the presence of the disruptors, seen also during the second disruptor tests for both the flashing light and sound disruptor. The average number of responses in these tests is displayed in Figure 6.6. When the individual stimuli were presented alongside either the flashing light or sound, there was an increase in responding to both the right yellow and right blue keys for every hen, and to the left green key for almost all hens. Despite the increase in right key responding, right blue key responding still remained less persistent than right yellow key responding, further supporting the findings.

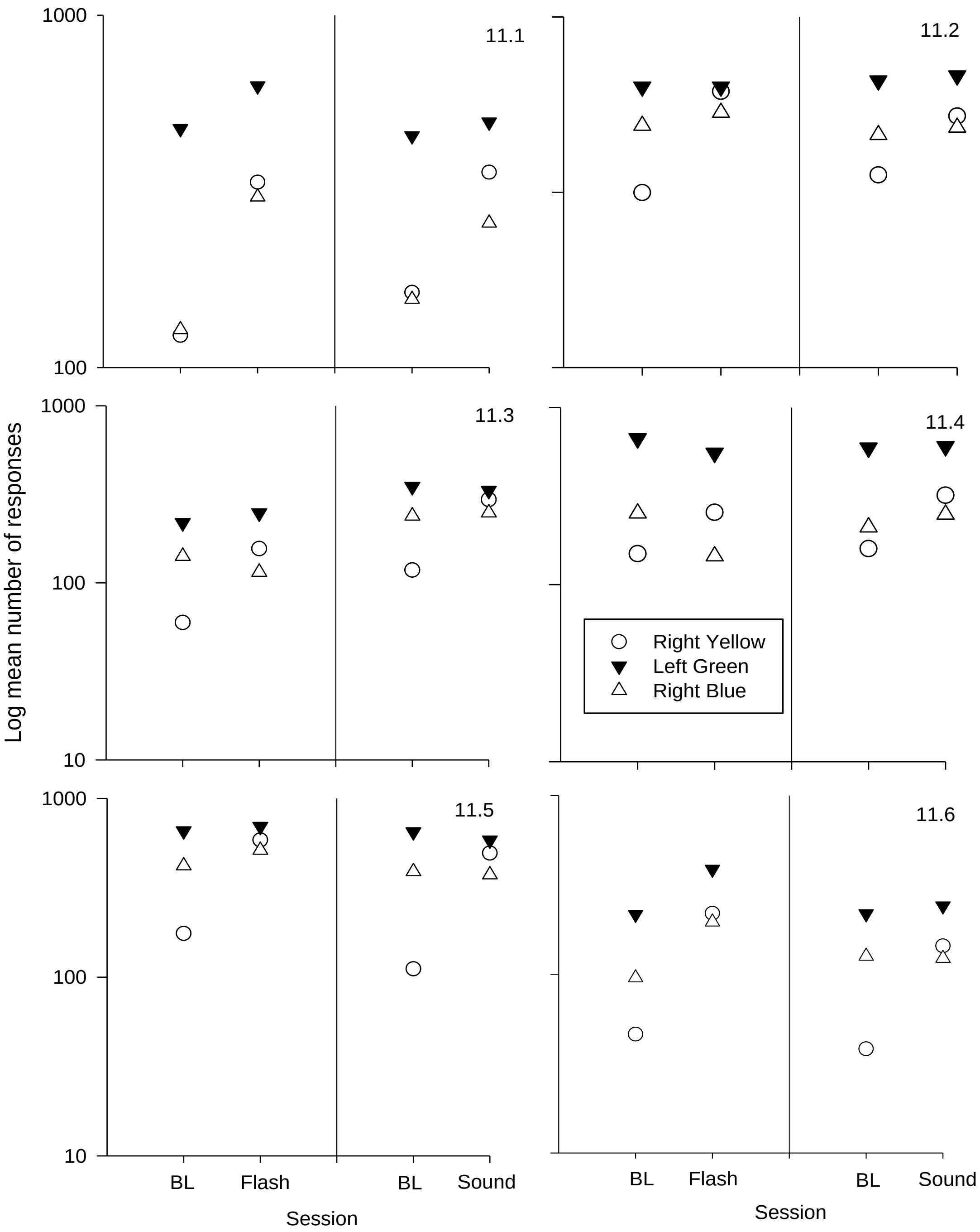


Figure 6.6. Mean number of responses across all sessions of the second baseline exposure, and all sessions of the second disruptor test of the flashing light and sound experiments. The y-axis is presented on a log scale. Open circles represent responding on the right yellow key, filled triangles represent responding on the left green key and open triangles show responding on the right blue key.

An increase in responding to the right yellow key makes sense when the hens are only presented with the right yellow key as an individual stimulus during the second disruptor test of each experiment. This is most likely because there is an association with both of the yellow keys in the context, and the combined richer reinforcement schedule available due to the richer schedule on the left yellow key. What is less clear, however, is why responding continues to increase on this right yellow key in the face of disruption, even when the left yellow key is still presented with as part of the Concurrent Component. This finding of increased responding proportionate to baseline on the right yellow key continues to contradict the findings of behavioural momentum theory, and recent research suggesting that responses trained in the presence of the same stimuli should have equal persistence (Bai et al., 2016). It is quite possible that the present findings showing this increased persistence on the right yellow or DRA Target key alone do not support previous research because previous research typically investigates persistence in extinction conditions, which is not true of the present study, where reinforcement is maintained. Still, reinforcement on the two yellow keys in the Concurrent Component does not change between baseline and disruptor tests, so it is still unclear why right key responding does change between the two.

It is evident from the above figures that responding overall did not drop consistently in the presence of the either flashing light or sound disruptors; in some cases the opposite was true and responding actually increased. There are at least two possibilities as to why this might be. Firstly, it is possible that the flashing light and the sound did not provide enough of a disrupting effect to alter responding beyond that of the first session, or to alter responding at all. Secondly it is also a possibility that an increase in responding is related to combining two separately trained stimuli in the first place.

Throughout previous literature, there is support for both the increase and decrease in responses following the combination of two stimuli (see Podlesnik and Bai (2015) for a discussion), and so one cannot rule out the possibility that combining the left green and right blue keys is also generating higher levels of responding, especially when reinforcement is maintained. However, the absence of reduction in responding overall compared to baseline was evident on both the yellow keys as well (which were not trained separately and combined), and the findings discussed here so far, along with previous research (Podlesnik & Bai, 2015; Podlesnik et al., 2012; Podlesnik, Bai, & Skinner, 2016) conclude generally that combining two stimuli trained separately reduces responding, not increases it.

Furthermore, although there was not the same reduction in responding in the presence of the flashing light and sound as seen with the use of previous disruptor (i.e., the red key), responding on the right blue key (Combined Target) was still generally less persistent than responding on the right yellow key (DRA Target). This observed reduced persistence of responding to the Combined Target key provides more support to the methodology of training behaviours in separate contexts, instead of in the same context, as a way to reduce the persistence of responding. Therefore, despite the need to acknowledge that increases in responding could be possible due to the combination of two separately trained stimuli, it seems more likely in this case that the combination of stimuli are in fact reducing responding, particularly to the Combined Target (right blue key).

Despite some inconsistent findings from the use of these two disruptors, they have still provided a useful investigation into the effects of this procedure without any changes to the reinforcement in the context. Sound in particular allowed for the investigation into a potential disruptor that could not be tampered with in any way, meaning also that no responding could be attributed anywhere else. There is a large body of basic and applied research currently investigating the persistence of problem behaviour, and these two experiments have contributed to this investigation using basic research, but by allowing reinforcement to be maintained and by using disruptors that may be analogous to the type of disruption or distraction found in an applied setting. It is studies such as these that continue to examine clinical issues in controlled experimental conditions that will help further the understanding of persistence of problem behaviour.

Experiment 7: Perspex

Previous findings throughout this investigation, and unpublished data discussed in Podlesnik & DeLeon (2015), raised the question of whether the key colours alone presented in the Combined Component are different enough to adequately signal two different contexts associated with two different behaviours, the alternative and the target. Data from Experiments 1-3 suggest that the Concurrent Component is viewed as one stimulus context, thought to be because of the same colour of the two keys within it (yellow), but it is also possible that the two different key colours used in the Combined Component are also being treated as one stimulus context.

Wider stimulus contexts have been examined in an applied investigation. Mace and colleagues (2010) examined the persistence of a pro-social (alternative) behaviour with two male participants in a context in which no reinforcement had previously been received for disruptive (target) behaviour. In that experiment, the stimulus context referred to two instructors wearing different coloured hospital gowns and using different coloured rooms, a much greater physical context change than that of just a lit key side and colour. They found that persistence of the target behaviour was reduced, and in one case avoided entirely, through training the alternative behaviour in a separate context (Mace et al., 2010). This was compared to using extinction alone, and a traditional DRA component where the alternative behaviour was trained in the same context as the target behaviour. The present study was not designed to replicate that experiment exactly, but it was designed to look at the effects of a context beyond just one key or small change in the environment, and so it was similar to Mace et al., (2010).

One possible way to change the greater context is to change the physical setting in which the Concurrent and Combined Component are presented after training in baseline. This would allow investigation into changing the physical environment as a disruptor. Therefore, in this experiment, all baseline training took place in a standard Plywood operant chamber, but the disruptor test took place in an operant chamber made of Perspex, a clear plastic which allowed the whole experiment room to be visible to hens. As with previous experiments, this disruptor test combined the alternative and target stimuli into one (Combined) component and alternated with the Concurrent Component. This investigated the persistence of responding on each of the target keys in those components. All experimental conditions remained the same in the Perspex chamber, but it was a different physical environment, or context. This procedure enabled a direct measure of the effect of changing the physical location of the disruptor test; both of the persistence of the two types of target responding, and also, of whether the Perspex box itself acted as disruptor.

The aim of the next experiment, then, was to examine the degree of disruption caused by the changing to a Perspex box, and to compare the persistence of responding between the two target response types (right yellow key and right blue key) in the Perspex box.

Method

Subjects

The subjects were four of the six hens from Experiment 6. Unfortunately, Hen 8.1 died unexpectedly and so a replacement hen started the experiment afresh. Hen

8.4 was also a replacement hen but did not complete the disruptor test due to health reasons.

Apparatus

Two experimental chambers were used in this experiment. The first chamber was the same one used and described in Experiments 1-4. This was used only for the duration of the first phase (baseline procedure) in this experiment. The second chamber was used for the second phase (disruptor test) and was set out as follows, as shown in the photograph in Figure 8.1. Three keys were situated at one end of an experimental chamber, approximately 350mm off the floor of the chamber. Multi-colour LED light panels allowed a number of different key colours to light each key. The chamber was made of clear Perspex, with three of the four sides, and the roof, completely see-through. The end of the chamber that housed the keys described above was made of plywood and painted white. Underneath the keys, a 90mm wide rectangular hole allowed the hen's access to wheat in the magazine when the hopper was raised and lit.

Figure 7.1. One of the hens working inside the Perspex box, also showing the layout of the keys and the location of reinforcer access.

The magazine was operated automatically and situated outside of the chamber. A nearby computer running MED-PC programmed and recorded all experimental conditions and data. The Perspex box was placed in a reasonably busy part of the lab where several people went about their duties throughout the day. This included, but was not limited to, data entry, cleaning, and weighing of other hens all taking place within the vicinity of the Perspex box.

Procedure

Baseline

The hens were placed in the Plywood experimental chamber for the first phase of this experiment (baseline). The same baseline procedure as Experiment 6 was used throughout this experiment. Hens were all exposed to a 12-session baseline period. When Hen 8.6 started baseline, her responding dropped suddenly, and so she experienced an extra nine sessions of baseline.

Disruptor Test

During the second test of this experiment, the hens were placed in the Perspex box. There were six test sessions, which involved the presentation of the Concurrent Component (left and right yellow keys) and the Combined Component (left green and right blue keys), as shown in Figure 8.2. The total session duration of test was 32.5 minutes per hen.

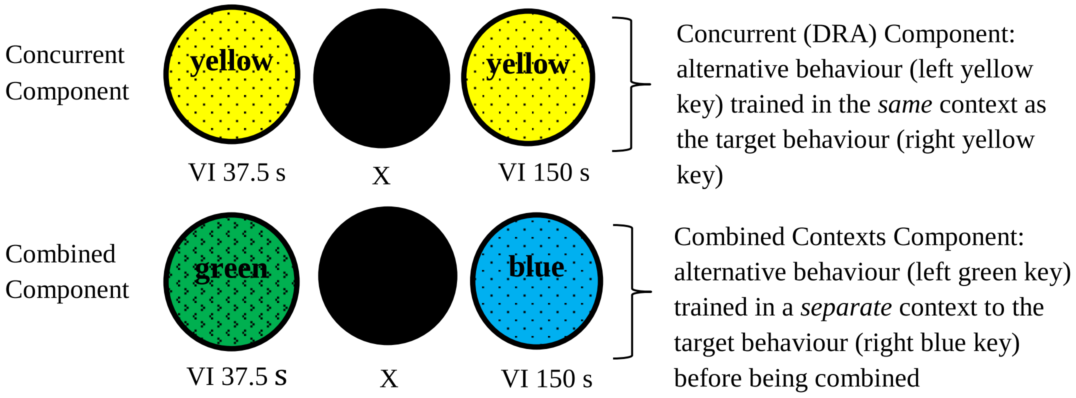


Figure 7.2. Key colours and schedules presented during the Perspex box.

Results

Figure 7.3 shows the number of responses during the last six sessions of baseline before the Perspex box was used, and the number of responses during the six sessions of the Perspex box disruptor test. During baseline, all hens' responding was lower on the right yellow key, although this was less clear for Hens 8.1 and 8.2. For four of the five hens, responding was generally higher on the right blue key presented alone. All of the hens responded almost equally to both of the left keys. Hen 8.1's responding during baseline was less stable than other hens, possibly due to her reduced experience comparative to the others.

During the disruptor test, responding on the right blue key was lower than responding on the right yellow key for Hens 8.1 and 8.5, as shown in Figure 7.3. Hens 8.2, 8.3, and 8.6 had very similar levels of responding on both right keys, but responding on the right yellow key was generally lower. Rates of responding on the two left keys (yellow and green) remained very similar to each other for all hens. Whilst different hens showed different patterns of responding across the test, (Hen 8.1's responding rose throughout the test, Hen 8.3's decreased and responding remained quite stable throughout for the other hens), responses to the left yellow and left green keys followed the same pattern for each individual hen.

A two-way repeated measures ANOVA comparing the number of responses on the right yellow and right blue key over the disruptor test showed no significant difference in responding to the two types of right key (blue and yellow); $F(1,4) = .878$, $p > .05$, $\eta_p^2 = .180$, no significant effect across sessions, $F(5,20) = 1.404$, $p > .05$, $\eta_p^2 = .260$ and no significant interaction between sessions or key colours; $F(5,20) = .233$, $p > .05$, $\eta_p^2 = .055$.

Responding plotted as a proportion of baseline is displayed in Figure 7.4. For all hens, responding dropped proportionate to baseline on the right blue key of the Combined Component and remained lower than baseline levels for all hens except 8.6 throughout the remainder of the test. Again with the exception of Hen 8.6, responding on this key remained lower than responding on all other keys, including the right yellow key, proportionate to baseline. A paired-samples t-test comparing the mean proportion of baseline responding on the right yellow key with the mean proportion of baseline responding on the right blue key was significant, $t(4) = 2.872$, $p = .045$, $d = 1.358$. Responding on all other keys increased proportionate to baseline for all hens, 8.1 and 8.5 in particular. The exception to this was Hen 8.4, whose data from this experiment was limited.

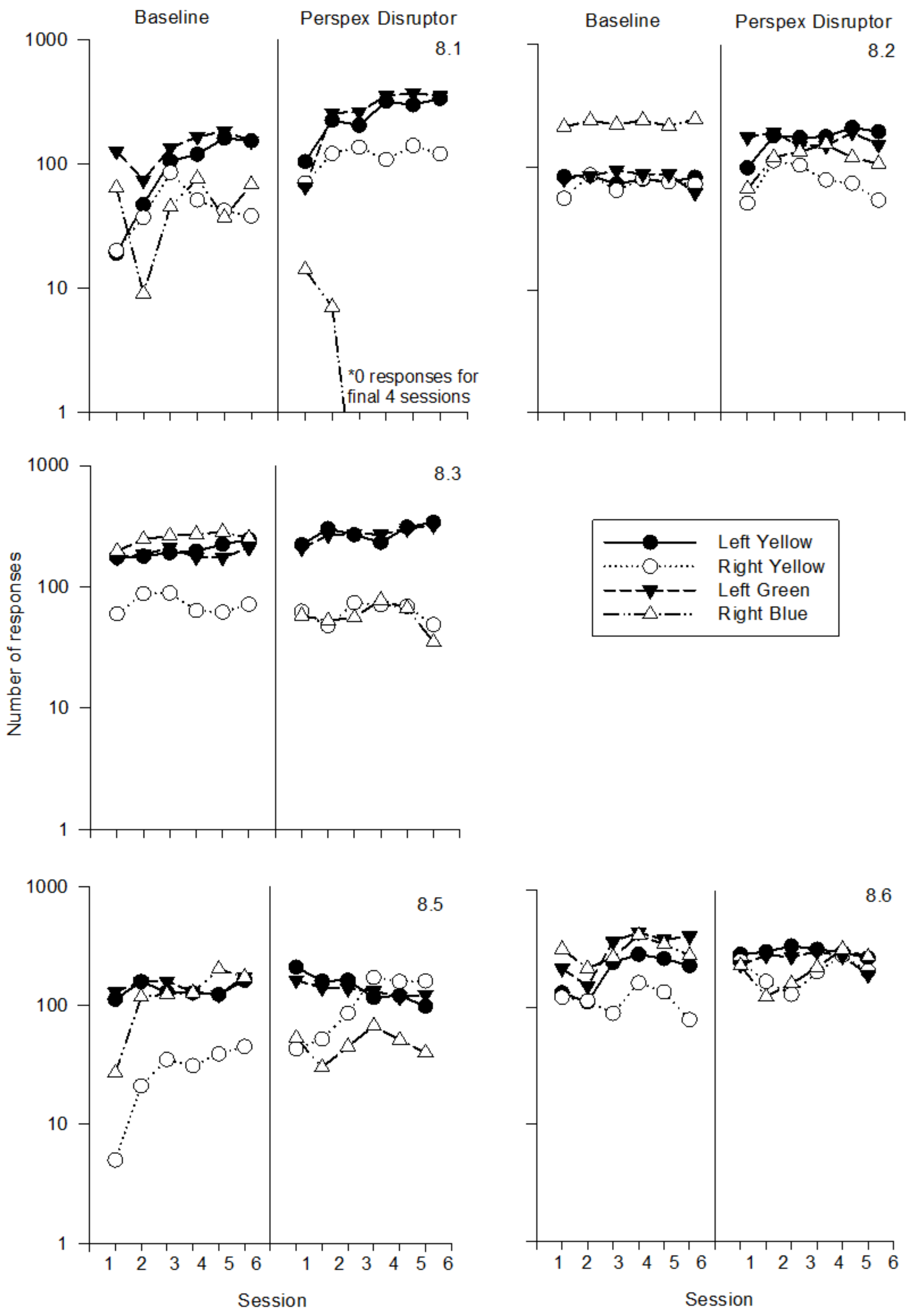


Figure 7.3. Response rates for all hens during baseline sessions and the Perspex disruptor test. The y-axis is on a log scale. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) while triangles (filled = left green key, open = right blue key) represent the two stimuli trained separately before being combined during the disruptor test.

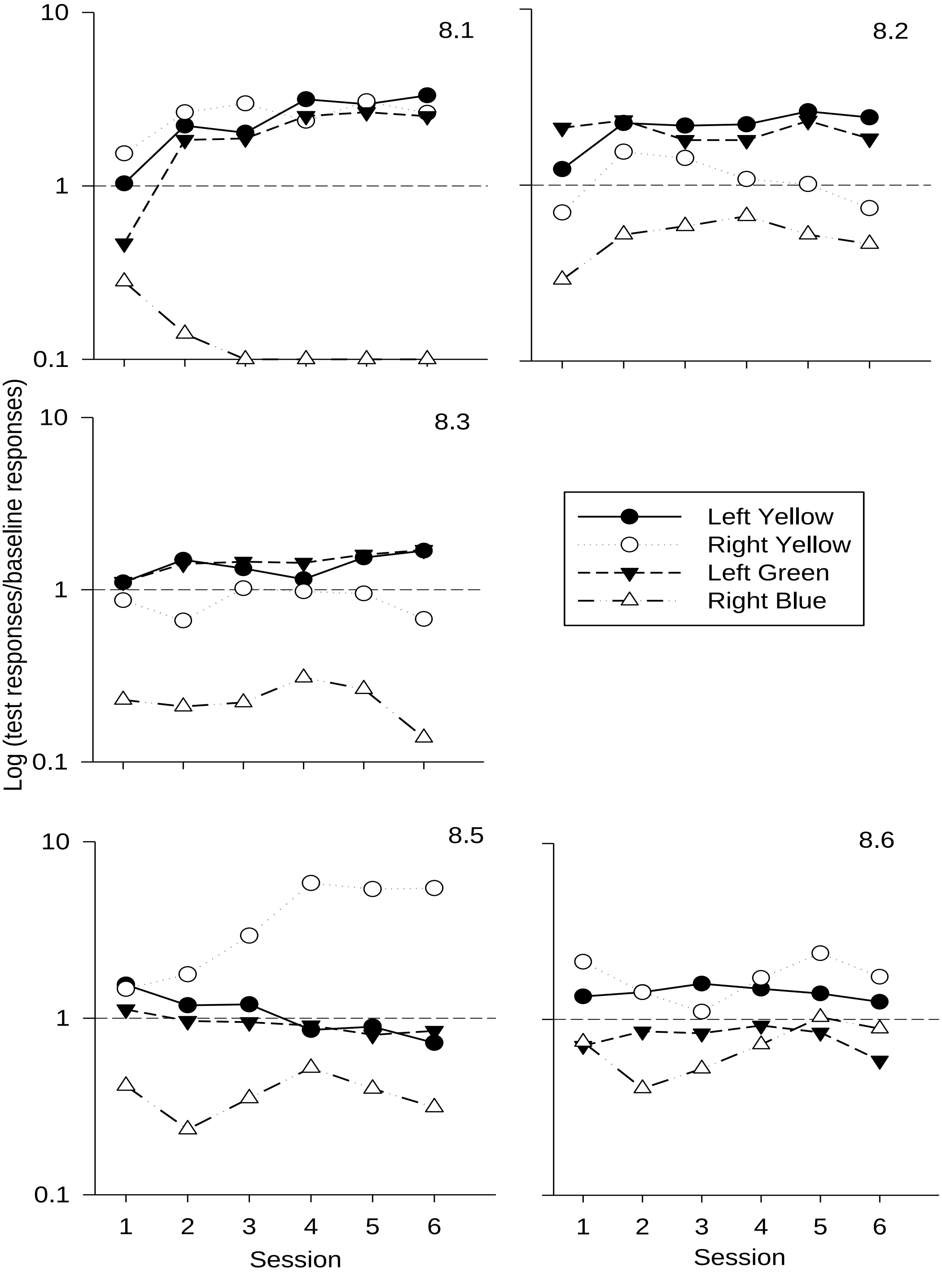


Figure 7.4. Responses plotted as a proportion of baseline during the Perspex disruptor test. The y-axis is presented on a log scale. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) and triangles represent the Combined Component (filled = left green key, open = right blue key).

Discussion

Experiment 7 aimed to investigate the effects of changing physical locations between the baseline (Plywood operant chamber) and disruptor tests (Perspex operant chamber). Of interest was the degree of disruption caused by moving to the Perspex box. This would be shown by any change in responding overall in the Perspex box as compared to responding in the original chamber. Also of interest was the persistence of the two target response types (right yellow key and right blue key) in the Perspex box, to investigate persistence of responding using this procedure as an alternative to a DRA procedure that would train the alternative and target behaviour in the same context.

Using the proportion of baseline data, responding was less persistent on the right blue key (Combined Component) compared to the right yellow key (Concurrent Component) supporting the use of training the alternative behaviour in a separate context prior to combining it with the target behaviour. These findings were supported statistically.

Placing the hens in the Perspex box had different effects on responding from those seen in earlier experiments. Previously, there was a reduction in responses overall in the presence of the disruptor and responding in the first few sessions was disrupted (Experiment 1-3), neither of these effects was seen here. There did not appear to be an effect of changing the physical location of the disruptor test, and this suggested that the Perspex chamber did not disrupt responding. In fact, responding increased initially for some of the hens during the first few sessions in the Perspex box and continued to rise on particularly the left yellow and left green keys over sessions. This was the opposite finding to that of

Experiment 6, where the sound decreased responding in the initial sessions but then did not disrupt responding as sessions progressed. This initial disruption in responding might have been expected when the hens were placed in the Perspex chamber.

Whilst this experiment was useful for investigation into the effects of changing the context as a disruptor, it did not really allow for the comparison of two clearly defined separate contexts relating to responding on each of the keys. The contexts were clearly different for the baseline (Plywood) and disruptor (Perspex) test, but not for the environment associated with the two components (i.e., Concurrent or Combined), which would really test to see if this method was successful at reducing persistence. What is required is a methodology that allows training each response type in clearly separate contexts, associated with stimulus differences beyond just a lit key, to examine the concept of context further (see Experiment 10).

There were also limitations to the use of the Perspex operant chamber in general, such as the inability to control what was happening in the environment outside of the Perspex chamber. This does resemble an applied situation where there are often many distractions that cannot be controlled or manipulated clearly. However, it makes concluding if it was the change in environment, or the possibility of different visuals, sounds and other environmental stimuli, that affected behaviour difficult.

Using the Perspex box as a disruptor had mixed findings in relation to its effects as a disruptor, and to the persistence of responding. Hens responding did not reduce overall when they were placed in the Perspex box, suggesting that it was not effective at disrupting responding. The proportion of baseline data also did not show a reduction in persistence of responding overall between baseline and the disruptor test. There was a reduction in the persistence of responding on the right blue (Combined Target) key, during the disruptor test, and this finding is in line with previous experiments showing reduced persistence of target responding following training the alternative and target behaviours in separate contexts. However, there were also cases where the rate of responding on the right blue key remained higher than that of the right yellow key, making these findings difficult to draw conclusions from, as with Experiment 4.

Chapter 5: Summary

Experiments 4-7 aimed to investigate the use of several disruptors that did not add (Experiments 2-3) or remove (Experiments 1; Mace et al. (2010), Podlesnik et al. (2012), Podlesnik and Bai (2015)), any additional reinforcement from either of the contexts in which persistence was being investigated. Furthermore, this series of experiments continued to examine the effects of training an alternative behaviour in a separate context to that in which a target behaviour was occurring, before combining them in the presence of the disruptors. Target responding in this Combined Component was then compared to target responding where an alternative behaviour had been trained in the same context (Concurrent Component), such as in a traditional DRA. Although it was difficult to directly compare all of the disruptors used in this last series of experiments due to the differences in disruptors and in the subjects, some similarities can be discussed in relation to the findings.

A common finding across the last four experiments was the absence of reduction in responding on each of the keys between the baselines and the relevant disruptor tests. This was observed regardless of the disruptor used, and when responding was measured on the left green and right blue keys combined with no disruptor present. Although the disruptors investigated altered the baseline contingencies with which responding on all keys was associated, and could be applied equally to all components (see Introduction for the criteria for a disruptor), there was still no real change in responding observed in the presence of these disruptors.

Despite the above finding, there was, in most cases, changes observed in the persistence of responding to the right blue, or Combined Target key, when compared to the right yellow, or Concurrent/DRA Target key, in the presence of the disruptors investigated. This finding was important, because it is in line with previous research suggesting that the persistence of responding to the Combined Target key is likely to decrease when the associated alternative behaviour has been trained in a separate context to the target, and then combined in the presence of a disruptor. This finding also has applied significance, because all of the disruptors examined in these last four experiments aimed to draw analogies to applied settings, and this opens further potential for investigation into the method of Combined Contexts DRA for reducing the persistence of target responding.

One possible limitation to this methodology as an alternative to traditional DRA's, was shown by data analysis in two of the previous four experiments. This was the differences in findings between the response rate data during disruptor tests, and that of the proportion of baseline, or persistence, during the disruptor tests. Proportion of baseline data clearly showed reduced persistence of responding to the right blue (Combined Target) key when compared to that of the right yellow (Concurrent/DRA) Target key, as discussed above. The response rates on the right blue key however, were in some cases higher than that of the right yellow key. Whilst response rate does not equate to persistence in the basic literature, the differences in findings between the two types of data could still lead to different conclusions regarding the implications of the data, if this methodology was used as an alternative to DRA interventions in an applied setting (see Experiment 4 Discussion for a more detailed explanation of this).

A further limitation to this methodology was the initial baseline procedure. It was realised that the target, or right keys under investigation, do not start out equally presented to compare responding following addition of an alternative behaviour, or any disruption that may be applied to those contexts. For example, the right blue key is always presented alone initially, so the level of responding to that key is known, and likely relatively high as there is no response competition. However, the right yellow key is never presented alone initially, and is always a response option against a much richer alternative. Whilst this part of the procedure is essential to compare the effects of training two behaviours trained in the same or in separate contexts, it makes comparing the two types of target responding difficult as they did not start out equally. It is also unlikely a DRA would occur in this way in an applied setting, for example, it is more likely that the problem behaviour would be occurring alone before an alternative behaviour is introduced in the same setting as part of an intervention (see Experiment 9). These two limitations suggest that there might be larger procedural issues that prevent clear interpretation of data coming from this type of experiment.

As mentioned previously, the differences in the disruptors used in the last four experiments, and the differences in subjects, made comparison between these experiments difficult beyond the similarities in findings discussed in this summary. However, what all of the previous experiments have done, including those used in Chapter 2, is examine the persistence of responding under some form of disruption, and investigate training an alternative and target behaviour in two separate contexts before combining them in the presence of a disruptor. This method has been used as a possible method to minimise the persistence-strengthening effects of typical DRA interventions.

As techniques to reduce the persistence-strengthening effects of DRA interventions is an area receiving a sizeable amount of interest currently, there are other potential methods proposed to have these persistence reducing effects. Many of these methods, however, are investigating the effects of changing some formal property associated with the alternative behaviour in relation to the effects on persistence of target responding. These include; thinning the alternative reinforcement schedule (Sweeney & Shahan, 2013), addition and removal of the alternative stimulus (Podlesnik & Kelley, 2014), training the alternative behaviour on the same key as the target behaviour (Podlesnik & Bai, 2015), manipulating the reinforcement conditions associated with the alternative response (Podlesnik et al., 2016), signalling the alternative reinforcement (Nevin et al., 2016) and manipulating the alternative stimulus itself (Podlesnik, Miranda-Dukoski, Chan, Bland, & Bai, 2017).

Changing an association to the alternative behaviour is one way to examine the persistence of target responding, but there are many other processes occurring in this procedure that also warrant further investigation, as found in the most recent experiments in this series of investigation. These include investigating the effects of changing the alternative reinforcement rate but without removing it entirely (such as during previous studies mentioned above that have used extinction), and training a new baseline that allows responding to the two types of target stimuli to be equal, before further manipulations begin. The additional processes also include the effects of training the response types in different contexts beyond that of a key side and colour. The need for further investigations into these three areas particularly influenced the designs of the final three experiments in this thesis.

Chapter 6: Experiments 8-10

Experiment 8: Thinning Schedules

Sweeney and Shahan (2013) proposed the use of an additional behavioural process in an attempt to prevent the persistence-strengthening effects of DRA interventions. They suggested thinning the reinforcement schedules associated with the alternative behaviour introduced alongside the target (or problem behaviour) in the context.

Sweeney and Shahan (2013) used both high, low and thinning schedules of reinforcement in their trial experiment with rats, and compared all findings to those from a control group who were exposed to a typical resurgence procedure (see Introduction for an explanation). High rates of reinforcement reduced the target behaviour faster than the low-rate or thinning schedules, but as soon as the high rate of reinforcement was discontinued, resurgence was much greater. Whilst the low and thinning schedules did not reduce the target behaviour as effectively, there was no resurgence when the treatment ended (Sweeney & Shahan, 2013).

In a clinical model, Pritchard, Hoerger, Mace, et al. (2014) successfully reduced problem behaviour maintained by attention for an adult male using both high and low rates of DRA. The problem behaviour was maintained on a VI 60-s schedule in two components during baseline, with a different therapist associated with each component. During the intervention phase, one therapist’s attention was given at a four times higher rate (high-rate DRA) than the other (low-rate DRA). Whilst treatment was effective with both therapists, relapse, following the reinstatement of baseline levels of reinforcement, was 2.6 times greater with the therapist using the higher rates of DRA, and resurgence, during extinction, was

2.1 times greater than the relapse for the lower rates of DRA. A possible confound in this experiment was that the alternative behaviour required by the participant was topographically different from, and required less effort (appropriate communication instead of physical aggression or escape), than the problem behaviour. The authors hypothesised that the low-rate DRA may have been successful as the ‘easier’ alternative behaviour was favoured by the participant (Pritchard, Hoerger, Mace, et al., 2014).

Whilst both of these studies, and others, have furthered our understanding relating to treatment relapse, questions remain. Sweeney and Shahan (2013) used two different behaviours for their target and alternative behaviour (lever pressing and nose poking) and their procedure took place across three different contexts (as per usual resurgence procedures) while they investigated different rates of reinforcement, and the thinning of alternative reinforcement schedules. This did not answer the question of what happens with behaviours occurring in the same context while such changes are made to the alternative reinforcement schedule, or what happens when topographically similar behaviours are being reinforced on a thinner schedule, such as answering questions appropriately instead of shouting out in the classroom.

There is limited research suggesting what happens if the schedules are thinned gradually, after the initial DRA intervention. The experimental literature in this area is largely focused on the effects of thinning an alternative reinforcement schedule when the reinforcement schedule maintaining the target behaviour is stopped entirely, and the subsequent resurgence of that target behaviour (for example; Sweeney and Shahan (2013); Winterbauer and Bouton (2012)). Much of the applied research in this area relates to the effects of thinning reinforcement schedules during functional communication training (FCT) procedures (see Greer, Fisher, Siani, Owen, and Jones (2016) for a recent review and Hagopian, Boelter, and Jarmolowicz (2011) for recommendations on schedule thinning in FCT). Whilst FCT is an application of differential reinforcement procedures, the alternative behaviour in an FCT procedure is a communicative response, whereas alternative behaviours reinforced in DRA procedures can be any behaviour, depending on the circumstance and setting (Cooper et al., 2007).

The effects of thinning schedules on the persistence of a target behaviour in a DRA-type intervention following an alternate context training procedure, such as the one used in previous experiments, is yet to be examined. Understanding the effects of thinning a reinforcement schedule is of interest, because a common problem with treatment in applied situations is that the alternative reinforcement rate is not sustainable after the intervention has finished. For example, the therapist leaves the classroom after the problem behaviour has successfully reduced and 1:1 attention is no longer available to maintain the alternative reinforcement schedule, or, if a procedure such as fading is used in addition to a DRA intervention, the alternative reinforcement rate is gradually reduced over time anyway.

This next experiment investigated the effects of thinning the reinforcement schedules for the alternative behaviour on the persistence of that, and the target, behaviour. For one group of hens, the reinforcement schedule maintaining the alternative behaviour was thinned in two separate multiple schedule components; the Concurrent Component (analogous to a traditional DRA) and the Combined Component (analogous to combining two stimuli already trained in separate contexts). Once the schedules were thinned and responding had stabilised, an alternative source of reinforcement, which was previously demonstrated to function as a disruptor (see Chapter 3), was added to the both the Concurrent and Combined Contexts. This allowed reinforcement to remain in effect, and enabled investigation into the effects of thinning the schedules, after training in separate contexts, on the persistence of the target behaviour, compared to responses trained concurrently. This is similar to investigating the effects of thinning the schedule after an intervention (either traditional DRA or Combined Contexts) has taken place in an applied setting.

A second group of hens was exposed to a three-component multiple schedule (the baseline procedure used in previous experiments), a Concurrent Component (analogous to a traditional DRA with an alternative and target behaviour) and two individual stimuli, an alternative and a target behaviour trained in separate contexts. The schedules associated with the alternative behaviours were presented alone, and as part of the Concurrent Component, were both subjected to a thinning procedure. Once a new baseline was established and responding was stable at these rates, the alternative and target behaviours trained separately were combined into one component, and the red key disruptor that maintained responding was applied to both the Concurrent and Combined Components. This allowed comparison of the effects of thinning the schedule for the alternative behaviour both within the same context (Concurrent Component) and prior to combining it in the same context as the target schedule (Combined Component) on the persistence of the target behaviour. This is analogous to thinning the schedules before the Combined Contexts intervention has taken place in an applied setting. Using two groups of hens allowed comparison between thinning schedules before and after the alternative and target stimuli were combined.

Method

Subjects

The subjects in Group 1 were the six hens from Experiment 6, numbered individually from 11.1-11.6. The subjects in Group 2 were the six hens from Experiment 7, numbered individually from 8.1-8.6. Whilst Hen 8.4's health had improved enough for her to return to work at the start of the experiment, it soon deteriorated again and she was removed from the experiment before the disruptor test without further replacement.

Apparatus

The same experimental chamber as used and described in Experiments 5 and 6 was used for Group 1 hens, and the same experimental chamber as used and described in Experiment 7 was used for Group 2 hens.

Procedure

Thinning Schedules – Group 1

This experiment immediately followed Experiment 6, and there was no exposure to the original baseline schedules between the two experiments. The left green and right blue keys remained lit and active in the Combined Component, and the two yellow keys were lit and active in the Concurrent Component. All active keys provided reinforcement; the schedules on both the left keys (green and yellow) started on a VI 37.5-s schedule with the interval programmed to increase by 11.3-s each day. At the end of the 12th session, the schedule on the left key was equal to the schedule on the right key (VI 150-s) in both components. The final reinforcement schedules and the key presentation in each component for Group 1 hens are shown in Figure 8.1.

Thinning Schedules – Group 2

This experiment continued directly on from Experiment 7. The same key colours and components previously used in baseline conditions were presented and the schedules on both right keys remained the same as the original baseline (see Figure 8.1). The schedules on both the left keys, however, started on a VI 37.5-s schedule as per the original baseline, but with the interval programmed to increase by 11.3-s each day. At the end of the 12th session, the schedules associated with the left yellow and green keys were equal to the schedules associated with the right yellow and blue keys (VI 150 s). This final reinforcement schedules and key colours presented in each component are shown in Figure 8.1.

Once all hens were exposed to equal VI 150-s schedules across all keys, the schedules remained in place until responding was stable. After approximately 20 sessions for Group 1 and 30 sessions for Group 2 at this new baseline level, responding did not approach the levels of stability previously seen in the respective baselines. However, a visual analysis determined responding was stable enough in the final six sessions of the new baseline procedure to enable proportion of baseline data to be calculated. Therefore the decision was made to move onto the disruptor test. Hen 11.4 had three fewer sessions than other hens in Group 1 due to egg-laying in the chamber. Typically, data gained if eggs were laid during a session were discarded, as there is no knowledge of how much time was spent laying without responding.

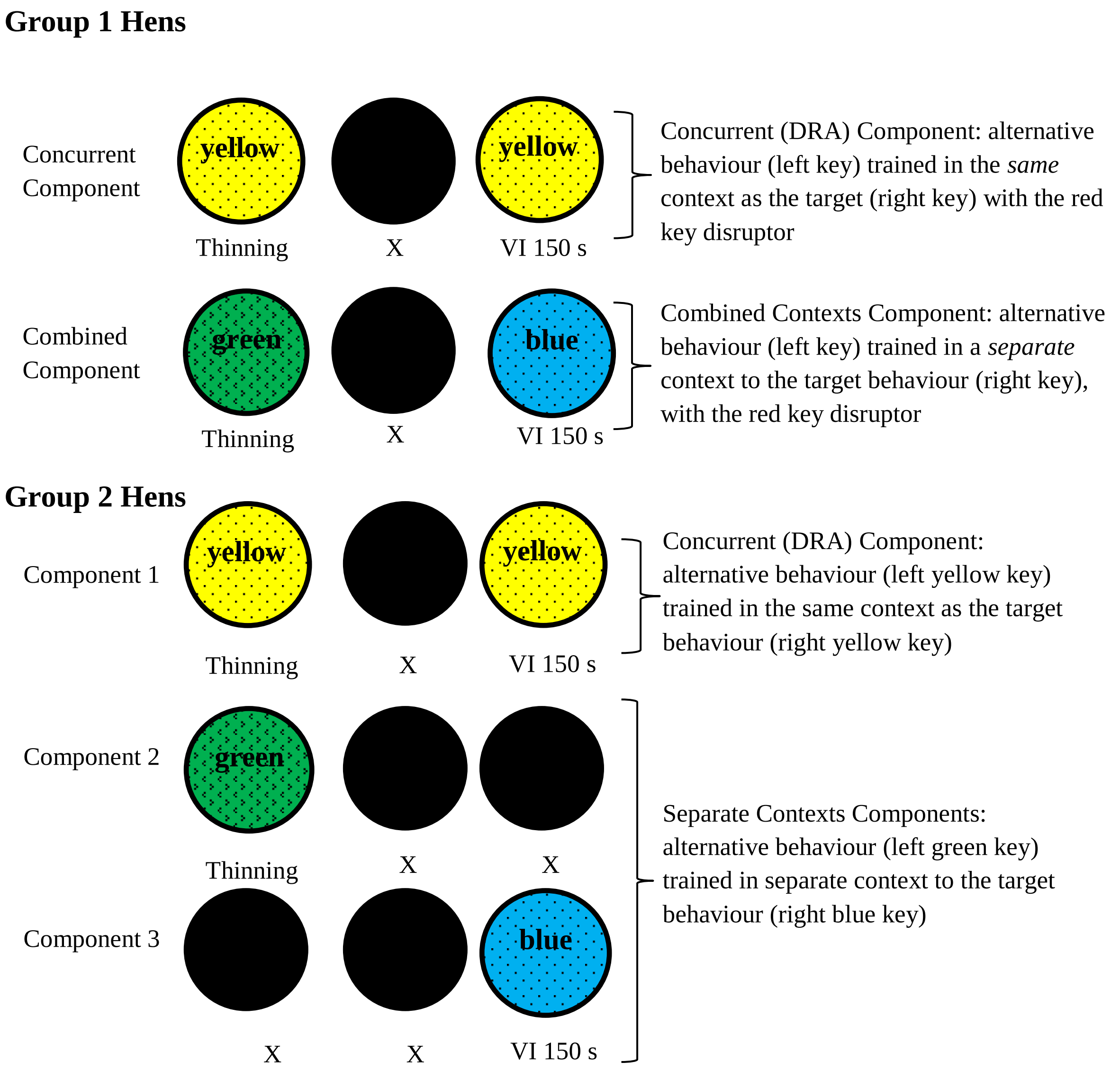


Figure 8.1. The key colours and schedules that Group 1 Hens (top diagram) and Group 2 Hens (lower diagram) were exposed to during the thinning part of the experiment.

Disruptor Test – Group 1

The disruptor was the centre red key, associated with a VI 150-s schedule. As the left green and right blue keys were already combined during the thinning phase and baseline parts of the procedure, the only change to the stimulus presentation during the disruptor test was the lighting of the centre key to red. All schedules remained exactly as the new baseline procedure, as shown in Figure 8.2.

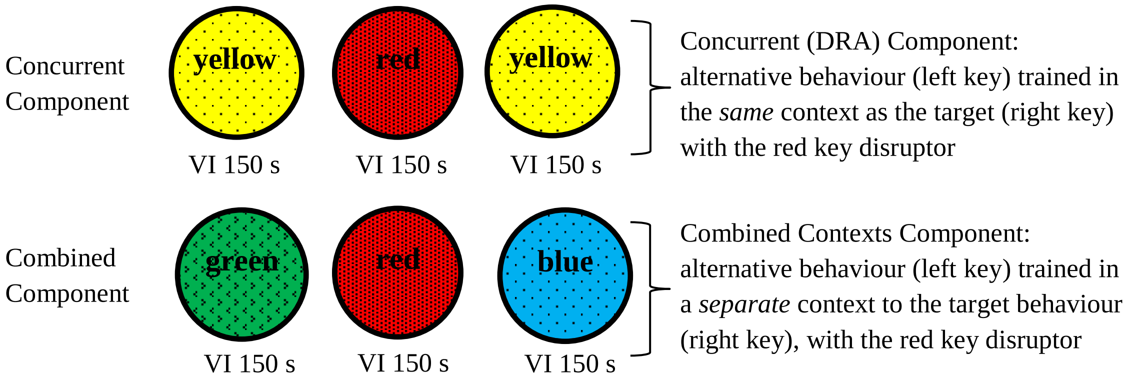


Figure 8.2. Key colours and schedules as arranged during the disruptor component for both groups of hens.

Disruptor Test – Group 2

The same centre red key disruptor was used for this group of hens. However, as the left green and right blue keys had not been combined during the thinning and baseline stages, they were combined into one component and presented with the red key in between them for the duration of the disruptor test. The Concurrent Component (both yellow keys) remained as it was in the thinning and baseline stages, but with the red centre key lit and operative. All schedules remained as in the most recent baseline procedure. Therefore, both groups of hens were exposed to the same disruptor test, including the combination of stimuli and reinforcement schedules, as shown in Figure 8.2. The differences between the groups were in the key combinations during the thinning phase of the experiment.

In the disruptor tests the two components were each presented 12 times, totalling 24 component presentations per session. Components were presented in random order and were separated by a 20-s ICI. The sessions started and ended with an ICI, and 3-s access to wheat was provided for reinforcement. Total session length was 32.5 minutes, and there were six sessions during the disruptor test.

Results

Thinning Schedules

Figures 8.3 and 8.4 show the response rates for all hens in Groups 1 and 2 respectively during the 12-session thinning schedule part of the experiment, and the sessions that followed to re-establish responding at this new lower baseline rate. Hen 8.4’s data are not included.

Despite changes to the schedules, the majority of Group 1 hens continued to respond at stable and consistent levels throughout this entire part of the experiment, as shown in Figure 8.3. The only slight changes in responding were to the right (target) yellow and right blue keys, even though the schedules on these keys were unchanged. Responding on both of the right keys increased for most of the hens as the schedules on the left (alternative) keys were thinned. Once all four keys were associated with the same VI schedule, responding across all keys became very similar to each other and quite stable throughout this part of the experiment. The only time responding dropped on the left keys that had been associated with the thinning schedules was for the last few sessions for Hen 11.4, after she had been exposed to the thinner reinforcement schedule for approximately 15 days.

In contrast to these findings, responding for Group 2 was much less stable and consistent for this part of the experiment, and there were fewer clear patterns across hens, as shown in Figure 8.4. Left key responding, associated with the reducing reinforcement rate, decreased for Hens 8.1 and 8.5 initially, but Hen 8.1’s responding stabilised as the schedule reached VI 150-s. Hen 8.5’s left key responding continued to trend down across all sessions. Hens 8.3 and 8.6 showed relatively stable rates of left key responding which did not change a great amount across this part of the experiment, and Hen 8.2’s left key responding increased as the schedules associated with those keys started to decrease, before stabilising shortly after the schedule finished changing.

Unlike Group 1, whose responding on both right keys remained similar, Group 2, where the right blue key had remained separate for the duration of the thinning procedure, had very different levels of responding on each of the right keys. For Hens 8.1, 8.2 and 8.3, responding on the right yellow key rose as the schedules thinned, whilst responding on the right blue key remained relatively consistent across sessions, as did Hen 8.5 and 8.6’s right yellow key responding.

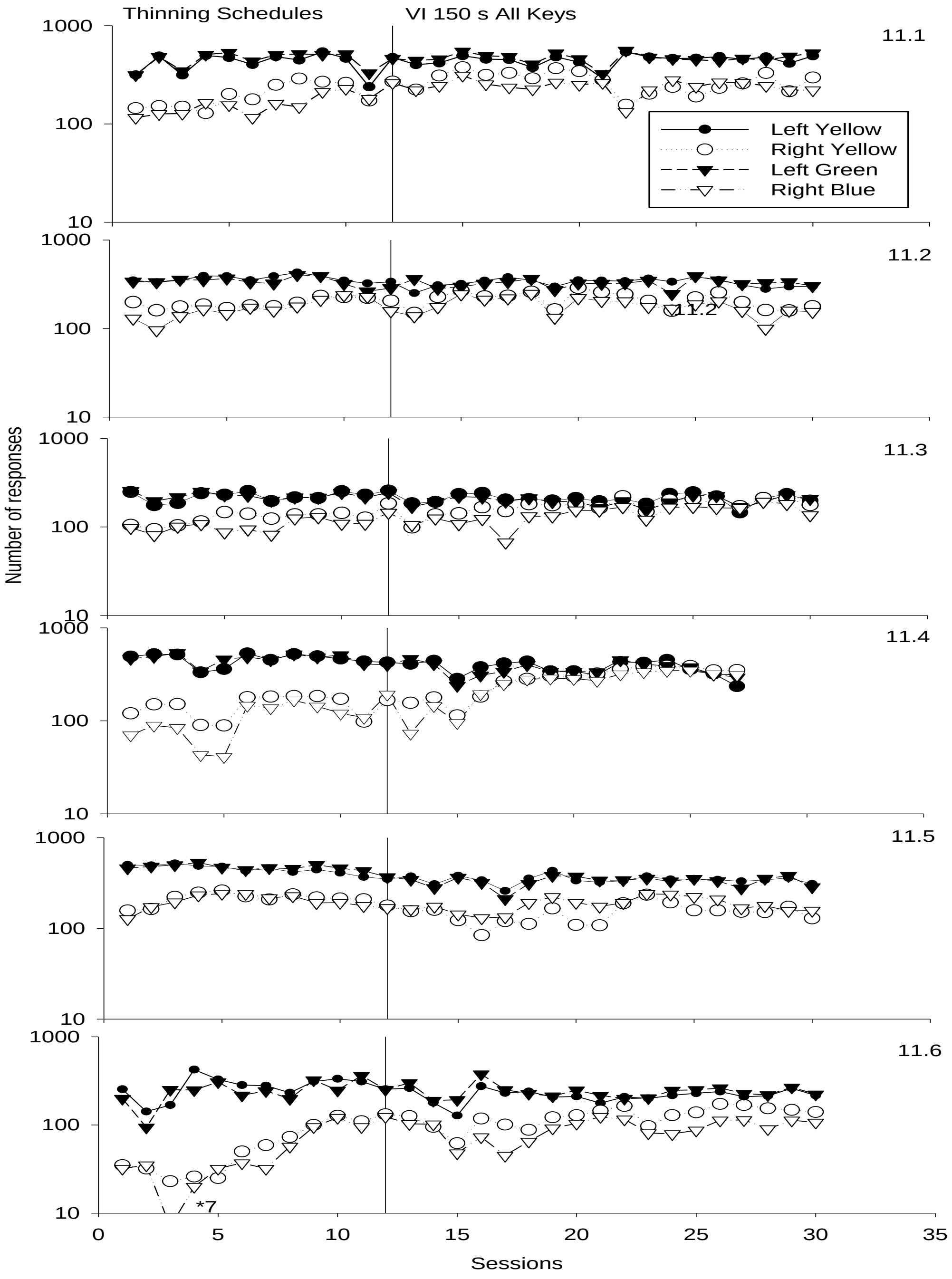


Figure 8.3. Response rates during the thinning sessions (first column) and the new baseline sessions (second column) for all Group 1 hens prior to the addition of the red key disruptor. The y-axis is on a log scale, circles represent the Concurrent Component, and triangles represent the Combined Component.

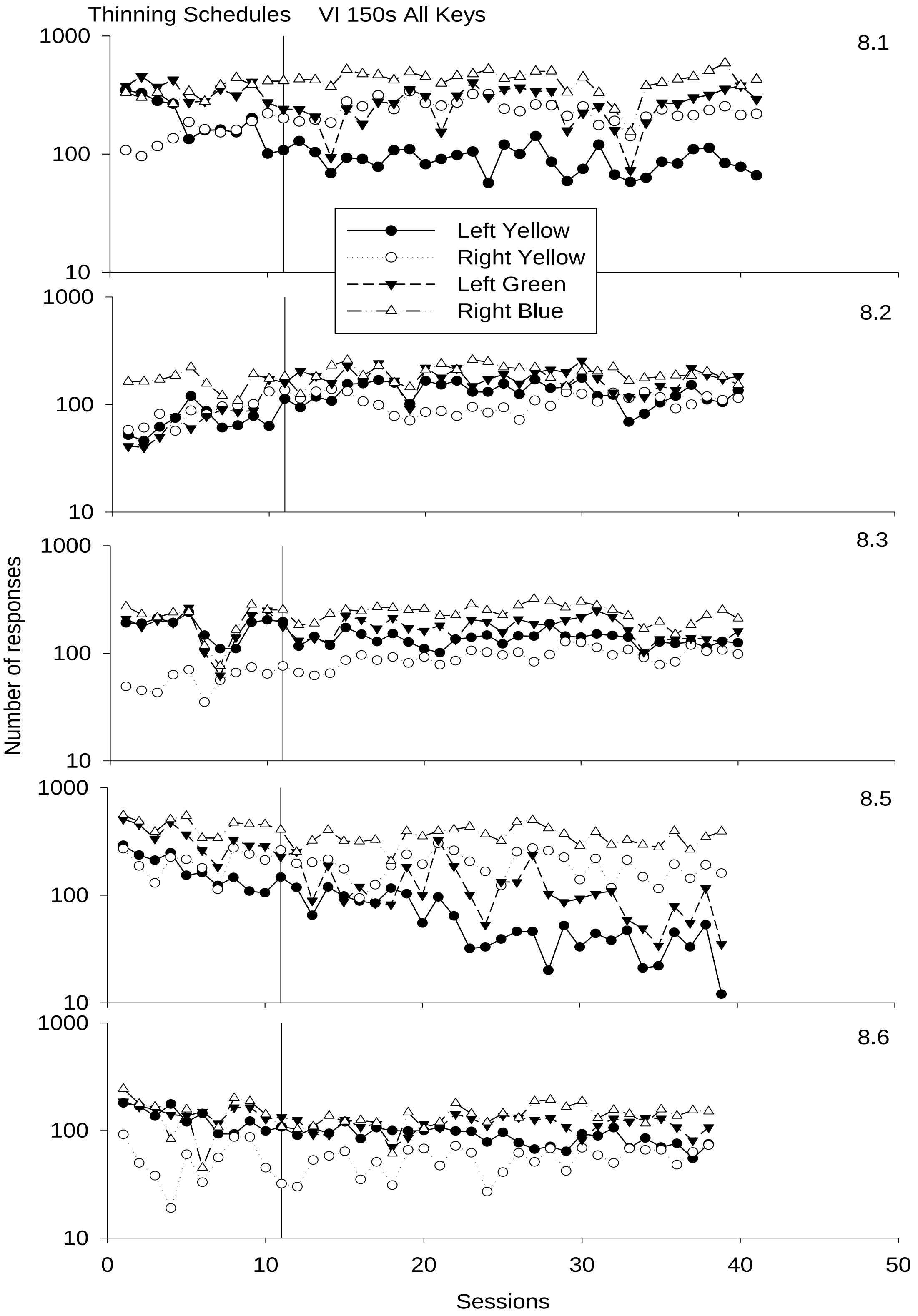


Figure 8.4. Response rates during the thinning sessions (first column) and the new baseline sessions (second column) for all Group 1 hens prior to the addition of the red key disruptor. The y-axis is on a log scale, circles represent the Concurrent Component, and triangles represent the Combined Component.

Disruptor Test

The proportion of baseline responding during the red key disruptor test is presented in Figure 8.5 (Group 1) and Figure 8.6 (Group 2). Three of the Group 1 hens, 11.1, 113 and 11.5, all showed more responding proportionate to baseline to the right keys, with this measure showing very similar levels on both right yellow and right blue keys. The other three hens responded similar to baseline levels on the left keys, with similar patterns on both left yellow and left green keys. For the majority of hens, responding as a proportion of baseline trended downwards across sessions, although there was some variability to this for individual hens on individual keys. A paired-samples t-test, comparing the mean proportion of baseline responses across sessions on the right yellow key with the mean proportion of baseline responses on the right blue key, found no significant difference between the two types of right key responding, $t(5) = -.487$, $p = .647$, $d = -0.089$.

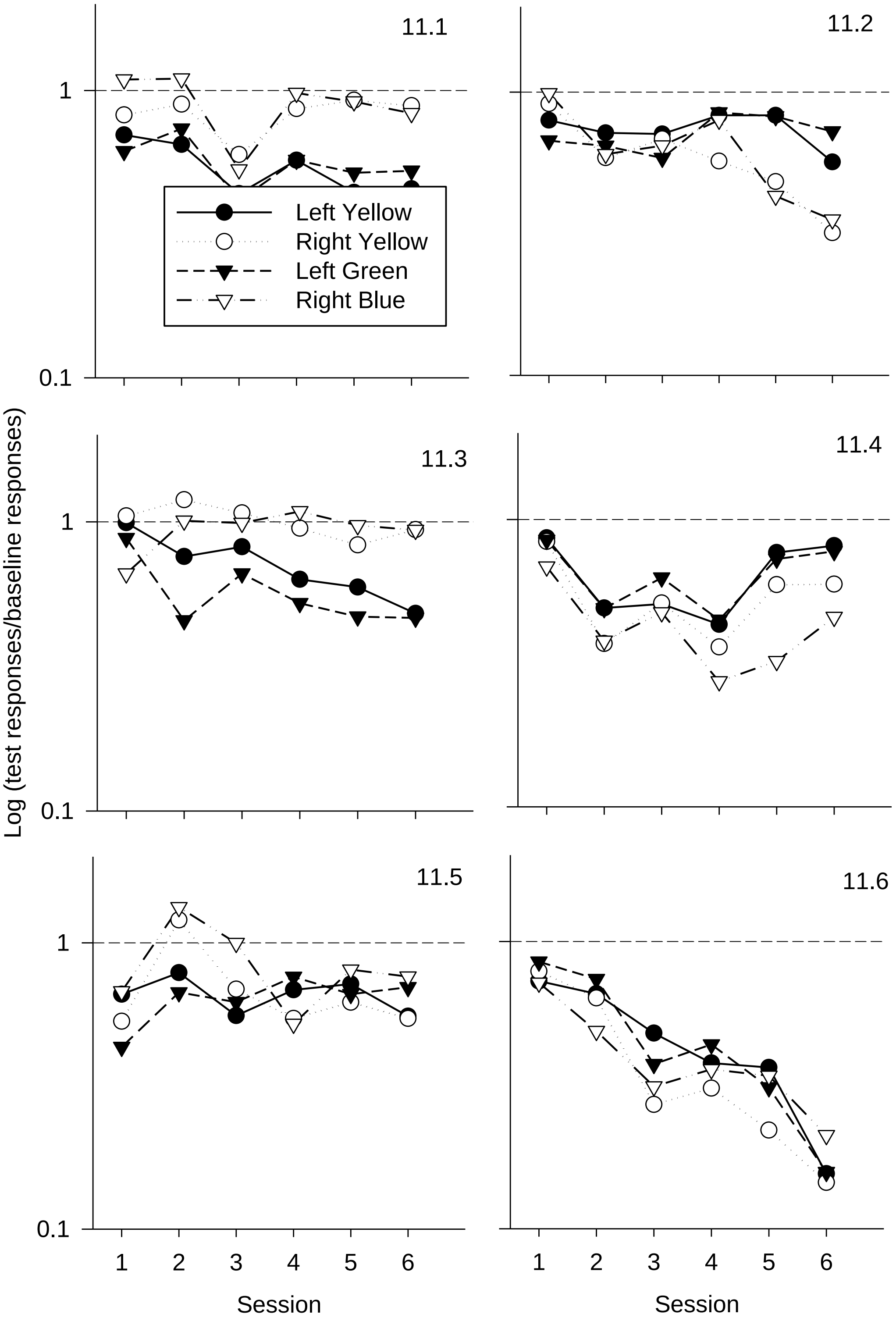


Figure 8.5. Responding plotted as a proportion of baseline for Group 1 hens during the red key disruptor test that followed thinning of the schedules on the left keys. Circles represent responding in the Concurrent Component (filled = left yellow, open = right yellow) and triangles represent responding in the Combined Component (filled = left green, open = right blue).

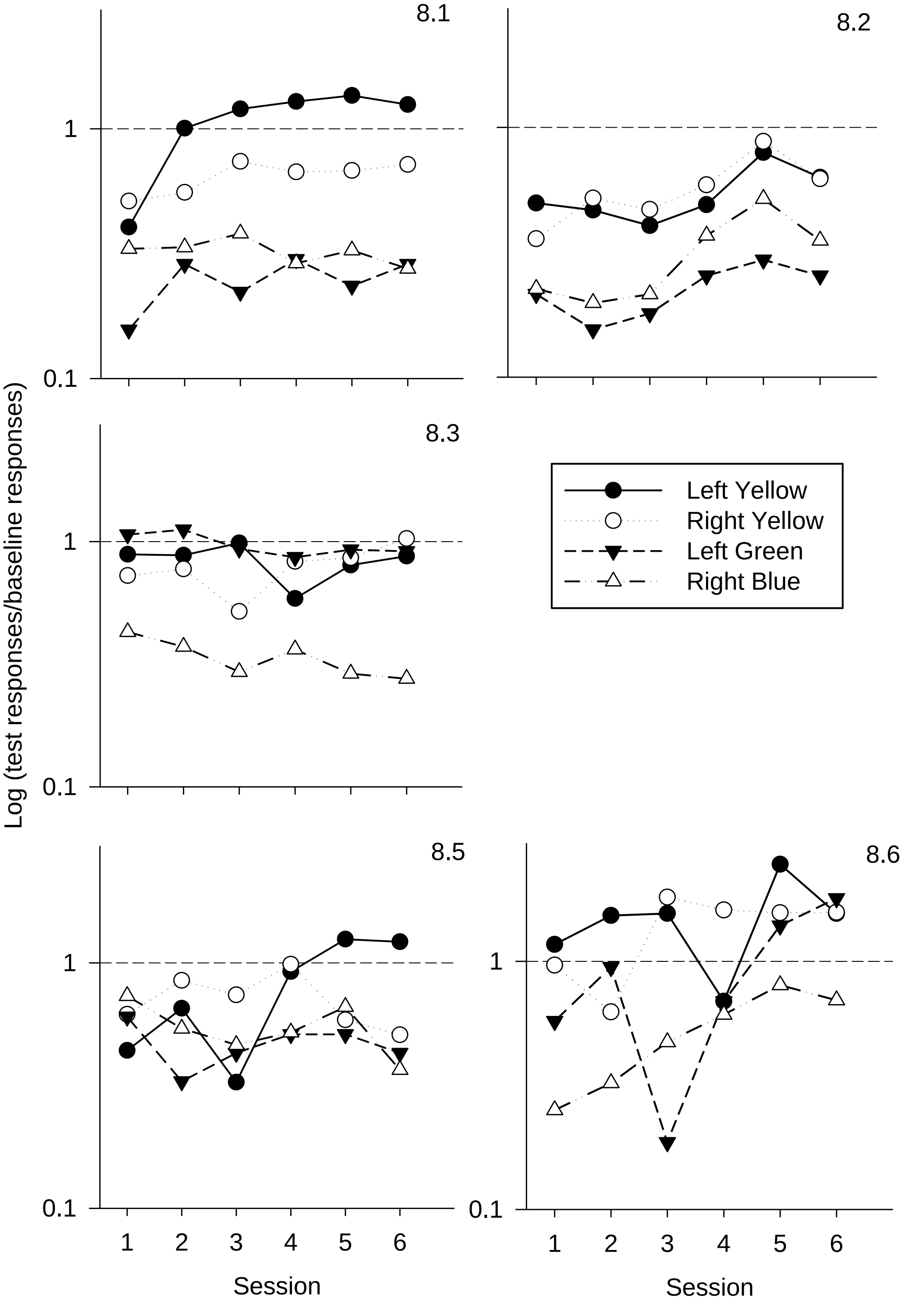


Figure 8.6. Responding plotted as a proportion of baseline for Group 2 hens during the red key disruptor test that followed thinning of the schedules on the left keys. Circles represent responding in the Concurrent Component (filled = left yellow, open = right yellow) and triangles represent responding in the Combined Component (filled = left green, open = right blue).

Findings for Group 2 hens contrasted to those described for Group 1 above. Responding proportionate to baseline dropped on the first session of the disruptor test (see Figure 8.6), but generally increased across sessions after this initial drop. Left and right yellow key responding proportionate to baseline was higher for all hens other than 8.3, whose left green key responding proportionate to baseline was generally higher than responding on both the yellow keys. Right blue key responding proportionate to baseline was generally slightly higher than this measure on the left green key for most hens, but for Hens 8.3 and 8.6, responding proportionate to baseline on the right blue key was the lowest overall. There was a statistically significant difference between the mean proportion of baseline responding on the right yellow key compared to the mean proportion of baseline responding on the right blue key, $t(4) = 3.503$, $p = .025$, $d = 1.297$, suggesting that right blue key responding was less persistent than right yellow key responding. Group 2 hens’ responding proportionate to baseline was much less consistent on all keys than that of Group 1 hens, with several sudden increases and decreases in responding as sessions progressed.

The overall decrease in responding for Group 1 hens during the disruptor test could possibly be explained by the large number of responses on the centre red key. Figure 8.7 shows the red key response rate for Group 1 hens, both when the red key was presented with the Concurrent Component and with the Combined Component. Responding in both components was very high, with hens regularly exceeding 500, and in some cases 1000 responses per session. Unlike previous experiments, there was no consistent pattern of higher responding in one particular component, with most hens responding similarly on the red key across both components throughout the disruptor test.

Figure 8.8 shows the number of red key responses for Group 2 hens during the disruptor test, when both the Concurrent and Combined Components were presented. Responding on the red key for this group of hens was much lower than for Group 1, with most hens responding consistently just over 100 times a session. Hen 8.4’s responses on the red key started off lower than 100. Once again, unlike previous experiments there was no consistent pattern of greater responding on the red key in either component, with the exception of Hen 8.6 who responded more on the red key when it was presented in between the left green and right blue keys of the Combined Component.

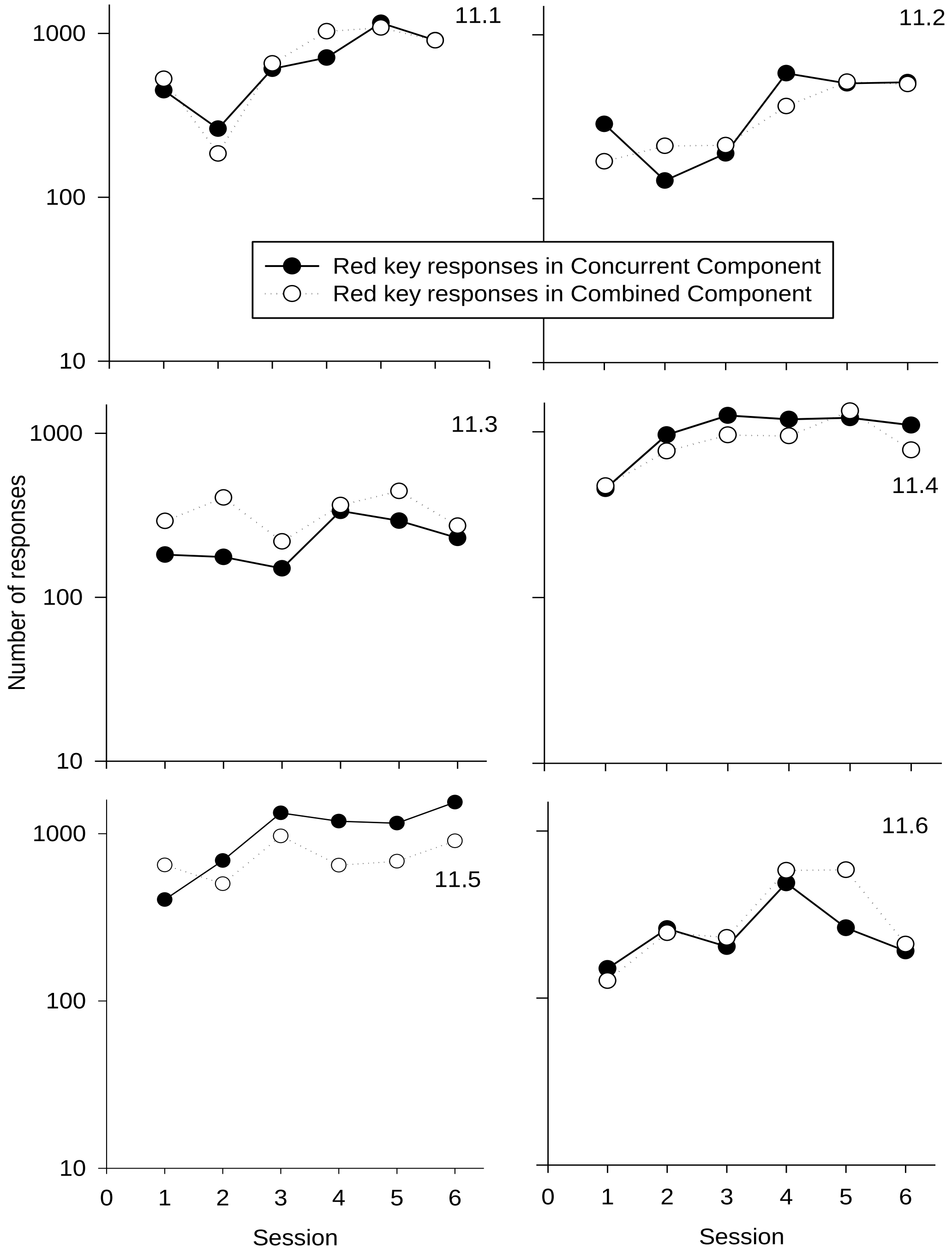


Figure 8.7. Number of responses on the centre red key for all Group 1 hens during the disruptor test. The y-axis is on a log scale and filled circles represent red key responses between the two yellow keys (Concurrent Component), while open circles represent red key responding between the left green and right blue keys (Combined Component).

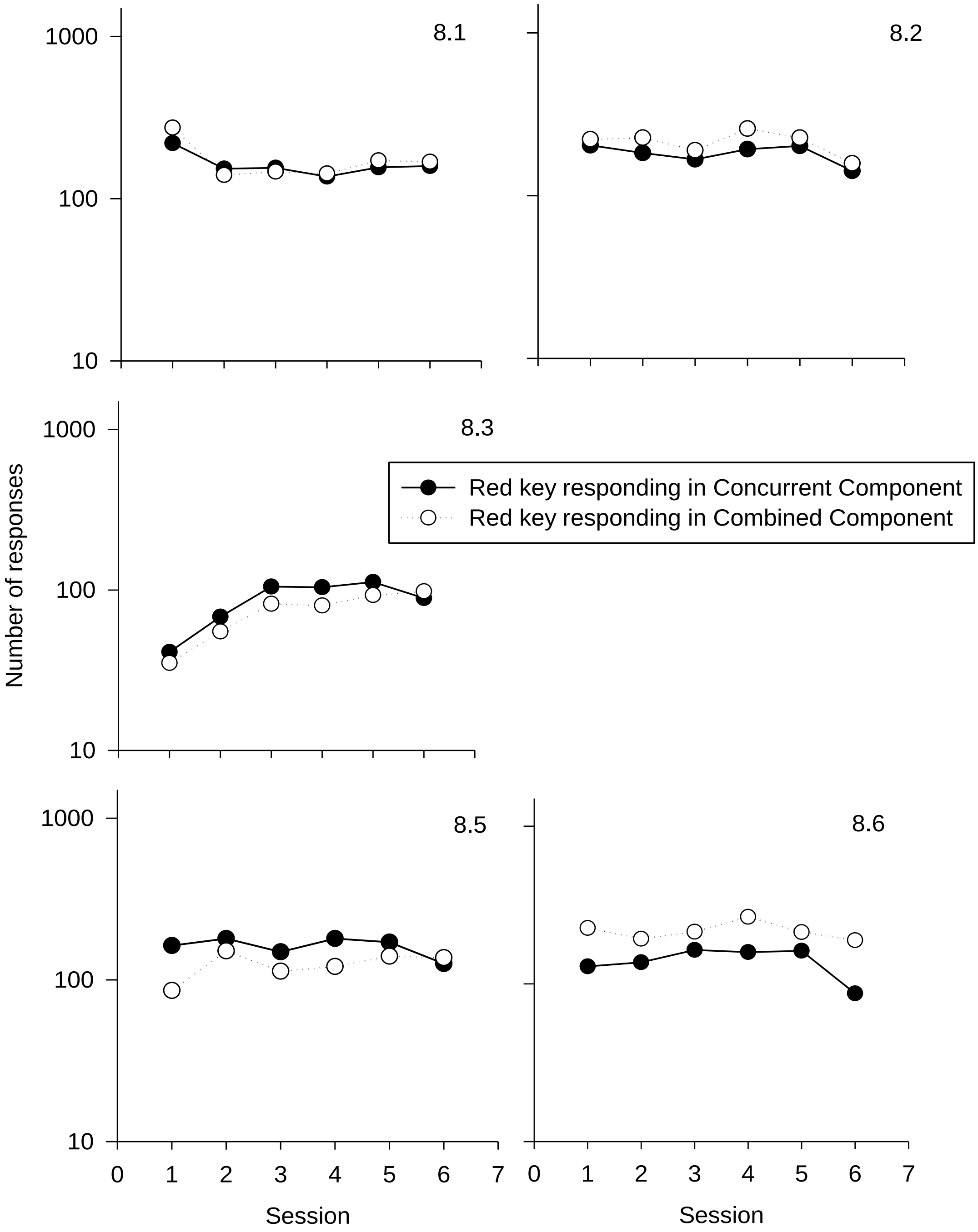


Figure 8.8. Number of responses on the centre red key for all Group 2 hens during the disruptor test. The y-axis is on a log scale and filled circles represent red key responses between the two yellow keys (Concurrent Component), while open circles represent red key responding between the left green and right blue keys (Combined Component).

Discussion

Aims and Overall Findings

The experiment investigated the effects on target response persistence of a combination of two proposed solutions to the persistence-strengthening effects of DRA procedures, thinning schedules and training the alternative and target behaviours in separate contexts before combining them. In particular, the reinforcement schedules associated with the alternative behaviour (left yellow and left green keys) were thinned to the same reinforcement rate as the target behaviour (right yellow and right blue keys), in two different ways with two groups of hens.

There were two key findings to examine: firstly the persistence of responding to the right blue (Combined Target) key compared to the right yellow (DRA Target) key, and secondly persistence of responding on all keys during the disruptor test compared to baseline levels of responding. Responding was less persistent to the right blue key (Combined Target) for Group 2 hens, who were exposed to schedule thinning on the alternative key before this alternative behaviour was combined with the target behaviour during disruption. In many cases for Group 1 hens, however, persistence of responding on the right blue (Combined Target) key was actually greater than persistence of responding on the right yellow (DRA Target) key. Both of the above findings were supported statistically, with no significant difference between the two right key response options for Group 1 hens, but a significant difference between the two right key response options for Group 2 hens. The implications of these findings suggest that combining the schedules prior to the thinning procedure beginning actually increased persistence of target (right blue) key responding, rather than decrease it as intended. A decrease in the persistence of target (right blue) key was, however, found for Group 2 hens who were exposed to the thinning procedure during baseline, where the left green key and right blue key remained in two separate components.

When comparing the persistence of responding overall during the disruptor test (so average responding on each of the individual keys compared to baseline), there was a greater reduction in persistence of responding on all keys for nearly all Group 1 hens. This was compared to Group 2 hens who showed some increases, some decreases and few general patterns of responding during the disruptor test. The implications of these findings suggest that thinning the schedules whilst the left green and right blue keys were presented in one component reduced the persistence of responding overall compared to thinning the schedules while the keys were in separate components. The disruption of responding was greater by the red key when it was presented within the Concurrent and Combined Components that had been occurring together for the thinning part of the experiment, as well as just the disruptor test.

To summarise the above two findings, a greater reduction in the persistence of responding overall between the baseline and disruptor test parts of the experiment occurred when the schedules were thinned during the presentation of the Combined Component (Group 1 Hens). This method did not create a reduction in the persistence of right blue key responding compared to right yellow key responding during the disruptor test. However, the opposite of this finding was true when the schedules were thinned during the original baseline procedure (Group 2 Hens); there was little change in the persistence of responding overall between baseline and the disruptor test, but a clear reduction in the persistence of right blue key responding compared to right yellow key responding.

Comparison Between Groups

The proportion of baseline data (see Figures 8.5 and 8.6) differed between the two groups of hens. A reduction in this measure for the left yellow and left green keys that was seen for Group 1 hens (Figure 8.5) might be expected given that the reinforcement associated with those keys was reduced. The higher levels of responding proportionate to baseline seen on the right yellow and right blue keys for Group 1 hens was less expected; throughout previous experiments both right yellow and right blue keys were typically associated with leaner schedules of reinforcement than the left yellow and left green keys.

It is not the first time that persistence has been greater for responses associated with leaner schedules of reinforcement, for example, throughout the previous experiments reported here, responding on the right yellow key was frequently more persistent, even though, considered alone, the right yellow key was associated with a leaner schedule of reinforcement. Higher persistence of responding associated with leaner schedules of reinforcement has also been observed in applied investigations of persistence (Romani et al., 2016) and throughout basic research (see Craig et al. (2014) and Chapter 7 of Nevin (2015) on challenges to behavioural momentum theory).

However, responding overall (on both yellow, and the green and blue keys) did reduce more comparative to baseline levels for Group 1 hens, than for Group 2 hens. The greater reduction in persistence of responding on all keys for Group 1 hens could be explained in part by responding on the red key during the disruptor tests. Responses on the red key itself were high, and this could be because this group of hens had not been exposed to the red key as a disruptor before, whereas Group 2 hens had experienced the red key disruptor in previous experiments. The first time Group 2 hens were exposed to the red key (see Experiment 2), responding overall dropped in its presence compared to baseline levels, so this decrease in responding from Group 1 hens in the presence of the red key here are in line with those seen previously. The main difference, however, was that during Experiment 2, although responding on all other keys dropped in the presence of the red key, the number of responses on the red key itself did not increase, as they did here. It is unclear why red key responses increased during this experiment and not during Experiment 2, but does continue to show support for the use of the centre red key as an effective disruptor.

Aside from the slight increase in responding on right yellow and right blue keys, particularly for Group 1 hens, during the thinning schedules part of the experiment, there was no other major changes to responding while the schedules were thinned. Multiple schedule studies with pigeons suggest that behaviour under these schedules is generally insensitive to reinforcement rate changes in the environment (Shull, 2005), when reinforcement rates remain above a certain rate, and when compared to other species. Although, hens' behaviour was not included in the analysis of reinforcement rate sensitivity (Shull, 2005), it is possible it has similar sensitivities to reinforcement rate changes as does pigeons' behaviour, and this might explain the insensitivity to the thinning schedules shown in the present study.

Whilst there was no change directly to the reinforcement schedule that either of the right yellow or right blue keys were associated with directly, it is possible that behavioural contrast could explain this increase in responding. Behavioural contrast refers to a situation where responding changes on an unaltered component of a multiple schedule, due to changes in the schedule associated with another component in the multiple schedule (Cooper et al., 2007). Typically, the direction in which responding changes in the unaltered schedule, will be in the opposite direction to the changes caused in the adjusted schedule (Reynolds, 1961). For example, if responding reduces due to a reduction of reinforcement on one schedule, responding will increase on the other, unaffected schedule, hence the contrast.

When the reinforcement schedule on the left yellow key in the present experiment was thinned, it was no longer richer than the schedule associated with the right yellow key, thereby possibly increasing responding to the right yellow key in the same component. The phenomenon of behavioural or concurrent contrast has been shown with both concurrent schedules (MacDonall, 2017), and with non-concurrent components of multiple schedules (Cooper et al., 2007; Reynolds, 1961). Although the left green key and right blue key were available in the same component during the thinning process for the hens that showed this increase in right blue key responding, there was a strong history of the keys being presented in two separate components, as in a multiple schedule. Therefore, it may not be possible to conclude that the changes on the right blue key were caused by schedule adjustments to the left green key in the short time they were presented together, or due to changes happening on the left yellow key in the separate component. It is likely these changes in responding on the right blue key were however due to behavioural contrast of the schedules thinning on one of the left keys. This issue is relevant to the question of whether two clear contexts were actually defined by the use of the two separate key colours presented in different components (Nevin, 2015).

Applied Implications and Combining Methodologies

Thinning the reinforcement schedule associated with the alternative behaviour could also mean this procedure in general is feasible in an applied setting. Many interventions face the challenge of reducing the rate of reinforcement associated with training a new pro-social behaviour in place of a problem behaviour. Thinning the schedules to lower and more maintainable levels of reinforcement seem to be effective at reducing the persistence of target responding, and in a natural setting may be a useful addition tool when transitioning between the initiation and maintenance phases of an intervention for problem behaviour. For example, an alternative behaviour may be trained separately at a higher rate of reinforcement in a separate classroom, before being thinned to a more maintainable, but lower rate of reinforcement. Then, the alternative behaviour associated with this lower reinforcement could be introduced into the same context as the target behaviour for the intervention.

Winterbauer and Bouton (2012) also investigated the effects of thinning the reinforcement schedule associated with an alternative response in a resurgence procedure with rats. Across three differing experiments, results were consistent with the idea that thinning the alternative schedule of reinforcement before it was put into extinction conditions reduced resurgence to the target behaviour initially trained. Regardless of the potential reasons for this reduced resurgence of target behaviour (see Winterbauer and Bouton (2012) for a discussion), their results, along with the present study, suggest that thinning the reinforcement schedule associated with the alternative response could be a viable means to reduce the persistence of, or entirely eliminate, the target behaviour.

Introducing an alternative behaviour at a lower rate of reinforcement is very similar to the low-rate DRA procedure explored by Pritchard, Hoerger, Mace, et al. (2014), who found less treatment relapse to the therapist paired with the low-rate DRA than the high-rate DRA. In their procedure however, the low-rate DRA treatment was introduced straight away without the alternative behaviour being trained in a separate context, or associated with a higher rate of reinforcement initially. This is the typical procedure for examining a low-rate DRA in the basic literature (for example, the low-rate DRA comparison group used by Sweeney and Shahan (2013)). The present methodology, however, essentially implemented a low-rate DRA after a thinning procedure had taken place. Perhaps then, a combination of the three potential solutions to the persistence-strengthening effects of DRA would be a worthwhile exploration. It seems that thinning reinforcement schedules alone is not sufficient to decrease the persistence of target responding (Sweeney & Shahan, 2013), however, using this method to achieve a lower rate of reinforcement associated with the alternative behaviour, in conjunction with training that behaviour elsewhere, before combining it with the target behaviour could further reduce the persistence-strengthening effects of DRA.

Due to the potential applied significance, investigating both Combined Contexts and Thinning Schedules procedures together should be explored further. Pushenko (2017) investigated the persistence of target responding during extinction in both a DRA and a Combined Context procedure, following thinning of the reinforcement schedules paired with the alternative stimuli in both components. The schedules were thinned while component presentation was identical to that of the baseline procedure used in the present experiments (so the same thinning procedure that Group 2 hens experienced).

According to a visual analysis, responding to the Combined Target key was less persistent than responding to the DRA Target key; however, these results were not statistically significant. Furthermore, prior to thinning the reinforcement schedules associated with the alternative stimuli, the reinforcement schedules associated with the target stimuli had been increased to equal those associated with the alternative stimuli. Although there was a return to the same baseline procedure as used in the present experiment in between the increase in target reinforcement rate and the decrease in the alternative reinforcement rate, it is noteworthy that the Combined Target responses were still less persistent, despite the previous, but short term, association with a richer reinforcement schedule (Pushenko, 2017). This finding strengthens the idea that combining an alternative and target stimuli that have been trained separately, in addition to thinning the schedule of reinforcement associated with the alternative response would make an effective applied intervention.

Limitations

An increase in persistence of responding to the right blue key for Group 1 hens might have been expected given the exposure to the Combined Component prior to disruption. This finding suggests that the effects of the previous experience of training the behaviours in two separate contexts had been lost. Unpublished data, discussed in Podlesnik and DeLeon (2015), suggest that longer term exposure to the two separately trained stimuli together in one component, eventually cause the Combined Target response to become no less persistent than the DRA/Concurrent

Target response (see Experiment 4 Discussion for a detailed explanation). This is the case despite the two separate key colours being associated with two separate contexts in the Combined Component (Podlesnik & DeLeon, 2015).

These concerns regarding long-term exposure to this procedure could be problematic for the transference of training two stimuli in separate contexts to an applied setting. In the unpublished study referred to above, pigeons were only exposed to the Combined Component with reinforcement maintained for 21 days (Podlesnik & DeLeon, 2015). In the current experiment, hens were exposed to the Combined Component with reinforcement for 30 days, although both the pigeons and the hens had experienced the same procedure prior to these experiments taking place. Still, an average of 25 days is not very long in terms of an intervention, where one might expect the alternative and the target behaviour to co-occur in the same environment (after training separately) for some time.

Allowing responding to stabilise after the schedules were thinned was also as limiting as it was necessary. Whilst it is common procedure in behaviour analysis to allow a baseline to stabilise, especially if a measure such as proportion of baseline is required, it meant that both groups of hens were exposed to quite a long period of the stimuli and associated conditions of reinforcement. This was problematic both due to the concerns discussed above with long term exposure to the Combined Component for Group 1 hens, and because of the amount of exposure to the learner reinforcement rates now associated with all available keys for both groups of hens.

The proportion of baseline, or persistence measure, was taken between 20 and 30 sessions after the schedules thinned, after the hens had been exposed to the equal VI schedules for all those sessions. This means that any findings could be attributed to either the effects of thinning the schedules or to the effects of having all reinforcement schedules the same throughout those baseline sessions. Future investigators might consider limiting the number of sessions subjects are exposed to after the schedules have been thinned, or accounting for any instability across those sessions to be sure that the proportion of baseline measure is not impacted. In order for this procedure to be utilised, more extensive research on longer-term exposure to the Combined Component, and its effects, would be essential.

Finally, all hens in both groups of this experiment had previous history in very similar procedures. The prior long-term exposure to the richer schedules on the left keys may attribute to some of the persistence seen to those keys during the disruptor test. Using naïve hens or hens with less experimental history prior to thinning the schedules may have resulted in different conclusions.

Conclusions

Overall, data from this experiment continue to show support for training the stimuli in separate environments initially; but also for thinning the schedule associated with the alternative behaviour and then combining it with the target stimuli. This is in contrast to combining the stimuli and then thinning the reinforcement schedules. This was shown by the reduced persistence of responding to the right blue (Combined Target) key for Group 2 hens. Responding reduced overall during the disruptor tests compared to baseline, for nearly all Group 1 hens, but the persistence of responding to the right blue key was often greater than that of the right yellow key for this group of hens. The present findings suggest that with further investigation, thinning the reinforcement schedule for the separately trained alternative behaviour first, before combining it with the target behaviour, may be more effective at reducing the persistence of the target behaviour than thinning the reinforcement schedule after combination.

Experiment 9: Target Key Exposure

Throughout all previous experiments exploring the method of combining the alternative and target behaviours following training in separate contexts, (e.g., Experiments 1-7, Mace et al. (2010); Podlesnik et al. (2012); Podlesnik and Bai (2015); Podlesnik et al. (2016)) there are possible confounds to the procedure impacting the persistence-reducing effects on the Combined Target (right blue) key. One of these possible confounds is that the DRA Target stimulus, or the right yellow key, is always concurrently presented with the left yellow key. In contrast, the initial exposure that the hens have had to the right blue key during baseline is always as a single stimulus, and findings from previous experiments in this thesis show that there are generally more responses, during baseline, on the right blue key than there are on the right yellow key. One would expect a greater number of responses to a key presented alone, than to a key presented alongside another key associated with a richer reinforcement schedule, and results consistent with this have been found throughout baselines of the previous experiments.

There is no argument that the Combined Target, or right blue key, needs to be alone initially to investigate the procedure of combining the target stimuli with an alternative stimulus after separate training. However, the differences in the initial presentation of the right yellow and right blue keys during baseline could be leading to different outcomes in the testing phases, particularly the ability to compare the two types of target or right key responding equally. This is because the comparison is being made between a stimuli always presented alone (i.e., Combined Target - right blue key) and a stimulus always presented alongside a richer alternative (i.e., DRA Target - right yellow key). It is possible that when the right blue key is presented in combination with the left green key, responding on the right blue key may reduce simply because it is now in competition with the left green key.

It is also possible that there are additional processes relevant to the conditions in which these responses were trained that are influencing the reduction of the right blue key responding. Behavioural Momentum Theory maintains that persistence is influenced by the Pavlovian stimulus-reinforcer relationships established during training (or baseline) (Bai et al., 2016; Nevin & Grace, 2000), and, in the previous experiments described here, the yellow keys, or combined stimulus context, are always associated with a combined richer rate of reinforcement than the blue key trained alone. This means that in the disruptor tests described here, disruptors are being applied to two components, but ones that have not started off equally.

Furthermore, when plotted as proportion of baseline, proportionally greater responses on the right blue key when it is alone during baseline could create the effect of reduced persistence. This is because a smaller number of right blue key responses during the disruptor tests have to be divided by a larger number of baseline responses often seen on that same key, resulting in a smaller proportion. On the other hand, a smaller number of responses on the right yellow key during baseline, and numbers of responses on the right yellow key during the disruptor tests which are often similar to baseline levels of responding on the right yellow key, result in a larger proportion of responding. Together, this potentially confounds the comparison between the right blue and right yellow keys through proportion of baseline measures alone.

Designing an alternative experimental procedure that maps more closely onto the DRA procedure used in applied settings would allow for direct comparison between the two types of DRA interventions examined through these experiments, the traditional DRA method and the Combined Contexts DRA. The baseline procedure used in the previous methodology described here, and that of Mace et al. (2010), Podlesnik et al. (2012) and Podlesnik and Bai (2015), is more in line with the intervention phase of a DRA procedure, than the baseline phase. This is because the alternative behaviour has already been introduced into the same context as the target behaviour in the Concurrent/DRA Component, and whilst both alternative and target behaviours of the Combined Component are presented individually during baseline, they still start in the same session. If this procedure were to be carried out at a clinical trial, it is more likely the introduction of this alternative behaviour would happen during an intervention phase. This intervention phase was also treated as the baseline phase in Podlesnik, Miranda-Dukoski, et al. (2017). In an applied setting, a problem, or target behaviour is likely to be occurring for some time prior to someone starting an intervention, and baseline data would be gathered on the occurrence of this target behaviour prior to the intervention starting.

Therefore, revisiting how a traditional DRA implementation occurs in applied settings may be one way to mitigate this confound. Instead, both of the target behaviours could be trained separately, before adding any alternative sources of reinforcement to either the same or another context. This generates a situation similar to that of an applied setting, in which the problem or target behaviour is already occurring before any additional reinforcement is added as an intervention.

In Experiment 9, the two types of target responding (right yellow and right blue keys) were trained separately with no additional alternative responding available, in a phase hereafter referred to as the Baseline phase. Following this period of training, the left yellow key was presented alongside the right yellow key, into the Concurrent/DRA Component. This is analogous to a traditional DRA beginning in an applied setting. The left green key was also introduced, but still in a separate component, analogous to a Combined Contexts DRA procedure. The introduction of the alternative behaviours occurred in the phase hereafter referred to as the Intervention phase. During the disruptor tests, the right blue and left green key were combined once again to compare to responding to the two yellow keys. By doing this, it created the ability to draw comparisons to the initial right key (target) responses, as if they were from a true baseline, rather than an intervention phase. The disruptor used was the red centre key, which provided an additional source of reinforcement, and allowed reinforcement on all other active keys to remain in effect.

The aims of this experiment were three-fold. Firstly, this experiment aimed to continue examining the effects of two different types of DRA interventions (traditional DRA and Combined Contexts DRA) on the persistence of target responding. Secondly, the persistence of responding in the presence of the disruptor was also of interest. Finally, the impact of training both target, or right key responses, during an initial Baseline phase before the intervention began was investigated in relation to the persistence of that target responding.

Method

Subjects

The subjects were six domestic Brown Shaver hens numbered 2.1 to 2.6 all under one year old at the start of the study. Key pecking had previously been shaped, but the hens were experimentally naïve. The hens were housed in individual cages in the same room with a 12-hour light and dark cycle. The hens had free access to water at all times, were weighed daily and kept at a body weight of 85% (+/- 5%) of their free-feeding body weight by supplemented feeding after each experimental session. In the home cage, the hens were fed using a commercial laying pellet. During the experiments, wheat was used as a reinforcer. In addition, the hens received grit and vitamins as necessary as part of their usual feeding routine.

Apparatus

Two experimental chambers were used for this experiment. In the first, three keys were situated at one end of the chamber, approximately 350mm off the floor of the chamber. Multi-colour LED light panels allowed a number of different key colours to light each key. The chamber was 650mm long by 490mm wide and made of particle board. A 90mm wide rectangular hole below the keys allowed the hens' access to wheat in the magazine when the hopper was raised and lit. The magazine was operated automatically and situated outside of the chamber. The walls inside the chamber were painted white and a black rubber mat was situated on the floor of the chamber to enable easy removal for cleaning. A nearby computer running MED-PC programmed and recorded all experimental conditions and data.

For any exposure to the red key alone (see Part 1), a second experimental chamber identical to the one previously described, but with a single red key in the centre of the panel, was used. The chamber size and layout were as described, including the magazine that gave access to wheat as a reinforcer. The same computer operating MED-PC also controlled all conditions and data collection for this chamber.

Procedure

Part 1. Disruptor Training

The hens were presented with a single lit key that alternated randomly between yellow and blue, under a VI 150-s schedule to assess whether any more shaping would be required to further train a key peck response. As all hens responded consistently and were eating from the magazine when it was raised for reinforcement, this process was discontinued after four sessions.

Hens were then moved to the second chamber and presented with a single red key under a VI 150-s schedule, to give them exposure to what would be the disruptor during the experiment. Sessions ran for 12 minutes, during which time a maximum of six reinforcers were available, and there were six sessions in total. After each disruptor test, hens were returned to this part of the procedure for a further six days each time.

Part 2. Baseline Phase

Hens were then returned to the first experimental chamber and presented with a yellow key on the right side in one component, and a blue key on the right side in another component, as shown in Figure 9.1. Both keys operated under a VI 150-s schedule of reinforcement. For the duration of this part of the procedure, all other keys remained unlit.

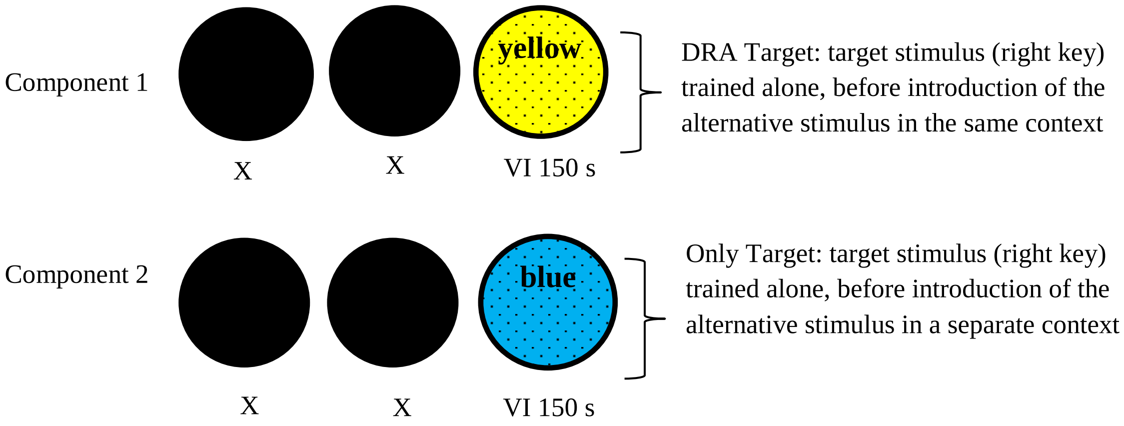


Figure 9.1. Key colours and schedules as presented during the Baseline part of the experiment.

The two components were presented in random order for a duration of 1-min each, separated by a 20 s inter-component-interval (ICI). If a reinforcer was earned, 3 s access to wheat was provided. There were 6 sessions for each hen in total, each lasting 32.5 minutes in duration.

Part 3. Intervention Phase

The Intervention procedure involved the presentation of the three components used in the baseline phases of previous experiments, each 1-min in length. In Component 1, there were two concurrently available yellow keys, on the left a VI 37.5 s schedule and on the right a VI 150 s schedule.

In Component 2, the left key was lit green, with a VI 37.5 s schedule associated with it. When this component was active, the right key remained dark and inoperative.

In Component 3, the right key was lit blue and associated with a VI 150 s schedule, and the left key remained dark and inoperative. The key colours and schedules arranged are shown in Figure 5.2 in the Method of Experiment 5.

The three different components were each presented 12 times, totalling 36 total component presentations per session. Components were presented in random order and were separated by a 20 s ICI. The sessions started and ended with an ICI, and 3 s access to wheat was provided for reinforcement. Sessions ran for a total of 48 minutes each. There were 6 sessions of this phase for each hen initially, followed by 6 sessions of this phase before each of the disruptor tests throughout the experiment.

Part 4. Disruptor Tests

Disruptor tests were similar to previous experiments in that the disruptor used was the red key (see Experiment 2 and 8) and there were three disruptor tests. The component combinations, key colours and schedules are outlined in Table 9.1. Component length, reinforcement access and ICI were the same as for the Intervention phase, except that the total session length of Disruptor Tests 1 and 3 were shorter, at 32.5 minutes, due to only having two components. There were six sessions of each disruptor test for each hen.

Table 9.1. The component combinations, key colours and schedules as presented during the disruptor tests. The numbers indicate the schedules active on each of the keys.

Disruptor Test	Components	Key Colours and Schedules		
1	comp. 1	🟨 37.5	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	🟦 150
2	comp. 1	▨	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	▨
	comp. 3	▨	🟥 150	🟦 150
3	comp. 1	🟨 37.5	🟥 150	🟨 150
	comp. 2	🟩 37.5	🟥 150	🟦 150

Results

Baseline and Intervention

Figure 9.2 shows the average number of responses on each key for each hen during the Baseline sessions and the Intervention phase that followed. During the Baseline phase, although some hens responded more overall than others, each of their average number of responses on the right yellow and right blue keys was very close to each other with a mean difference of only 22 responses between right yellow and right blue keys (*M* = 22.3405, *SD* = 40.1353*).* For four of the hens, responding was greater on the right yellow key than the right blue key, even if it was only by a small number of responses. Hens 2.4 and 2.6 responded more on the right blue key than the right blue key. A paired-samples t-test revealed no statistically significant difference between the number of responses on the right yellow key and the number of responses on the right blue key, *t*(5) = 1.350, *p* = .235.

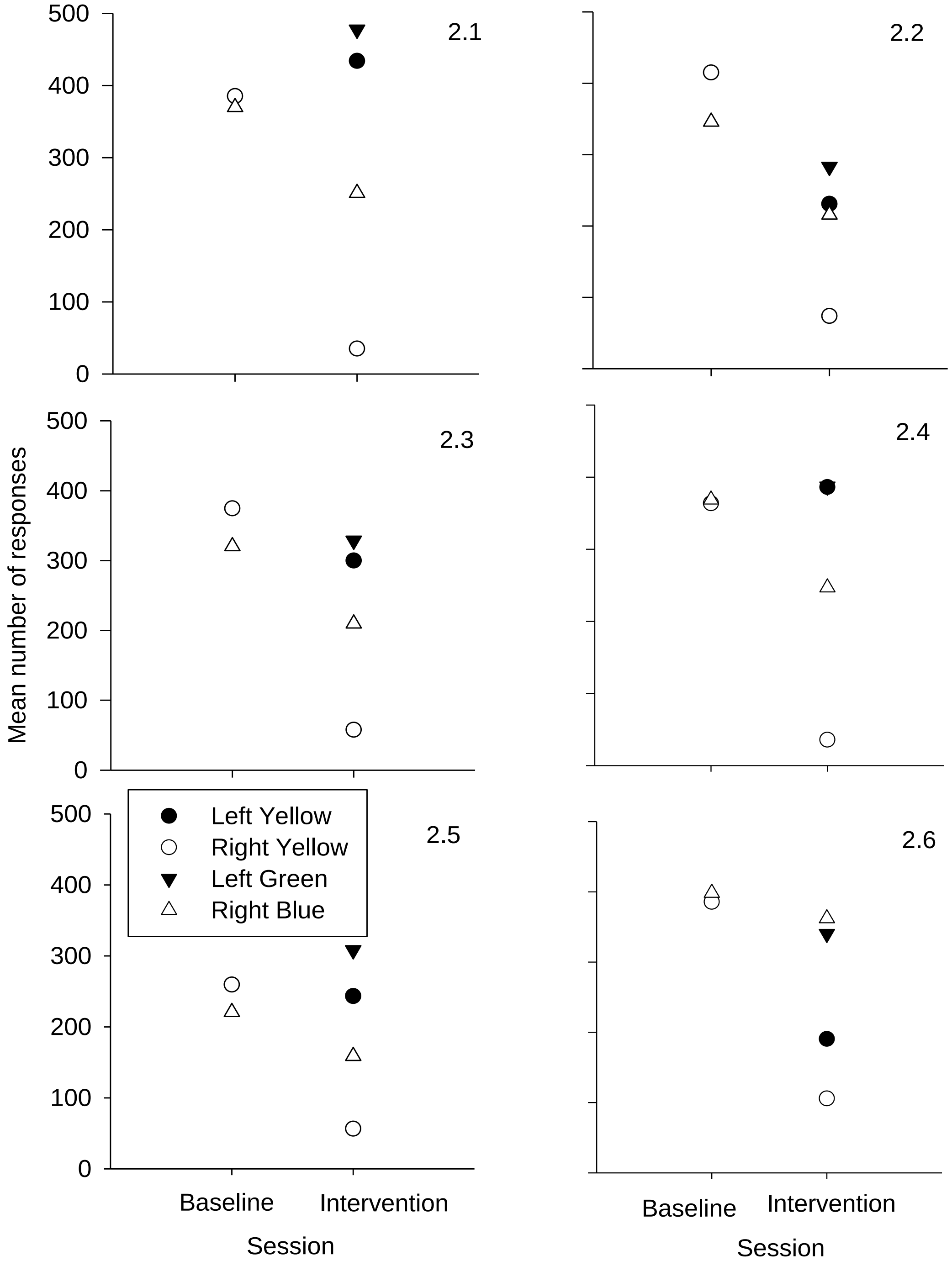


Figure 9.2. Mean number of responses on the target keys during the Baseline phase, and on all keys during the Intervention phase. Target responses are shown by open data points (right yellow = open circle, right blue = open triangle) and Alternative responses are shown by filled data points (left yellow = filled circles, left green = filled triangle).

Despite most of the hens showing greater responding to the right yellow key during the Baseline phase, this quickly reverted during Intervention sessions when the right yellow key was paired with the left yellow key. In all cases, average left yellow key responding was greater than average right yellow key responding. However, the average number of left green key responses was highest throughout the Intervention phase, for all hens other than Hen 2.6. Average responding on the right blue key was highest during this phase for Hen 2.6, but for all other hens, average right blue key responding was lower than average responding on either of the left keys, but higher than average right yellow key responding. Interestingly, the average number of responses on the right blue key reduced between the Baseline phase and the Intervention phase, even though the right blue key was not paired with an alternative response option during the Intervention phase.

Disruptor Test 1

Figure 9.3 shows responding during the first disruptor test plotted as a proportion of Intervention responding. This was calculated as proportion of baseline had been in previous experiments, but using the average number of responses during the Intervention phase instead. For all hens, responding was lower, relative to responding during the intervention phase, on the right blue key than it was for any other key, including the right yellow key. Responding on this right yellow key, proportionate to Intervention responding, was considerably higher than responding on any other key for three out of the six hens. Left (yellow and green) key responding proportionate to Intervention, remained very similar to each other for all of the hens throughout the duration of the disruptor test, rising initially above Intervention levels but reducing again for most hens as sessions progressed.

Overall, responding was lower proportionate to Intervention on the right blue key than the right yellow key overall during the disruptor test. A paired-samples t-test comparing the mean proportion of Intervention responding on the right yellow key with the mean proportion of baseline responding on the right blue key was significant, *t*(5) = 5.122, *p* = .004, *d* = 1.977.

Figure 9.4 displays responding during the same disruptor test, but plotted as a proportion of responding during the Baseline phase. This was calculated in the same way as previous proportion of baseline measures, but using the new baseline of just the two target keys. Proportionate to Baseline, responding was lower for all hens on the right blue key, compared to the right yellow key. A paired-samples t-test comparing the mean proportion of Baseline responding on the right yellow key with the mean proportion of Baseline responding on the right blue key was significant, *t*(5) = 4.260, *p* = .008, *d* = 1.935. Responding was lower during the disruptor test on both of the right keys than when they were presented in the Baseline phase, but this was to be expected as the right keys were presented alongside the left keys during the disruptor test, and presented alone during the Baseline phase.

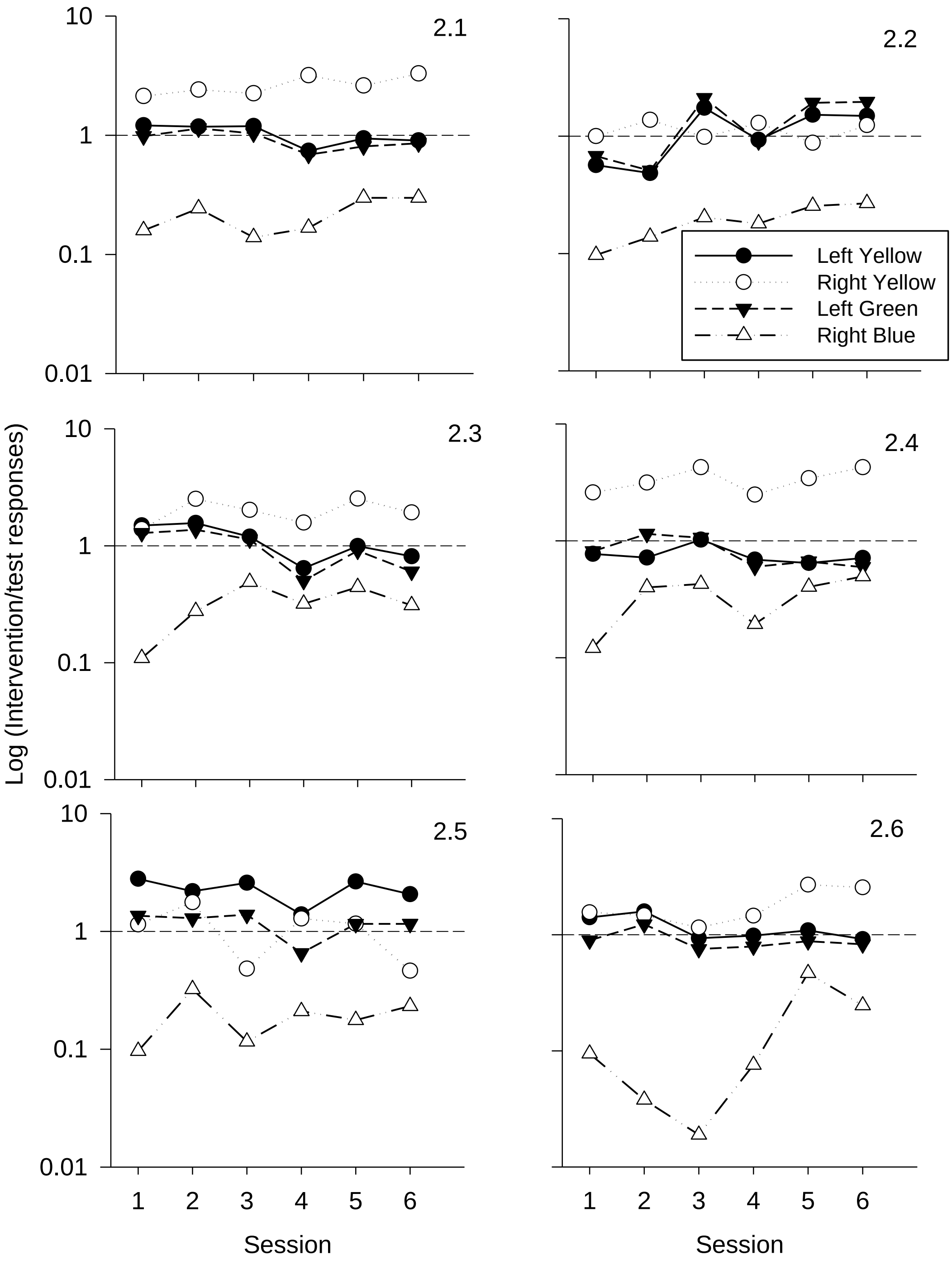


Figure 9.3. Responding on all keys during the first disruptor test plotted as a proportion of Intervention responding. The y-axis is presented on a log scale and the dashed line represents Intervention levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) and triangles represent the Combined Component (filled = left green key, open = right blue key). Red key responding is not shown on the graph.

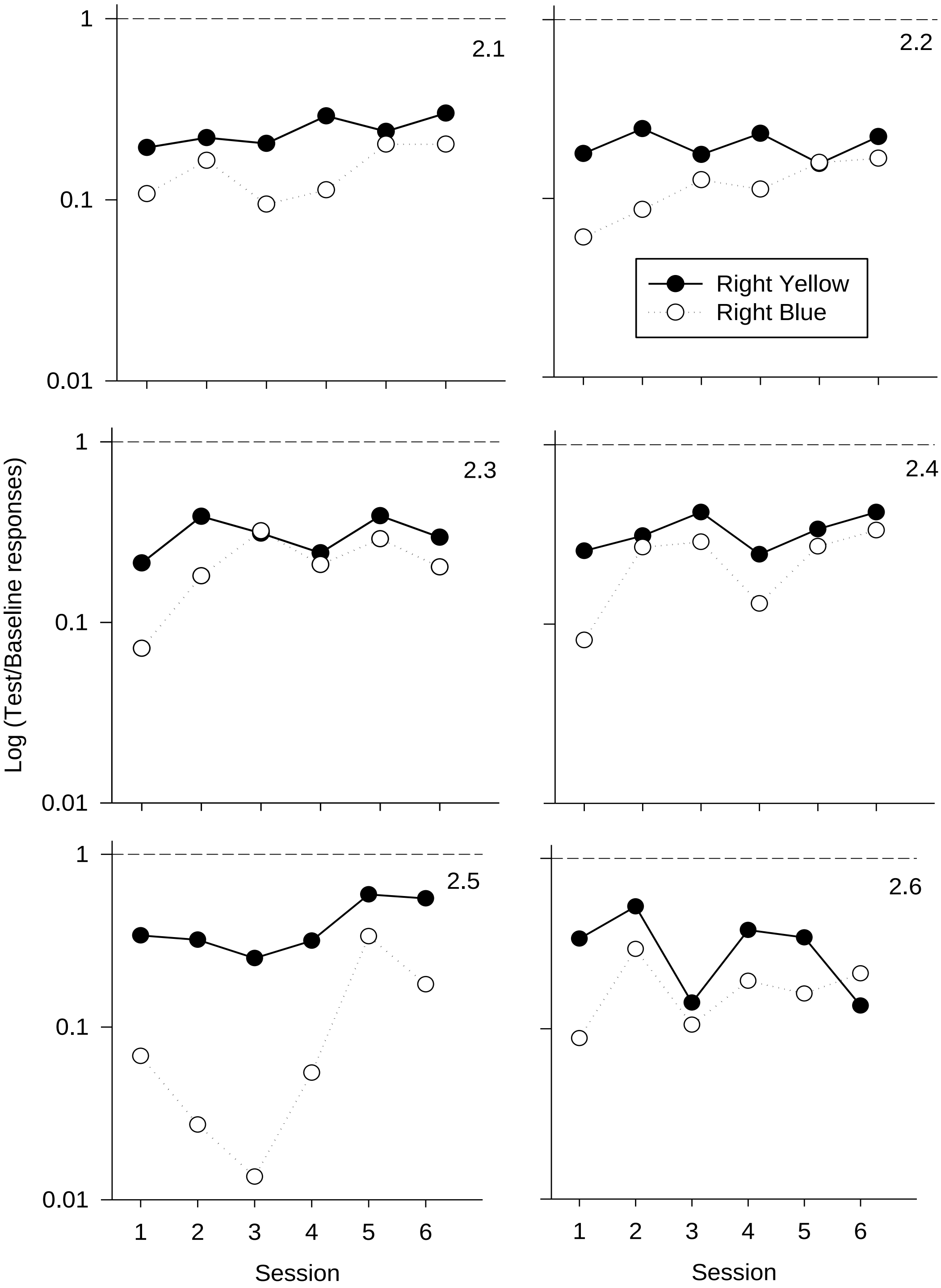


Figure 9.4. Responding plotted as a proportion of Baseline during the first disruptor test. Filled circles represent responding on the right yellow key and triangles represent responding on the right blue key. The dashed line represents Baseline levels of responding.

Figure 9.5 (column 1) shows the average number of responses during the first disruptor test and the average number of responses across the Intervention sessions that preceded the first disruptor test. For all of the hens left key responding remained very similar between the Intervention and disruptor tests. A paired-samples t-test comparing the mean number of responses on each of the keys during the Intervention phase, with the mean number of responses during the disruptor test, found no statistical difference between the number of responses emitted in the presence and the absence of the red key disruptor, $t(5) = 2.529$, $p = .053$.

In two cases (Hens 2.2 and 2.6), left key responding actually rose in the presence of the red key disruptor, and in no cases did left key responding decrease. Right key responding, however, did change in the presence of the disruptor, with right yellow key responding increasing in the presence of the red key for all hens, and right blue key responding decreasing in the presence of the red key. For all hens, right blue key responding was lower than right yellow key responding during the disruptor test, however, this was not supported statistically. A two-way repeated measures ANOVA comparing the number of responses on the right blue key with responses on the right yellow key during the first disruptor test showed no significant difference between the two types of right key responding; $F(1,5) = 55.127$, $p < .05$, = .917, but significant effect across sessions, $F(5,25) = 2.557$, $p > .05$, = .338 and no significant interaction between sessions and right key responding $F(5,20) = 1.138$, $p > .05$, = .185.

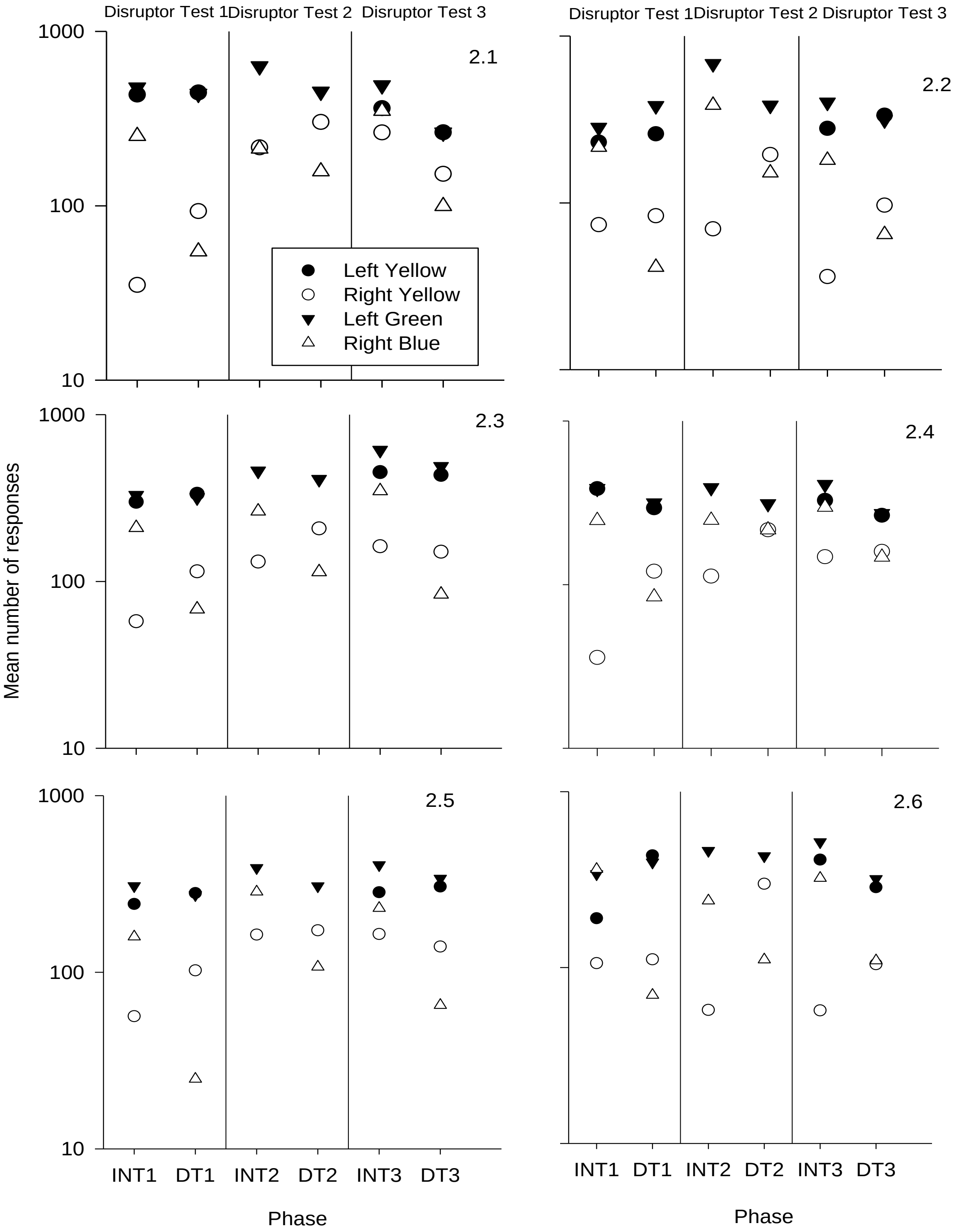


Figure 9.5. Mean number of responses across each of the Intervention conditions and across each of the disruptor tests. The y-axis is on a log scale. Filled circles represent responding on the left yellow key and open circles show responding on the right yellow key. Filled triangles show responding on the left green key and open triangles show responding on the right blue key.

Disruptor Test 2

During the second disruptor test, responding on the right blue key continued to be lower, relative to Intervention responses, than responding on the right yellow key. Figure 9.6 shows responding during the second disruptor test plotted as a proportion of Intervention responding. In all cases, right yellow key responding remained higher proportionate to Intervention than responding on either of the other keys, and for Hens 2.2 and 2.6 especially, right yellow key responding was considerably higher during this disruptor test than it was during the Intervention phase. Generally, responding on the left green key, proportionate to Intervention, fell in between the higher levels of responding seen to the right yellow key and the lower levels of responding seen to the right blue key, but on occasion, right blue key responding and left green key responding were proportionately very similar (see Hens 2.1 and 2.4 for example). A paired-samples t-test comparing the mean proportion of Intervention responses on the right yellow key during the second disruptor test with the mean proportion of Intervention responses on the right blue key was significant, $t(5) = 2.745$, $p = .041$, $d = 1.161$.

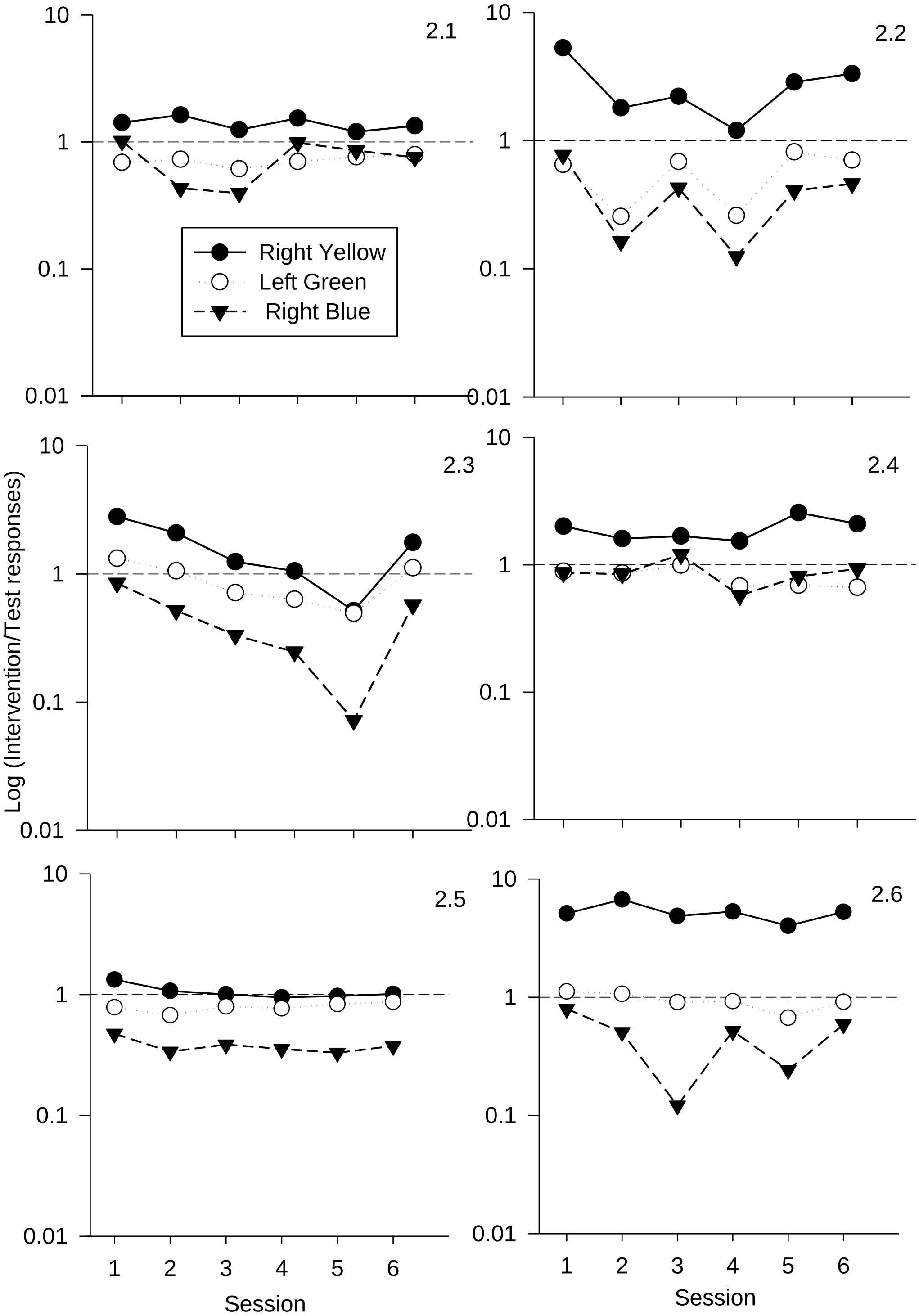


Figure 9.6. Responding during the second disruptor test plotted as a proportion of Intervention responding. The y-axis is presented on a log scale and the dashed line represents Intervention levels of responding. Filled circles represent responding on the right yellow key, open circles represent responding on the left green key and triangles represent responding on the right blue key.

Figure 9.7 shows responding during the disruptor test plotted as a proportion of the initial Baseline responding. Responding during the disruptor test was lower than Baseline levels of responding on the right yellow and right blue keys, but not as low as the first disruptor test when compared using this measure. For all hens, proportion of Baseline responding was lower on the right blue key than on the right yellow key, though for Hens 2.2 and 2.4 there were a few sessions where this was not the case. A paired-samples t-test comparing the mean proportion of Baseline responses on the right yellow key during the second disruptor test with the mean proportion of Baseline responses on the right blue key was significant, $t(5) = 2.631$, $p = .047$, $d = 1.597$.

The average number of left green key responses during the second disruptor test was actually higher than both right key responses, as also shown in Figure 9.5 (column 2). Responding on this key reduced comparative to Intervention levels, as did average responding on the right blue key, which remained lower than average numbers of responses elsewhere. Responding on the right yellow key, however, increased during the disruptor tests compared to Intervention levels of responding.

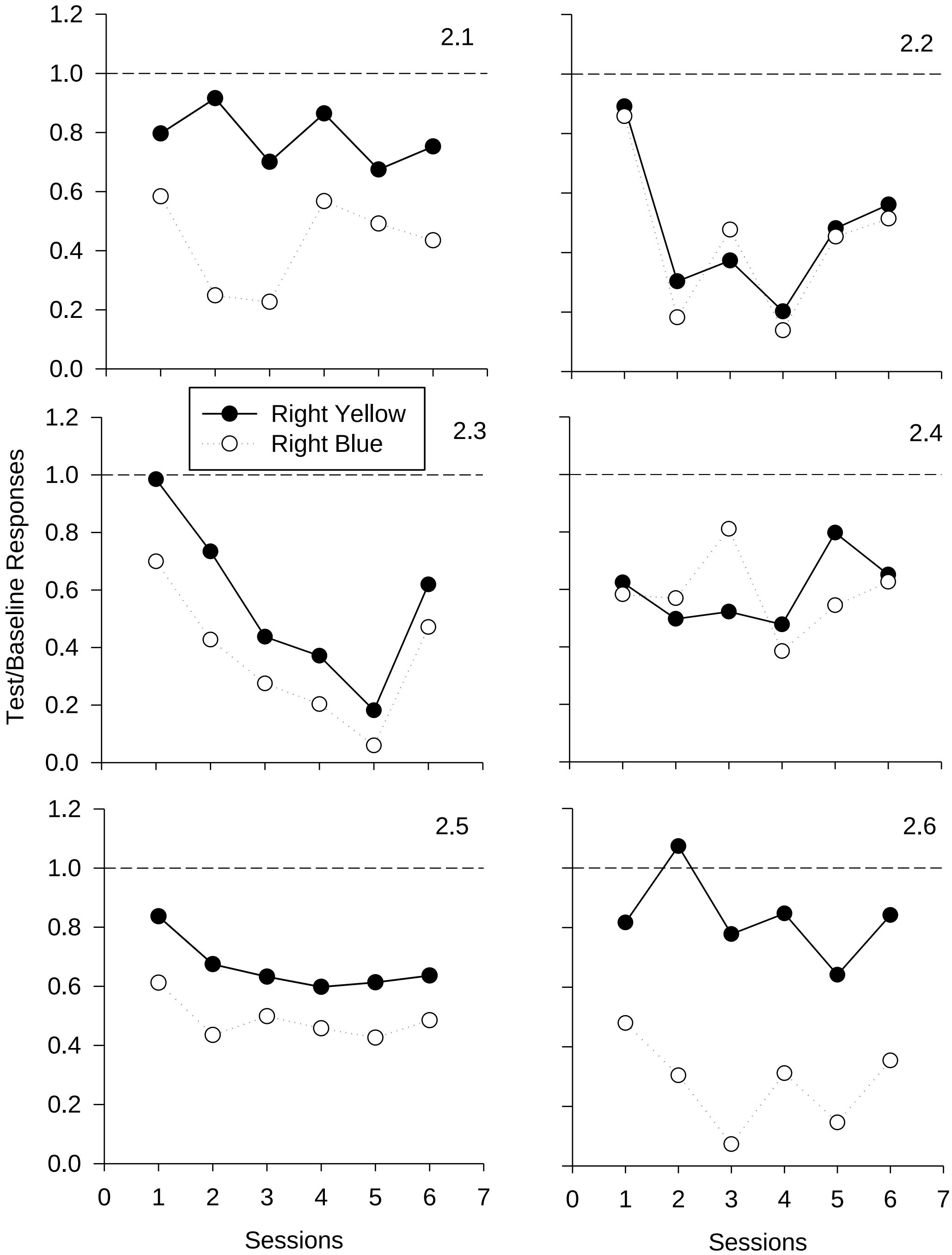


Figure 9.7. Responding plotted as a proportion of Baseline during the second disruptor test. Filled circles represent responding on the right yellow key and triangles represent responding on the right blue key. The dashed line represents Baseline levels of responding.

Disruptor Test 3

Figure 9.8 shows responding on all keys during the third disruptor test plotted as a proportion of Intervention responding. As with the first disruptor test, for all hens responding was lower, proportionate to Intervention, on the right blue key than on any other key. Right yellow key responding, relative to Intervention levels, was not as high as seen previously, but was still the key with the most responses to it for both Hens 2.2 and 2.6. Responding on both the left keys remained similar to one another for each of the hens, and was generally about the same as right yellow key responding. Overall, right yellow key responding continued to be proportionally greater than right blue key responding for all hens throughout the duration of the test. A paired-samples t-test comparing the mean proportion of Intervention responding on the right yellow key with those on the right blue key during the disruptor test was significant, $t(5) = 3.163$, p .025, $d = 1.259$.

Responding plotted as a proportion of initial baseline responding is shown in Figure 9.9. Responding was again lower than baseline levels, and more stable across sessions in this disruptor test than in the second disruptor test. Right yellow key responding was lower, proportionate to Baseline, than right blue key responding, however, there were some sessions were the opposite of this was true, especially for Hens 2.2, 2.4, 2.6. Despite this, a paired-samples t-test that compared the mean proportion of Baseline responding on the right yellow key with the mean proportion of Baseliner responding on the right blue key was significant, $t(5) = 2.928$, $p = .033$, $d = .944$.

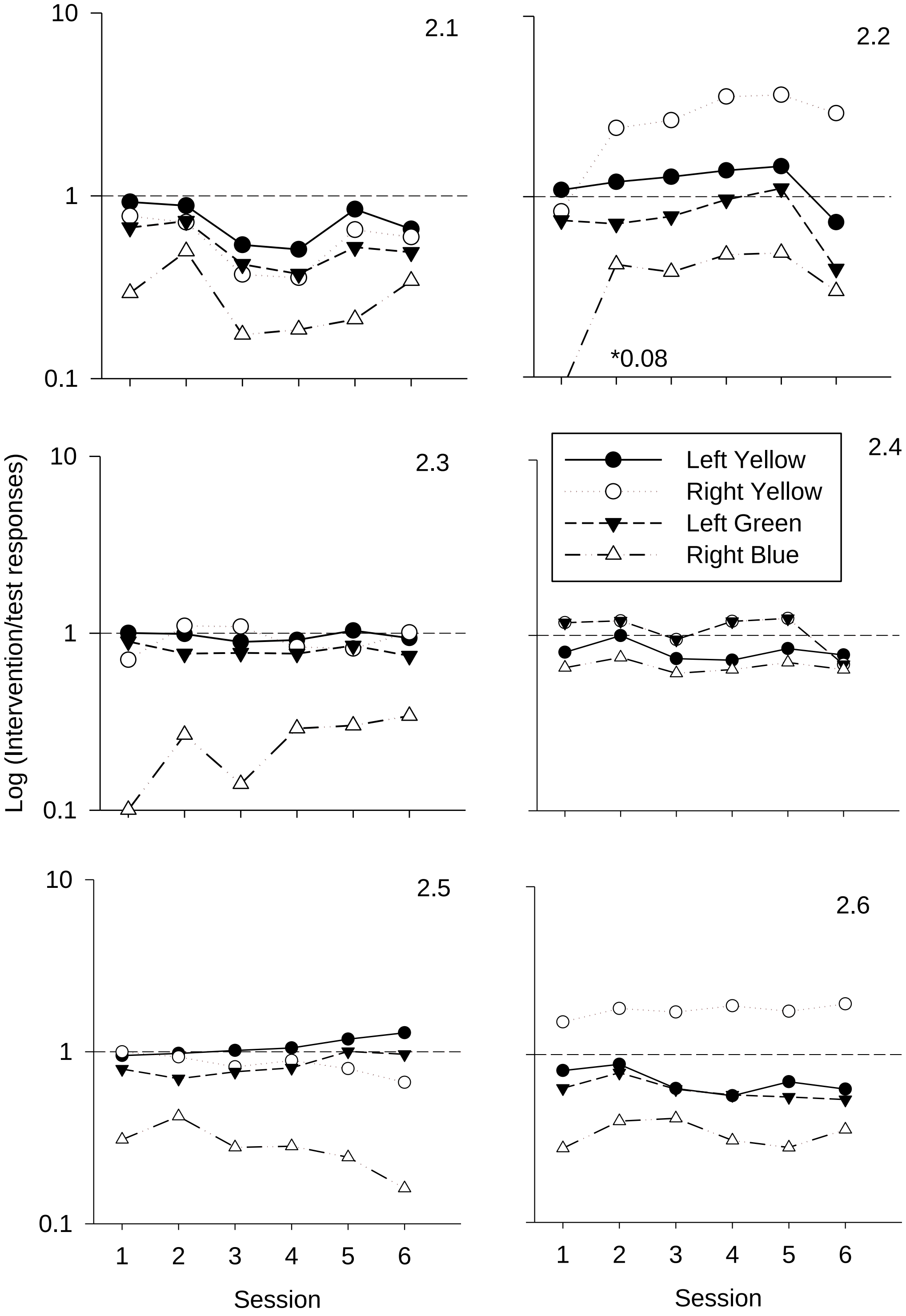


Figure 9.8. Responding on all keys during the third disruptor test plotted as a proportion of Intervention responding. The y-axis is presented on a log scale and the dashed line represents Intervention levels of responding. Circles represent the Concurrent Component (filled = left yellow key, open = right yellow key) and triangles represent the Combined Component (filled = left green key, open = right blue key). Red key responding is not shown on the graph.

Figure 9.5 (column 3) shows the average number of responses during the third disruptor test and the average number of responses across the final Intervention sessions that preceded the last disruptor test. This time, although right yellow key responding increased in the presence of the red key for Hens 2.2, 2.4 and 2.6, responding on all keys, including the right yellow key for all other hens, reduced during the disruptor test compared to average Intervention levels of responding. A paired-samples t-test comparing the mean number of responses on all keys during the Intervention phase, with the mean number of responses overall during the disruptor test, revealed a statistically significant difference between the number of responses emitted in the presence and the absence of the red key disruptor, $t(5) = 4.409$, $p = .007$.

Despite some decreases in the right yellow key responding, it remained at higher levels than right blue key responding for all hens other than Hen 2.6, whose right blue key responding was marginally higher. A two-way repeated measures ANOVA comparing the number of right yellow key responses with the number of right blue key responses across sessions during the disruptor test, revealed a significant effect of right key responding; $F(1,5) = 9.214$, $p <.05$, $\eta_p^2 = .648$, but no effect across sessions, $F(5,25) = 1.135$, $p >.05$, $\eta_p^2 = .185$ and no significant interaction between right key responding and sessions $F(5,20) = .856$, $p > .05$, $\eta_p^2 = .146$.

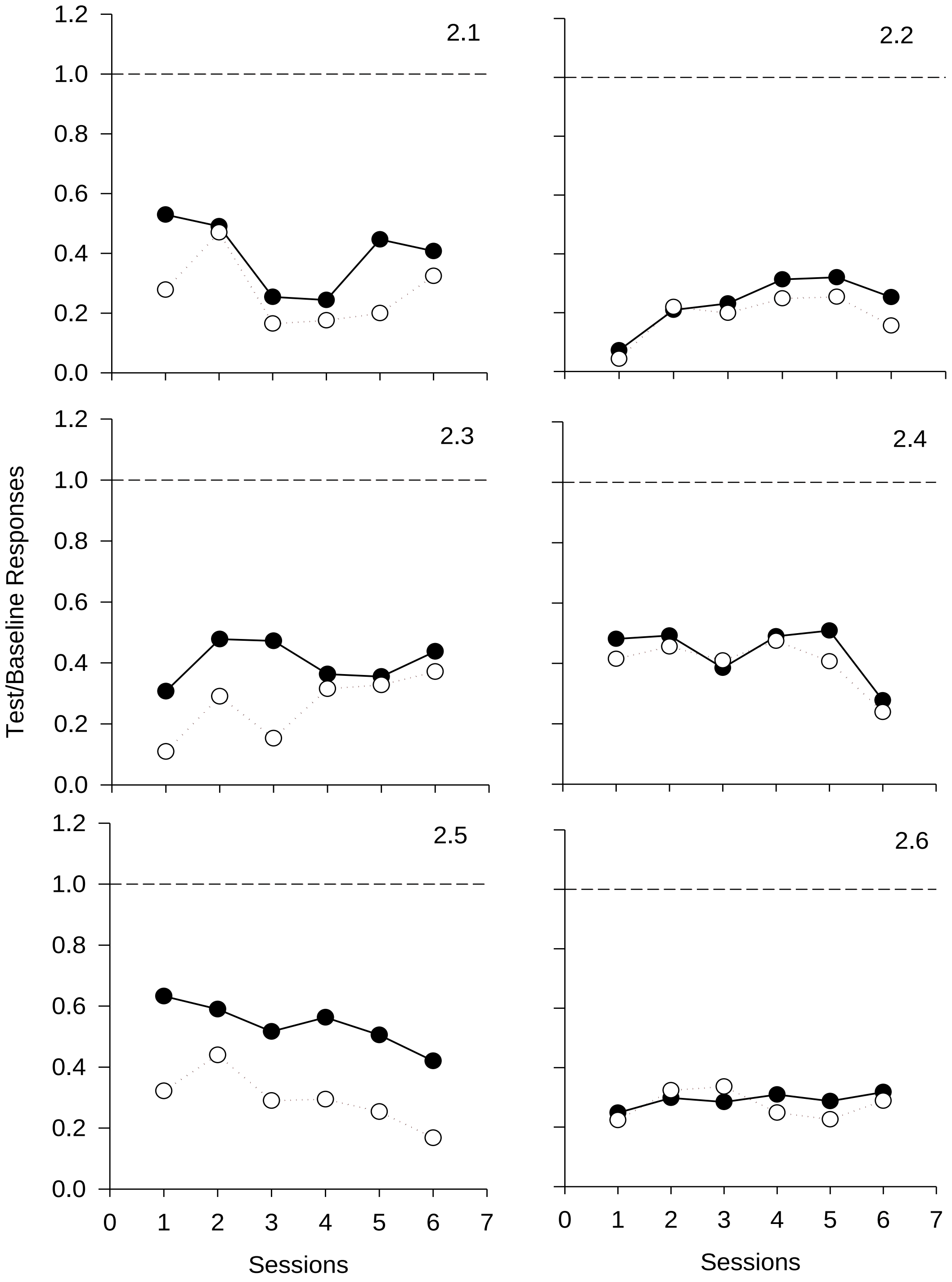


Figure 9.9. Responding plotted as a proportion of Baseline during the third disruptor test. Filled circles represent responding on the right yellow key and triangles represent responding on the right blue key. The dashed line represents Baseline levels of responding

Red Key Responding

Responding on the centre red key when it was presented alongside each of the components changed greatly across the three disruptor tests. Figure 9.10 presents red key responding during each of the disruptor tests, with the first and third columns showing red key responding when it was presented in between the Concurrent and Combined Components, and the middle column showing red key responding when it was presented alongside each of the individual stimuli.

During the first disruptor test, Hen 2.1-2.4’s red key responding began at very low rates, before increasing as the sessions progressed. Hen 2.5’s red key responding remained quite variable throughout and Hen 2.6 showed a reduction in responding on the red key as sessions went on. For all hens other than Hen 2.2, responding on the red key was greater when presented in between the left green and right blue keys.

As shown in the centre column of Figure 9.8, there were large increases in red key responding when it was presented alongside the individual stimuli. Responding rose for all hens, peaking in most cases on the second session of the disruptor test and reducing slightly after that. For some of the hens, there seemed to be a pattern of increased responding on the red key when presented with the right blue key, but this was not consistent across hens or sessions.

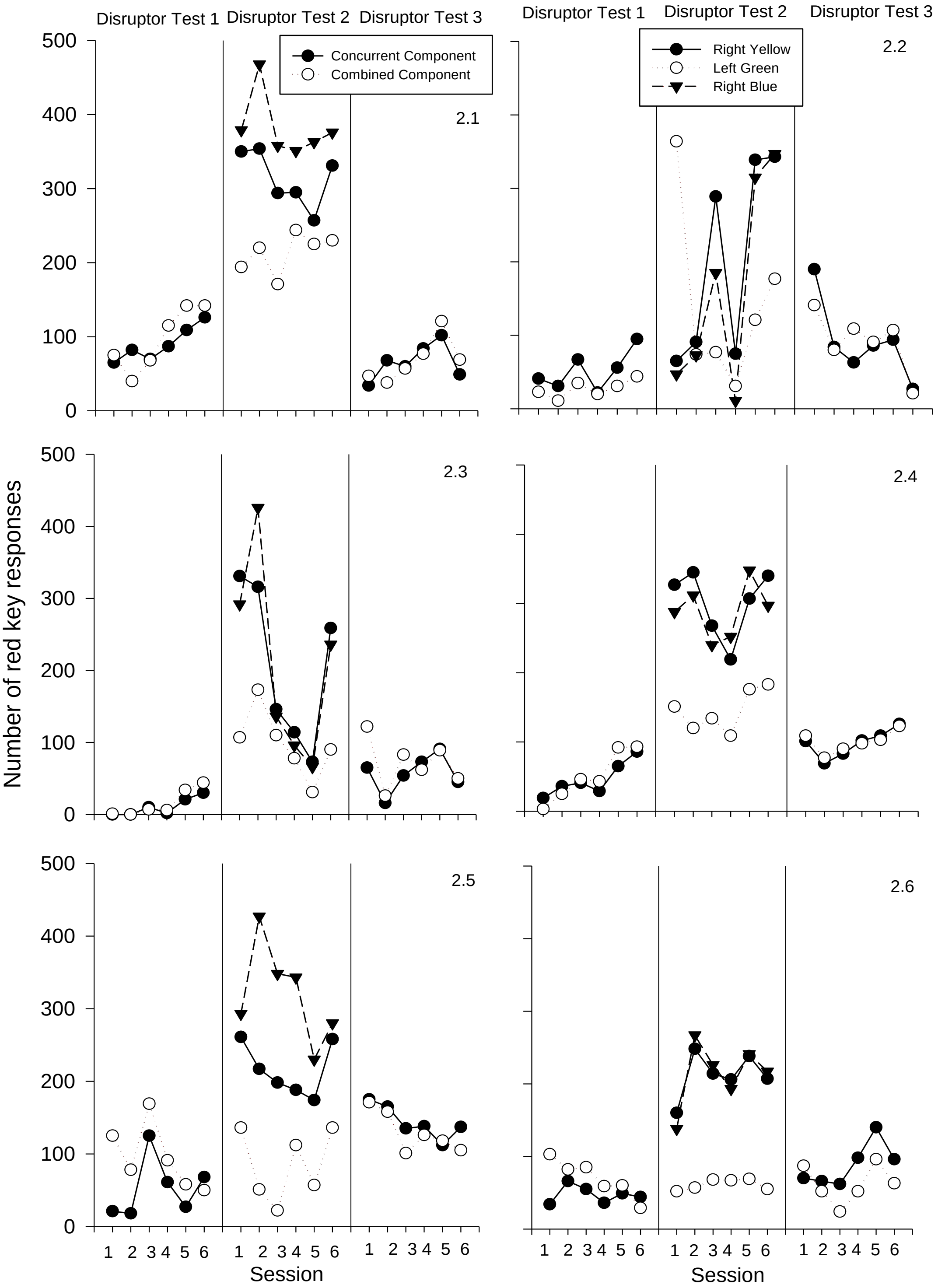


Figure 9.10. Number of responses on the centre red key during each of the three disruptor tests. In the first and third columns of each figure, the filled circles show red key responding when it was presented with the Concurrent Component (both yellow keys), and the open circles show red key responding when it was presented with the Combined Component. The centre column of the figures shows white key responding when it was presented individually with each of the three stimuli; filled circles = right yellow key, open circles = left green key and filled triangles = right blue key.

Discussion

Aims and Overall Findings

This experiment investigated the effect of exposing subjects to two target stimuli in an initial Baseline phase, before the persistence of those target behaviours was measured in the presence of a disruptor, following two different intervention procedures (traditional DRA and Combined Contexts DRA). This procedure intended to re-design the previously used procedures that had introduced the alternative response, at the same time as baseline data were collected on the target response. In creating an analogue of a traditional DRA implementation, both of the target behaviours were trained separately during the Baseline phase, before any alternative sources of reinforcement was added to either the same or another context during the Intervention phase.

Training an alternative behaviour in a separate context, before combining it with the target stimuli in the presence of a disruptor, was successful at reducing the persistence of responding to the right blue (Combined Target) key, compared to that of responding on the right yellow (DRA Target) key. This finding followed exposure to both of the target stimuli alone during the initial Baseline phase. Not only that, but this effect was obtained when the proportion of baseline measure was calculated on a measure of baseline comparable that was across both target response types, i.e., without an additional source of alternative reinforcement available in either component. Furthermore, proportion of Intervention measure data were similar to those obtained in previous experiments within this thesis that used the original proportion of baseline measure. These findings help to validate the use of the Combined Contexts procedure as a viable method to reduce the persistence-strengthening effects of DRA, when the target (or right yellow and right blue) exposure starts out equally. These findings also show that this effect was unlikely due to a richer association to the right yellow key during the previously used baseline procedures, a generally higher response rate to a single (right blue) key, or due to initial baseline levels of responding impacting proportion sizes when calculated during the disruptor tests.

When the hens were initially presented with the two target stimuli, the right yellow and right blue keys were both associated with the same reinforcement schedule (VI 150-s). It was predicted that responding to each of the keys would be about equal, providing an equal comparison to responding on both keys following different intervention processes. In addition, it allowed a point of comparison when persistence was measured, as initial exposure to these two target keys gave a stable baseline from which to calculate proportion of baseline. This proportion could be calculated on data obtained from two single key exposures (i.e., right yellow and right blue key responses) rather than one key presented as part of a concurrent (right yellow key as presented in previous baseline procedures), and one key presented alone (right blue key in previous baseline procedures).

Right yellow key responding was generally higher during this phase than right blue key responding, although there was no significant difference between the two types of right key responding. There was no known reason for these slightly higher yellow key response rates. All experimental variables were the same and the hens were naïve. They had never been exposed to the previous experimental contingencies of the richer yellow context. Despite this slight discrepancy in amounts of responding, it did mean that prior to both DRA and Combined Contexts manipulations taking place, the hens had experienced equal exposure to both of the target keys, and as in an applied setting, the target behaviour was occurring before an alternative behaviour was introduced as part of an intervention.

General Discussion of Experiment 9

In addition to analysing the data as a proportion of Intervention (same as the baseline calculation used in previous experiments), and an average number of responses on each key across the sessions, the number of responses during the disruptor tests were also plotted as a proportion of Baseline levels of responding. This was to evaluate responding in the Baseline phase. Although this phase produced higher numbers of responding on the right yellow key, as a proportion of their baselines, right blue key responding was, still lower than right yellow key responding during the disruptor tests. The proportion of Intervention data also showed right blue key responding to be lower than right yellow key responding with this measure. In addition, the average number of responses on the right blue key dropping below those of the right yellow key in all disruptor tests and across almost all hens. Thus, it is possible to conclude that the target behaviour trained in a separate context to the alternative behaviour was less persistent than the target behaviour trained in the same context. This experiment drew these conclusions from the use of an initial baseline phase that compares directly to the type of baseline that would be used in applied implementations of DRA procedures. Thus, these findings have strong applied significance.

Although these findings are in line with previous research (Mace et al., 2010; Podlesnik & Bai, 2015; Podlesnik et al., 2012; Podlesnik et al., 2016), there are two distinct differences in the present methodology. Unlike the studies previously cited, reinforcement was maintained in all conditions, and the centre red key associated with a lean reinforcement schedule was used as a disruptor.

Responding overall reduced in the presence of the red key disruptor and this was supported statistically, so there is evidence to suggest that both maintaining reinforcement and using the red key as a disruptor may be suitable methods to continue to explore the most efficient and effective ways to reduce the persistence of problem behaviour. In addition, this study differed in presenting both the target stimuli initially during Baseline, so that comparison of responding during the disruptor tests was made to these two stimuli that had been presented alone, rather than one individually, and one as part of a concurrent component, as in previous experiments.

Following an investigation into the effects of manipulating the alternative stimuli directly through changes in line orientation, Podlesnik, Miranda-Dukoski, et al. (2017) found increased persistence of the target response in DRA Probes (similar to DRA/Concurrent Components in the present experiment) during extinction, compared to the Combined Probes (similar to the Combined Component during the present experiment). The authors suggested that the increased persistence might have been due to both DRA and Combined Probes featuring concurrently available keys during the extinction tests, but only the DRA Component featuring these concurrently available keys during baseline (Podlesnik, Miranda-Dukoski, et al., 2017). This is the same issue as discussed in the introduction to the present experiment. Podlesnik, Miranda-Dukoski et al. (2017) propose a possible solution, in the form of arranging an alternative key that does not provide reinforcement, alongside the target key when it is presented during baseline. This allows for the same stimulus conditions during the baseline as during the training phase. The findings from the present experiment, however, offer another solution. Training both target keys separately during baseline, such as in the present experiment, rather than introducing a redundant alternative stimulus, prevents any possible responses to the alternative stimulus, and provides an equal comparison of initial target responding.

A similar model with pigeons, in which the target behaviour was trained alone initially, was used by Liddon, Kelley, and Podlesnik (2017). Although there was no comparison between DRA and Combined Contexts procedures, as it was not the focus of their investigation, the procedure they used in creating the DRA analogy trained the target response first. This was done to establish the equivalent of a problem behaviour occurring before an applied intervention (termed the pre-assessment baseline). The alternative stimulus was then presented, but responding to it was not reinforced, while reinforcement continued for the target response. This created a similar situation to that of a pre-intervention baseline, where the target response receives reinforcement but the alternative response does not. The alternative response was then differentially reinforced alongside the target response, which was extinguished, creating an analogy to a DRA intervention. Both responses were then exposed to extinction to test for resurgence or treatment maintenance.

The target behaviour resumed as soon as the alternative behaviour contacted extinction (Liddon et al., 2017), however, these outcomes are not the primary interest for discussion here. Of interest is the second part of the procedure, in which the alternative stimulus was presented but responding to it was not reinforced, alongside the target stimulus that was reinforced. Presenting a non-reinforced alternative such as this is the same suggestion as raised by Podlesnik, Miranda-Dukoski, et al. (2017) and discussed above.

However, one might argue that in applied settings, an alternative stimulus or response, is not usually present when the target behaviour is occurring at the baseline stage pre-intervention. For example, many alternative behaviours used in DRA interventions involve directly teaching a new behaviour in the presence of an alternative stimulus, and are associated with a reinforcer that was not previously present in that setting. Whilst this also raises a general question as to the differences of how DRA treatments are implemented (see Vollmer and Iwata (1992) for discussion on procedural variations), it seems even more unlikely that an alternative stimulus would be present in the environment, if DRA was implemented following training of the alternative and target behaviours in two separate contexts. Therefore, presenting and training responding to a target stimulus initially, such as in the present study, and in the methodology used by Liddon et al. (2017), but without the additional presentation of the alternative stimulus, may be an adjustment to the current procedure with two distinct benefits. Firstly, it is effective at ensuring that the persistence of the two types of target responding are being compared with a similar point of reference, and secondly, the procedure translates well to applied settings, where these findings might offer some insight into the means of reducing the long-term persistence of problem behaviour.

It is worth commenting on both responding overall in the presence of the red key disruptor, and responding on the red key itself. Firstly, a reduction in responding on yellow, green and blue keys in the presence of the red key was only observed during the second and third disruptor tests, in which there was a statistically significant reduction in responses in the presence of the disruptor. This is different from previous experiments using the red key, in which responding reduced during the first disruptor test (see Experiment 2 and 8). It is unclear why the red key did not initially impact responding with this particular group of hens, yet it did with others. Red key responding itself was quite variable across the three disruptor tests. This had been observed before with both the red key, and the other schedules and key colours investigated during Experiments 2 and 3. Further investigation to determine impact of red key responding, and its relevance to the persistence of responding on the other keys, is needed.

Conclusions

Overall, the findings from this experiment are similar to previous studies, suggesting that training an alternative behaviour in a separate context to a target behaviour before combining them in the presence of a disruptor reduces the persistence-strengthening effects of training an alternative behaviour in the same context as the target behaviour. This experiment addressed a key weakness in the previously implemented procedures by establishing baseline responding prior to the DRA intervention for both target responses - the decreased persistence of the target behaviour relative to this pre-intervention baseline was still observed following the separated DRA relative to the combined DR. This procedure seems to be a better analogue of the type of applied situations typical in implementing a DRA. Procedures that enable closer analogues of applied settings can greatly improve the translational use of such findings.

Experiment 10: Different Contexts

Training an alternative behaviour in a separate context to the target, or problem, behaviour, that is to be reduced seems like a potential solution to the persistence-strengthening effects of DRA interventions (Mace et al., 2010; Podlesnik et al., 2012). The previously discussed experiments built on these findings to evaluate this procedure with a range of disruptors and different procedural variables (such as thinning the alternative reinforcement schedules), with the aim of investigating the applied significance of these effects.

One question, however, that has resurfaced throughout these experiments and is also raised by Podlesnik and DeLeon (2015), is whether two keys, signalling the two response types in two different components with differing colours and location (left and right sides), are sufficient to generate two different contexts. As Nevin (2015) states, it is not clear if two separate contexts are successfully defined, or if "the entire experimental session, blackouts and all, constitute a single overall context" (p. 106). As discussed previously in the Experiment 4 Discussion, it is unclear if the left green key trained in a separate component, or context, from the right blue key, function as separate stimulus contexts. In an attempt to further define these stimulus contexts, and create an analogue to an applied setting, some consideration was given to how this Combined Contexts procedure might be implemented in applied settings.

For example, the procedure might be used in an intervention for a problem behaviour that is occurring already in a classroom, or in any situation where a traditional DRA procedure might be considered also. An alternative behaviour may be trained by a therapist outside of the classroom, while the student is receiving 1:1 support. Following this training period, the stimuli associated with the delivery of the alternative reinforcement (such as the therapist), might be introduced into the classroom environment. In a traditional DRA intervention, however, the alternative behaviour would be trained and reinforced in the classroom by the therapist initially, thereby adding the stimuli associated with the alternative reinforcement to the context in which the problem behaviour is occurring, as soon as the intervention process begins.

An experimental arrangement in which the broader contextual stimuli associated with the target behaviour, and the alternative behaviour, differ significantly during the Combined Contexts DRA intervention would be a better analogue of the arrangements in place in the applied example. The aim was to train a target behaviour in a separate context beyond that of a single key and colour, and an alternative behaviour in another separate context also beyond that of a single key and colour, before combining them in the presence of a disruptor. The persistence of the separately trained target behaviour was then compared to the persistence of a target behaviour trained in the same context as an alternative.

The above analogy of a separate room in which the alternative behaviour was trained can be drawn upon, in order to define the two clearly separate contexts in this experiment. The alternative and target behaviours were trained in two different operant chambers, with clear differences between them. Chamber 2 was painted dark grey and featured a lit green key, associated with the richer (VI 37.5-s) reinforcement schedule, or alternative response. Chamber 3 was painted white, and featured a lit blue key, associated with the leaner (VI 150-s) reinforcement schedule, or target response. The Concurrent Component, in which the alternative and target behaviours remained together, was trained in a third completely separate chamber (Chamber 1), also painted white, but featuring two concurrent yellow keys, associated with a VI 37.5-s (richer alternative) schedule on the left, and a VI 150-s (leaner target) schedule on the right. Two groups of hens were used again, one naïve and one with previous experimental history, to analyse any differences in the persistence of their target responding.

Method

Subjects

The subjects were 12 domestic Brown Shaver hens. Six of them, numbered 5.1 to 5.6 and hereafter referred to as Group 1, were under one year old at the start of the study, and although they had been shaped to key peck, they were experimentally naïve. The other six, numbered 11.1 to 11.6, were the same six hens last used in Experiment 8, hereafter referred to as Group 2. They were housed in individual cages in two separate rooms with a 12-hour light and dark cycle operating in each. The hens had free access to water at all times, were weighed daily and kept at 85% (+/- 5%) of their free-feeding body weight. The hens received supplemented feeding of a commercial laying pellet after each experimental session as required, and grit and vitamins as part of their usual feeding routine. In the experiment, wheat was used as a reinforcer.

Apparatus

Four experimental chambers were required for this experiment. The first chamber, in which the disruptor training took place, was the same chamber used for this purpose in Experiment 9, and featured a single red key situated approximately 150cm above the rectangular hole that allowed the hens access to the magazine when the hopper was raised and lit. The other three chambers were used as part of the main experiment. They all featured three keys, with multi-colour LED light panels, situated at one end of the chamber approximately 350mm off the floor of the chamber. Below the keys, a rectangular hole provided access to wheat from the magazine when the hopper was raised and lit. All three chambers were approximately the same size and made from the same material (plywood). Black rubber mats were placed on the floor in all three of them to allow for easy removal and cleaning. Chambers 1 and 3 were painted white inside, and Chamber 2 was painted a dark grey, as shown in Figure 10.1. With the exception of this deliberate colour change, and the keys presented in each chamber, care was taken to ensure all features of each of the chambers remained as similar as possible throughout this experiment.

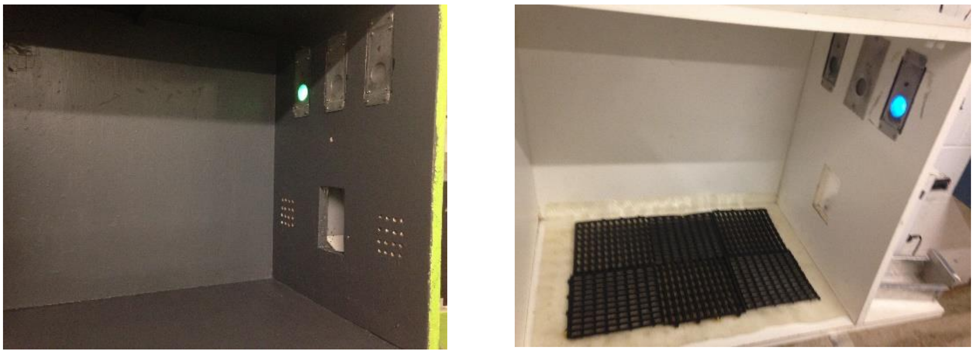


Figure 10.1. Photographs of the inside of Chamber 2 (painted dark grey) and Chamber 3 (white). Chamber 1 (not shown) was also painted white, but with different coloured keys (see Part 2 of the Procedure below).

Procedure

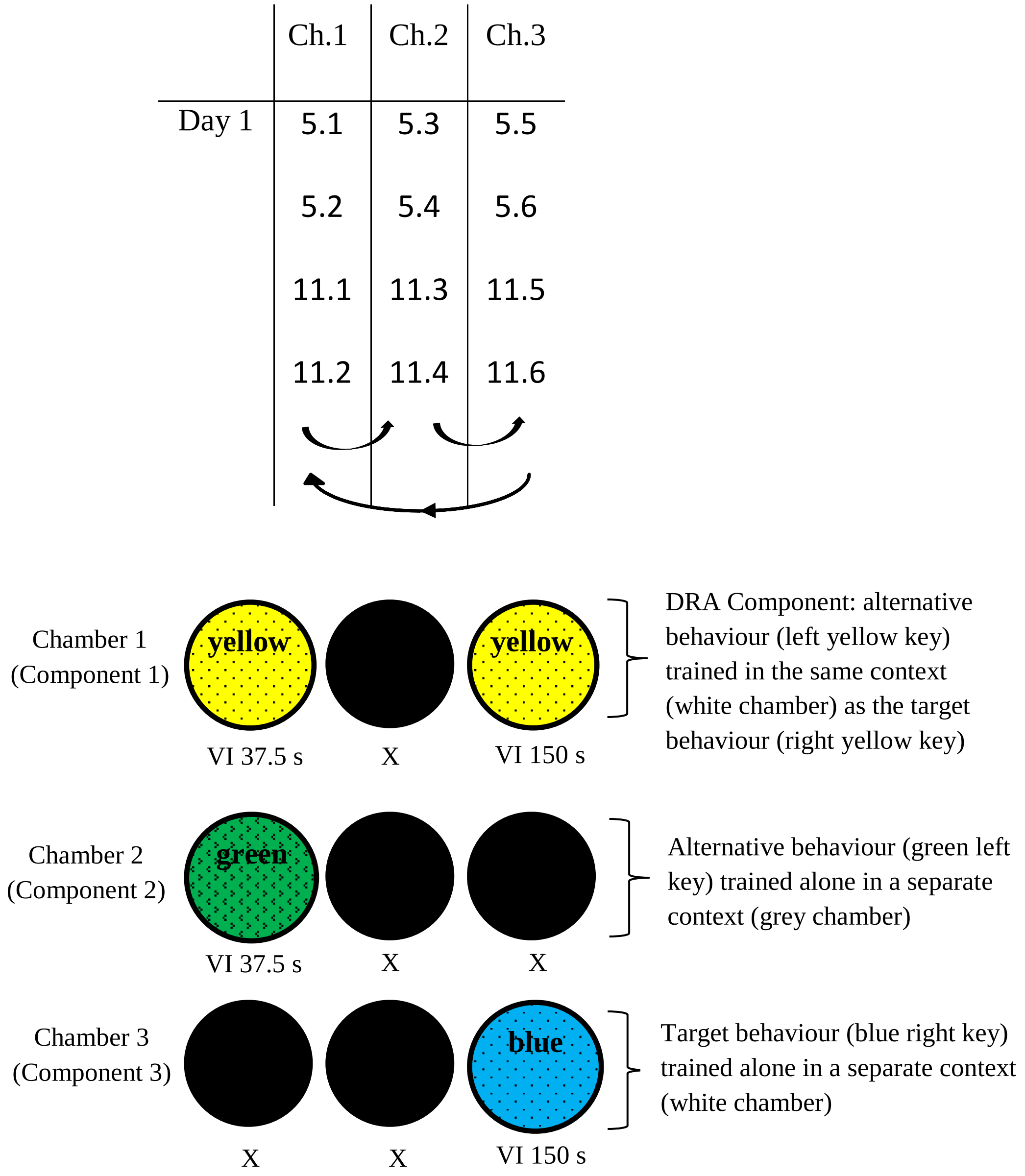
Hens 11.1-11.6 had most recently been used in the experiment investigating thinning of the reinforcement schedules associated with the left yellow and left green keys, so these six hens were exposed to six days of the baseline procedure outlined in Experiments 1-8, in which the left yellow and left green keys were associated with a VI 37.5-s reinforcement schedule. This occurred in a completely separate experimental chamber to those described above. This was to ensure responding on both of the left keys was reinstated to its previous levels (prior to thinning the schedules).

Part 1. Disruptor Training

All 12 hens were then presented with a single red key, under a VI 150-s schedule, to give them exposure to what would be the disruptor during this experiment. Sessions ran for 12 minutes, during which time a maximum of six reinforcers were available, and there were six sessions in total. As Group 1 Hens were experimentally naïve, this stage was closely monitored to ensure all hens were responding reliably. Hen 5.4 required two extra sessions of hand shaping until her level of responding was comparable to the rest of the group.

Part 2. Experimental Procedure

Each chamber was designed to expose the hens to a different context paired with a certain component. The experimental features of each chamber are demonstrated in Figure 10.1. Four hens responded in each of the chambers each day, rotating through the chambers in a clockwise direction, until each hen had been in each chamber six times, which was the same number of exposures to each component of the multiple-component schedule as previously used in baseline conditions (see earlier experiments). This process took 18 sessions in total. Each session was 16 minutes in length and the maximum number of reinforcers possible varied in each chamber due to the differing reinforcement schedule.



	Ch.1	Ch.2	Ch.3
Day 1	5.1	5.3	5.5
	5.2	5.4	5.6
	11.1	11.3	11.5
	11.2	11.4	11.6

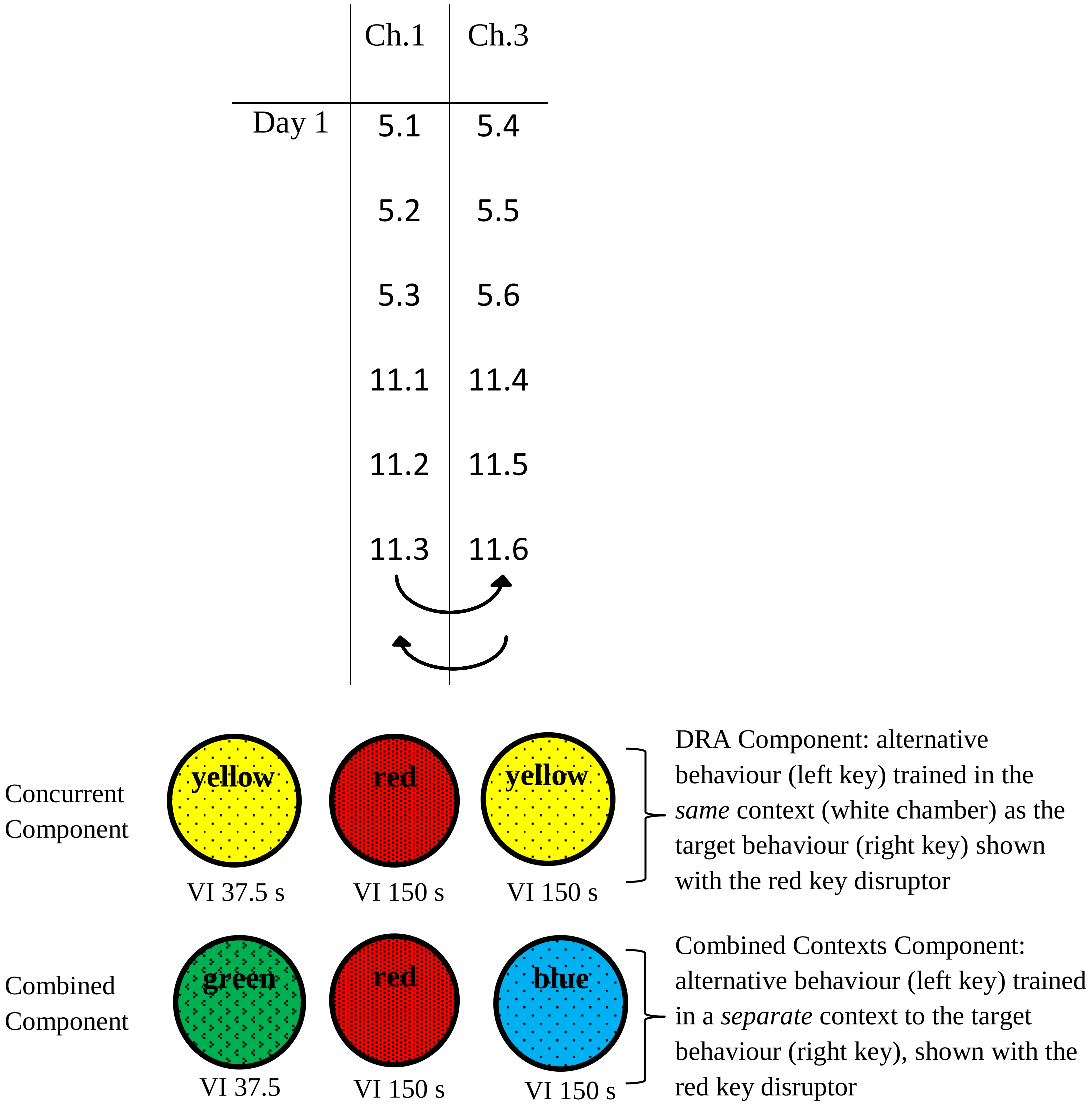
DRA Component: alternative behaviour (left yellow key) trained in the same context (white chamber) as the target behaviour (right yellow key)

Alternative behaviour (green left key) trained alone in a separate context (grey chamber)

Target behaviour (blue right key) trained alone in a separate context (white chamber)

Figure 10.2. The key colours and schedules as arranged in each of the three chambers, and the starting point of each of the hens during the baseline part of the experiment. The hens then rotated through all the chambers in a clockwise direction until they had reached six sessions in each one.

Once the baseline procedure was completed, the disruptor tests were conducted. Chamber 1, which was the Concurrent (DRA) Component, was used as shown in Figure 10.2, but with the red key disruptor situated between the two yellow keys. Chamber 2, the grey chamber with the left green key alone, was not used for the disruptor tests. Instead, Chamber 3, where the hens had been previously exposed to the right blue key, was used as the Combined Contexts Component, presenting both the left green key and the blue key together, in one combined context. Situated in between these two keys was the red key. Figure 10.3 shows the experimental features of each chamber during the disruptor tests. Once again, hens started these tests in one of the two boxes and rotated clockwise over sessions until each hen had been in each chamber six times, taking 12 sessions in total. Sessions remained at 16 minutes long, but the maximum number of reinforcers increased due to the presence of the red key in each of the chambers.



DRA Component: alternative behaviour (left key) trained in the *same* context (white chamber) as the target behaviour (right key) shown with the red key disruptor

Combined Contexts Component: alternative behaviour (left key) trained in a *separate* context to the target behaviour (right key), shown with the red key disruptor

Figure 10.3. The key colours and schedules as arranged in Chamber 1 (Concurrent Component) and Chamber 3 (Combined Component), and the starting chamber of each of the hens during the disruptor part of the experiment. The hens then rotated through both chambers in a clockwise direction until they had reached six sessions in each one.

Results

This experiment is a systematic replication of the earlier experiments using the red key, and uses the baseline procedure defined prior to Chapter 9. Therefore, baseline will refer to the phase of the procedure where the alternative responses were also trained either alongside, or in a separate context to the target behaviour, rather than referring to this as the Intervention phase as with Chapter 9. Figures 10.4 and 10.5 then, show the number of responses during baseline sessions and the disruptor test for Group 1 Hens 5.1-5.3 (Figure 10.4) and Group 1 Hens 5.4-5.6 (Figure 10.5). Responses during baseline are shown in the first column of the figures while responses during the disruptor test are shown in the second column.

For all hens, during baseline, left yellow and left green key responding was greater than both right yellow and right blue key responding, with left green key responding often higher than left yellow key responding. Right yellow key responding varied across hens and sessions, with no clear pattern. Right blue key responding started quite high (200-300 responses per session) for Hens 5.1, 5.2 and 5.3, but decreased as baseline sessions progressed. For the other three hens, right blue key responding started off very low (<10 responses per session), and increased slightly as sessions progressed, but not at the same rate as the other three hens.

During the disruptor test, left yellow and left green responding remained higher still than responding on both of the right keys, but responding on the left yellow key was generally greater than responding on the left green key, though this was not consistent across hens. Responding on both of the left keys did not change greatly from baseline levels. Responding on the right yellow key also did not change much compared to baseline levels, however responding on the right blue key did decrease for all of the hens, compared to baseline levels of responding on that key. There were some differences in responding on the right blue key across sessions, as responding increased as time went on for Hens 5.1, 5.2 and 5.5. With the exception of the final two sessions for Hen 2.1, responding on the right blue key was lower than responding on the right yellow key for all hens. A two-way repeated measures ANOVA comparing the number of right yellow key responding with right blue key responding across sessions found a significant difference in the two types of right key responding (yellow and blue); *F*(1,5) = 19.639, $p < .05$, = .797, but no effects of session, *F*(5,25) = .726, $p > .05$, = .127 and no significant interaction between session and right key response *F*(5,25) = .594, $p > .05$, = .106.

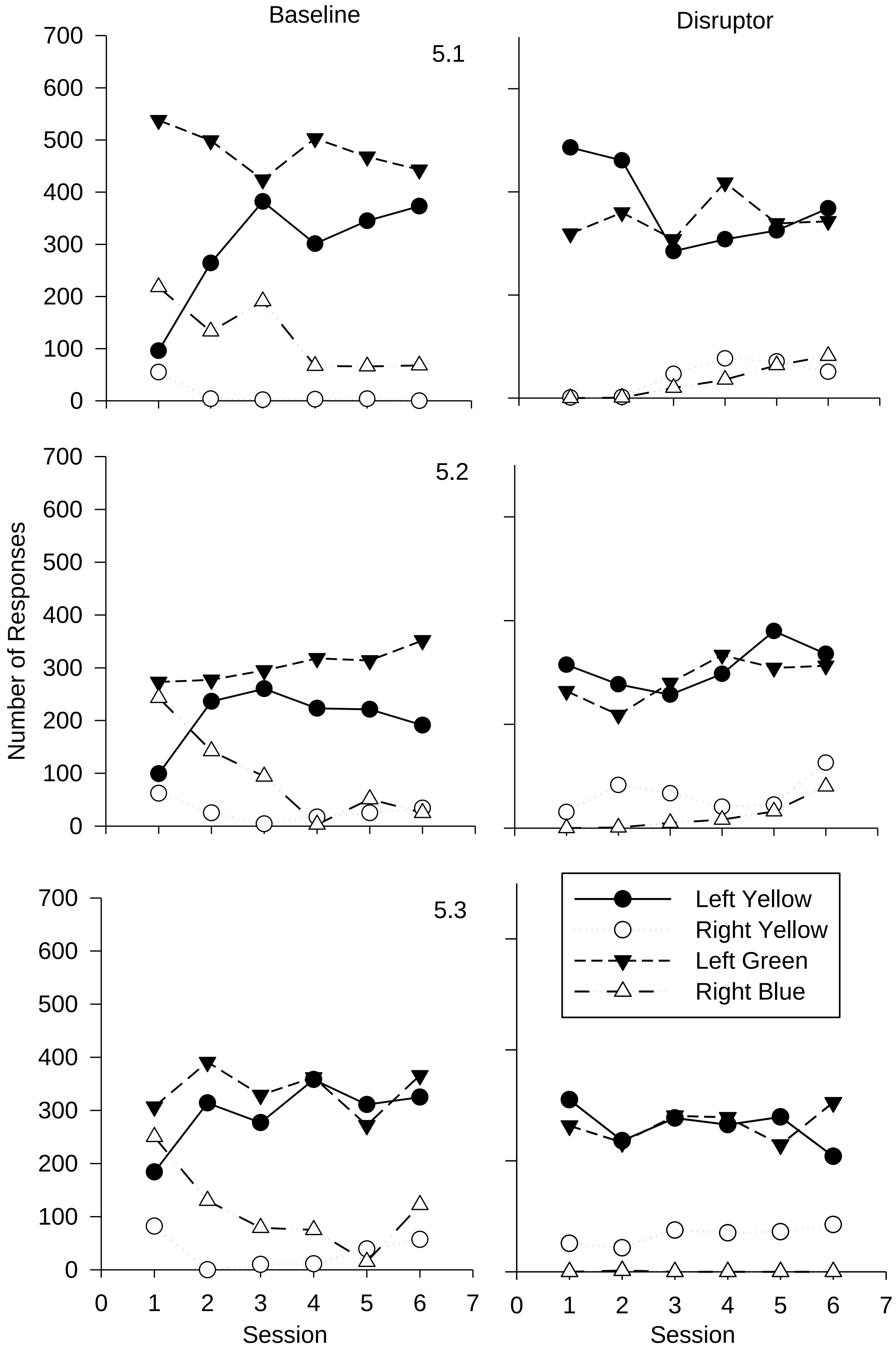


Figure 10.4. Number of responses in baseline (left column), and in the disruptor test (right column), for Group 1 hens 5.1-5.3. Circles show responding during the Concurrent Component (filled = left yellow key, open = right yellow key) and the triangles show responding on the keys that were trained in separate chambers during baseline and combined during the disruptor test (filled = left green key, open = right blue key).

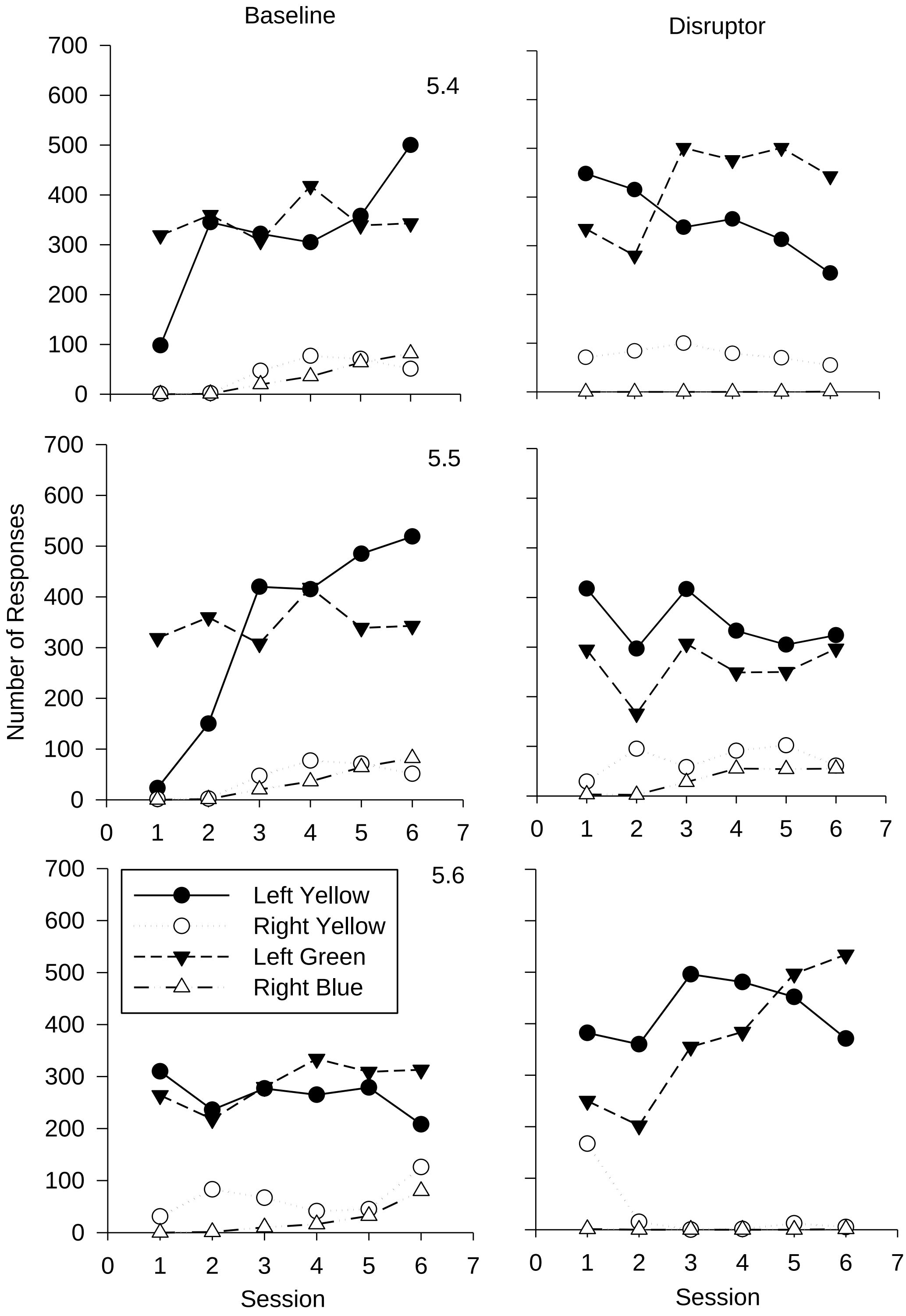


Figure 10.5. Number of responses in baseline (left column), and in the disruptor test (right column), for Group 1 hens 5.4-5.6. Circles show responding during the Concurrent Component (filled = left yellow key, open = right yellow key) and the triangles show responding on the keys that were trained in separate chambers during baseline and combined during the disruptor test (filled = left green key, open = right blue key).

Figures 10.6 and 10.7 show the number of responses during baseline sessions and the disruptor test for Group 2 Hens 11.1-11.3 (Figure 10.6) and Group 2 Hens 11.4-11.6 (Figure 10.7). Responses during baseline are shown in the first column of the figures while responses during the disruptor test are shown in the second column.

For all hens during baseline, left green key responding was consistently higher than responding on all other keys, although the first session did not begin this way for Hens 11.4, 11.5, and 11.6. There was also a comparably high number of left yellow key responses for most of the hens, but they also did not start out this way. In all cases, right blue key responding started higher than left yellow key responding, but right blue key responding decreased across sessions as left yellow key responding increased. The only hen for which this was not the case was Hen 11.3. Right yellow key responding remained lower than responding on any other key for almost all hens across baseline sessions.

Left yellow key responding did not change greatly during the disruptor test, remaining at a similar rate to baseline levels of responding. The left green key continued to receive high response rates, but these were lower than seen during baseline. Right yellow and right blue key responding changed more than left key responding when compared to baseline levels, with responding to both of these keys reducing. In particular, right blue key responses were lower than responding on the right yellow key. A two-way repeated measures ANOVA revealed a significant difference in the two types of right key responding (yellow and blue) across sessions; $F(1,5) = 15.614$, $p < .05$, $= .757$, but no significant effect of session $F(5,25) = 2.045$, $p > .05$, $= .290$ and no significant interaction between session and response $F(5,25) = 1.069$, $p > .05$, $= .176$.

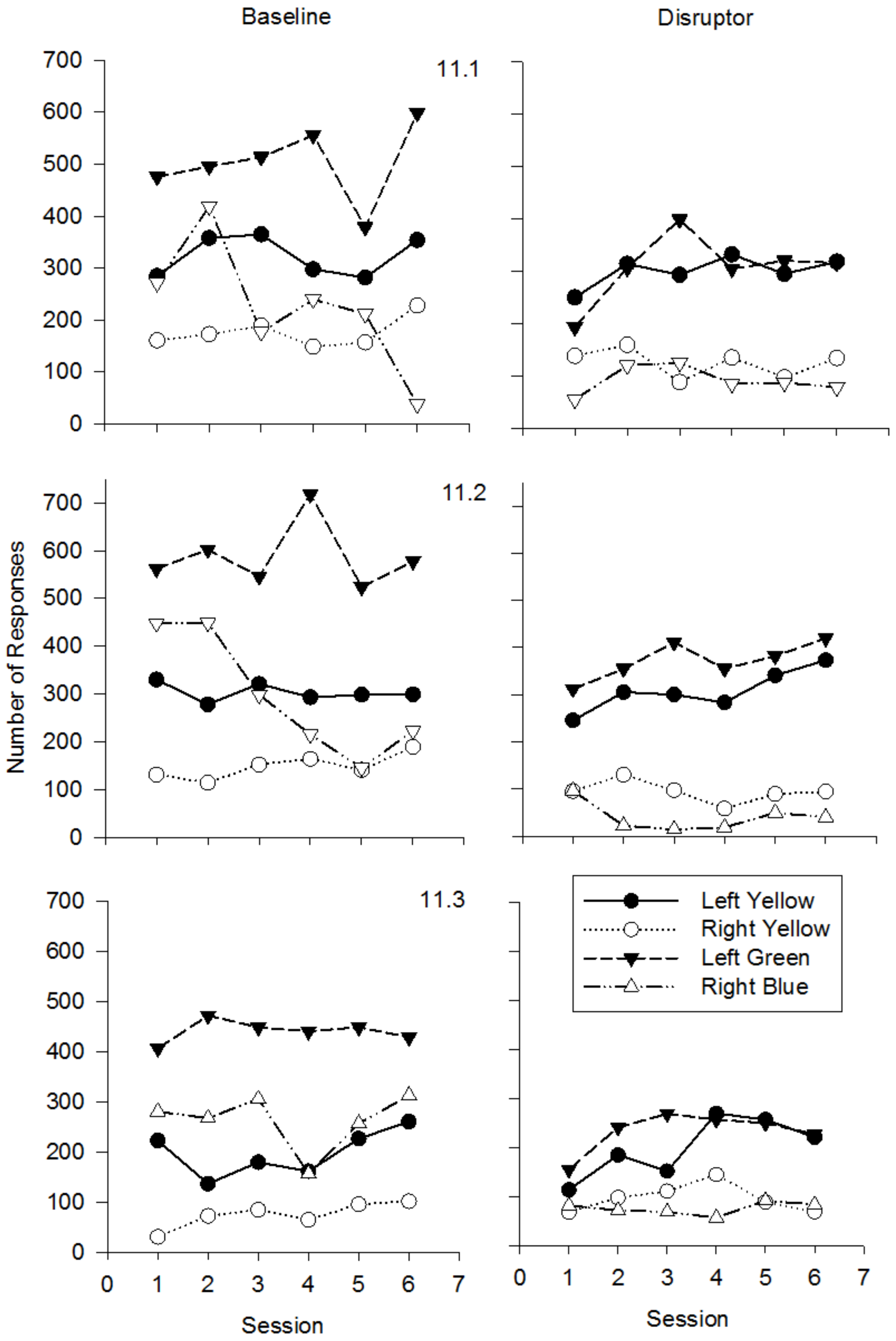


Figure 10.6. Number of responses in baseline (left column), and in the disruptor test (right column), for Group 2 hens 11.1-11.3. Circles show responding during the Concurrent Component (filled = left yellow key, open = right yellow key) and the triangles show responding on the keys that were trained in separate chambers during baseline and combined during the disruptor test (filled = left green key, open = right blue key).

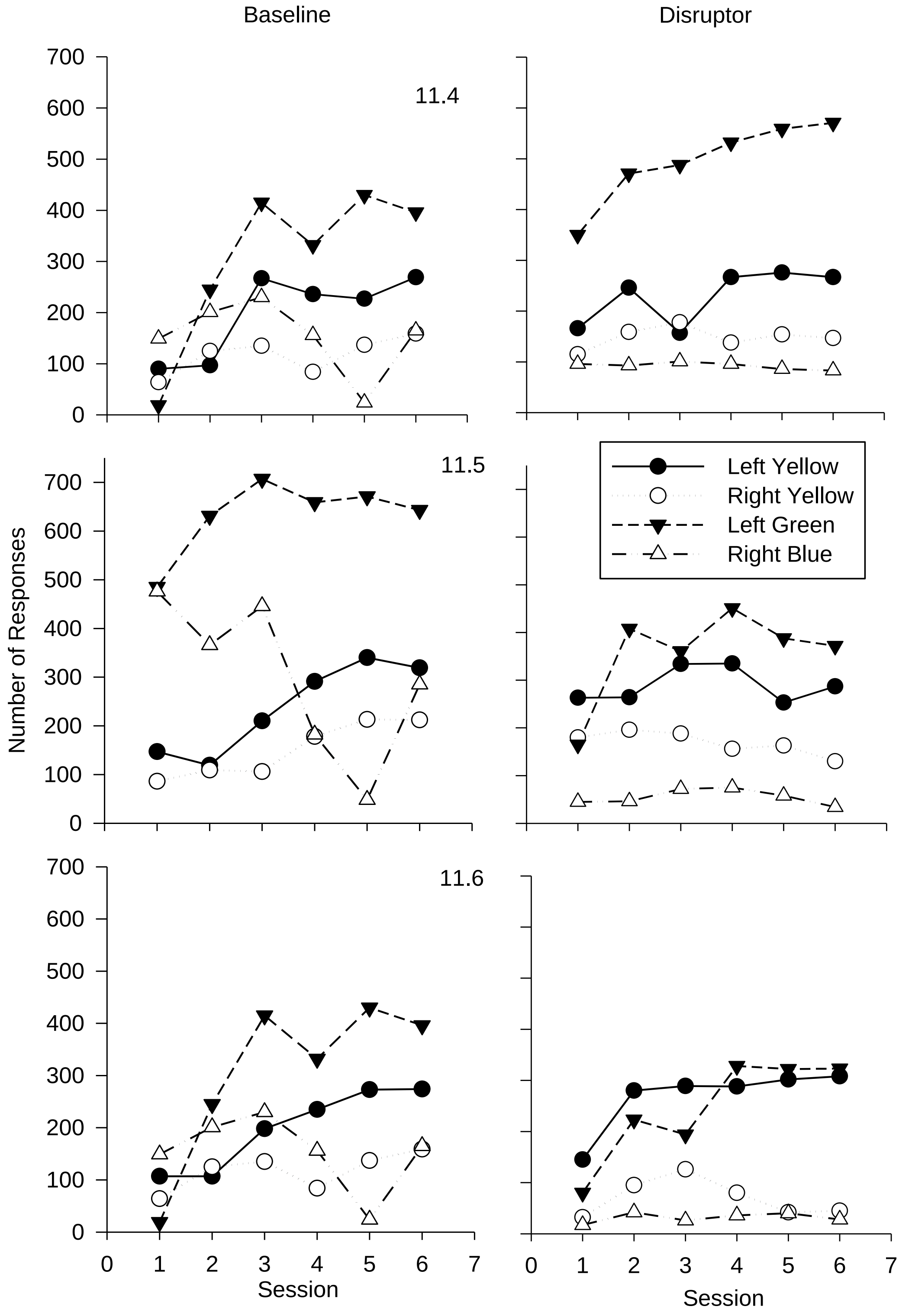


Figure 10.7. Number of responses in baseline (left column), and in the disruptor test (right column), for Group 2 hens 11.4-11.6. Circles show responding during the Concurrent Component (filled = left yellow key, open = right yellow key) and the triangles show responding on the keys that were trained in separate chambers during baseline and combined during the disruptor test (filled = left green key, open = right blue key).

Figures 10.8 (Group 1) and 10.9 (Group 2) show responding plotted as a proportion of baseline during the disruptor test. For all hens, right blue key responding was clearly less persistent, proportionate to baseline, than responding on all other keys and across almost all sessions. Group 1 Hens responding to the right blue key, proportionate to baseline, was on average lower and much more variable than Group 2 Hens proportion of baseline responding to the same key. Right yellow key responding was the most variable across all hens, with responding proportionate to baseline high for Hens 5.1, 5.2, 5.3, 5.4 and 11.3. For all other hens, responding on this key remained quite variable and at levels comparable to the left keys, with the exception of Hen 5.6 whose responding on the right yellow key, proportionate to baseline, was only marginally higher than her responding proportionate to baseline on the right blue key. Responding on both the left yellow and left green keys, proportionate to baseline, followed similar patterns to one another for most of the hens across sessions, but overall, left yellow key responding remained higher, proportionate to baseline, for all hens with the exception of Hen 5.4.

A paired-samples t-test comparing the mean proportion of baseline responding for Group 1 Hens on the right yellow key, with the mean proportion of baseline responding on the right blue key, was significant; $t(5) = 3.820$, $p = .012$, $d = 1.503$. A paired-samples t-test comparing the mean proportion of baseline responding for Group 2 Hens on the right yellow key, with the mean proportion of baseline responding on the right blue key, was also significant; $t(5) = 4.482$, $p = .007$, $d = 1.935$. These results supported the conclusion that responses to the right blue key were less persistent than response to the right yellow key across all hens.

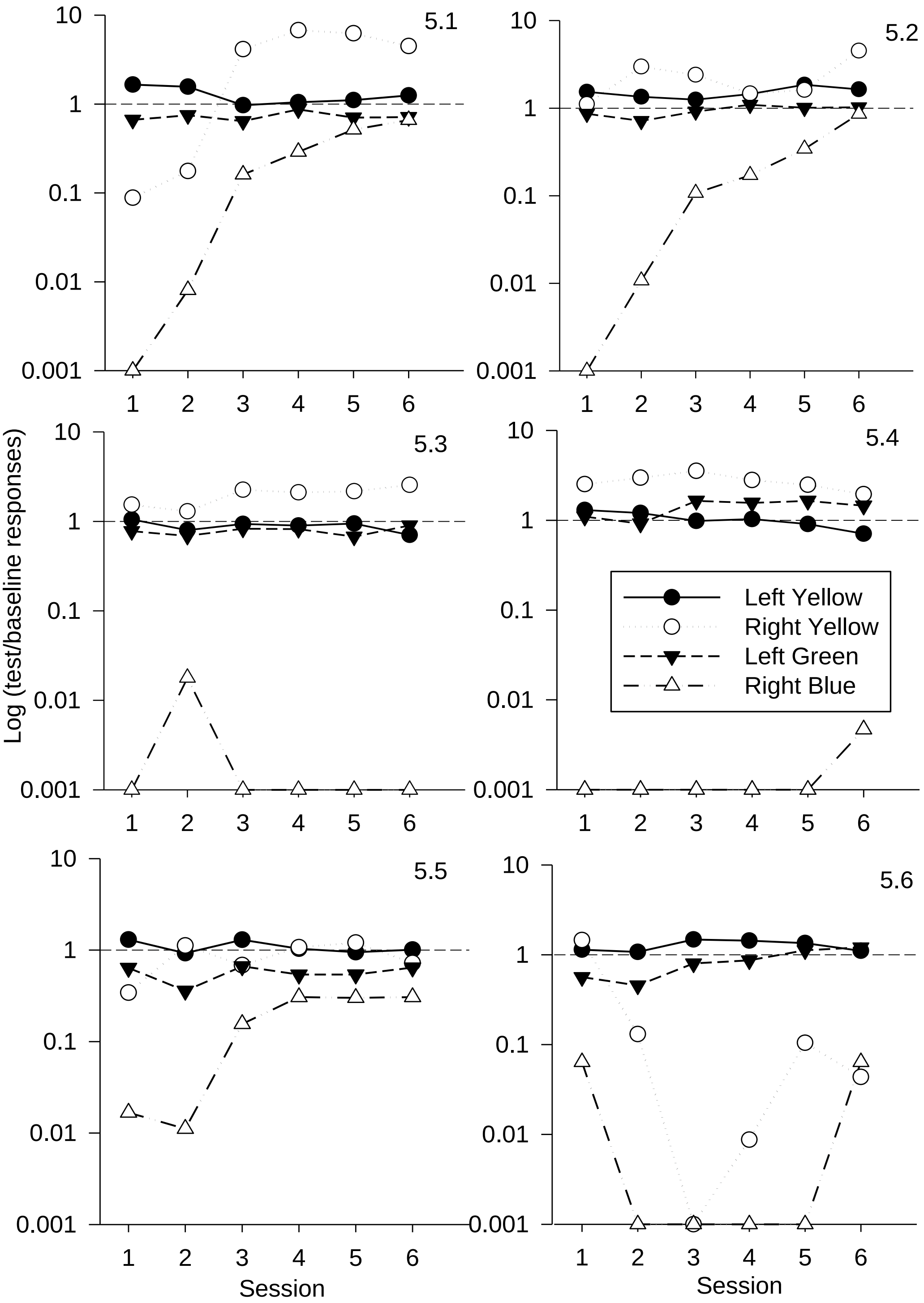


Figure 10.8. Responding plotted as a proportion of baseline during the disruptor test for all Group 1 Hens. The y-axis is on a log scale and the dashed line represents baseline levels of responding. The circles represent the Concurrent Component (filled = left yellow, open = right yellow) and the triangles represent the Combined Component (filled = left green, open = right blue).

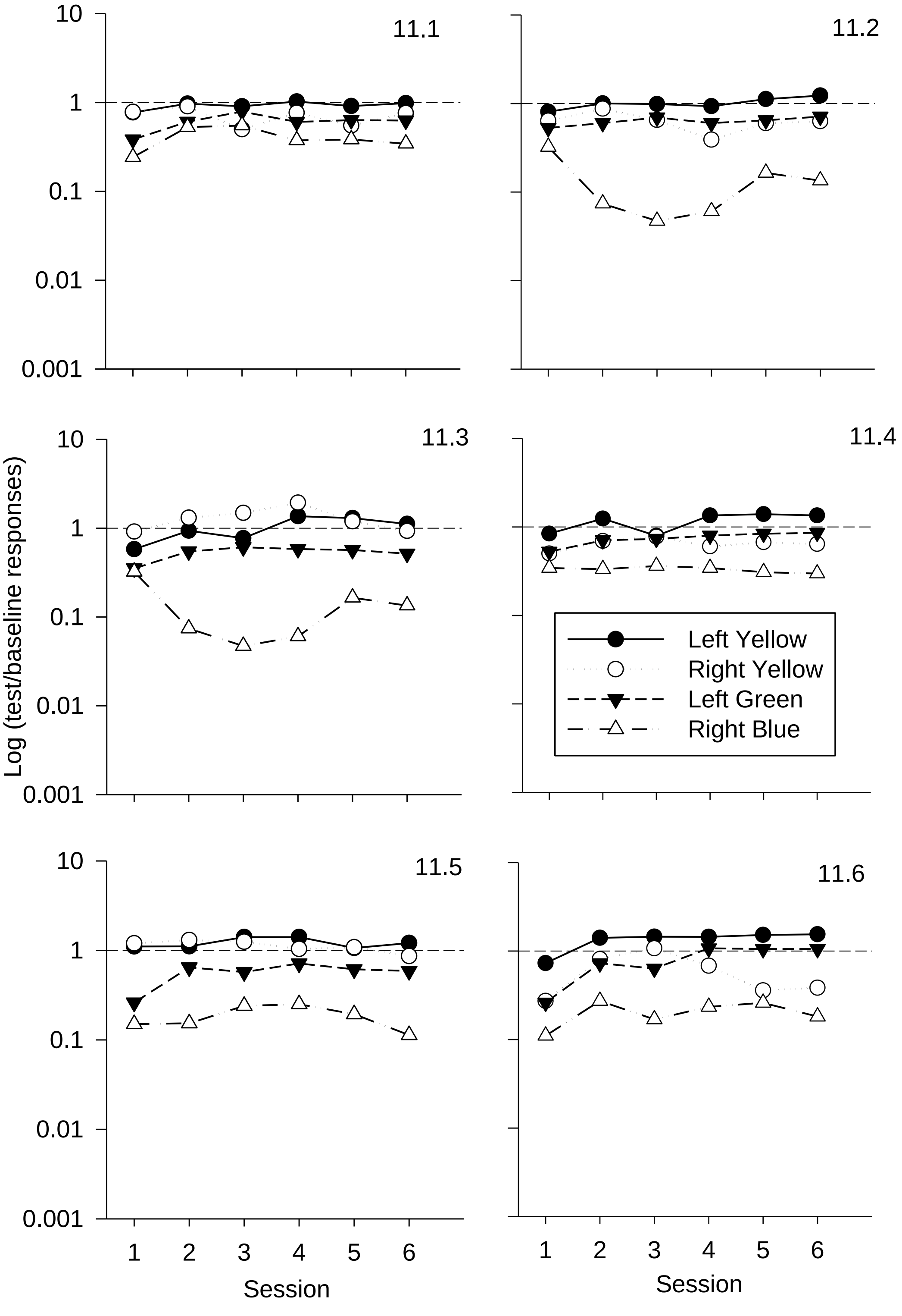


Figure 10.9. Responding plotted as a proportion of baseline during the disruptor test for all Group 2 Hens. The y-axis is on a log scale and the dashed line represents baseline levels of responding. The circles represent the Concurrent Component (filled = left yellow, open = right yellow) and the triangles represent the Combined Component (filled = left green, open = right blue).

Finally, Figures 10.10 and 10.11 show the number of responses on the red key disruptor when it was presented in between the Concurrent Component keys (filled data points) and the Combined Component keys (open data points). Most of the Group 1 Hens showed higher levels of responding to the red key when it was presented with the Combined Component, with the exception of a few individual sessions for 5.1 and 5.5. Hen 5.2 responded once to the red key on the first day and did not respond to it at all in either component for the rest of the disruptor test. In contrast, Group 2 Hens responded more to the red key overall in the Concurrent Component. There were some exceptions to this across individual hens and sessions, namely for Hens 11.2 and 11.4, who responded more to the red key when it was presented in the Combined Component across four out of the six sessions. In general, red key responding was lower for Group 2 Hens across both components in which it was presented.

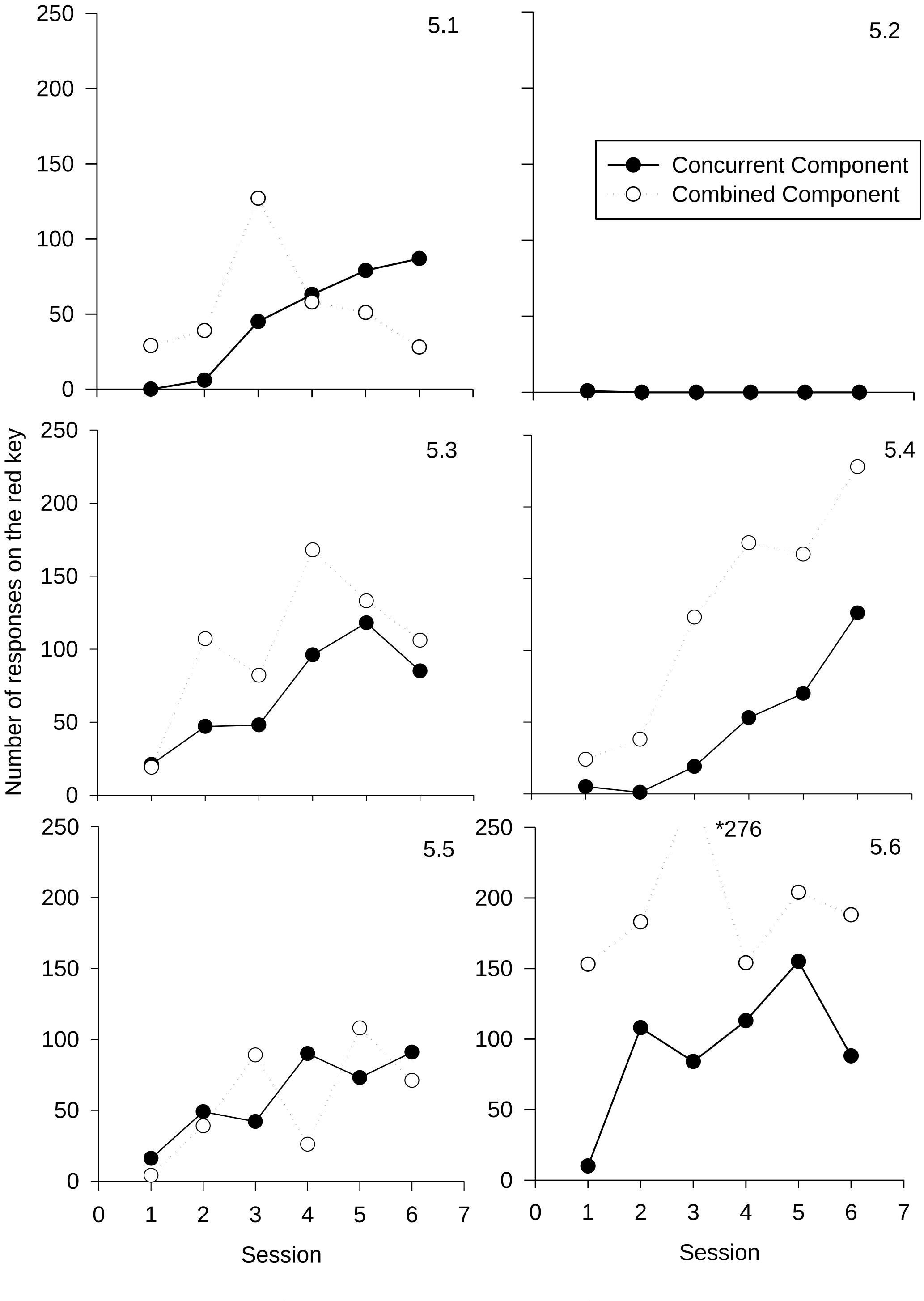


Figure 10.10. Number of responses on the red key for all Group 1 Hens during the disruptor test. The filled circles show red key responding when it was presented with the Concurrent Component (both yellow keys), and the open circles show red key responding when it was presented with the Combined Component.

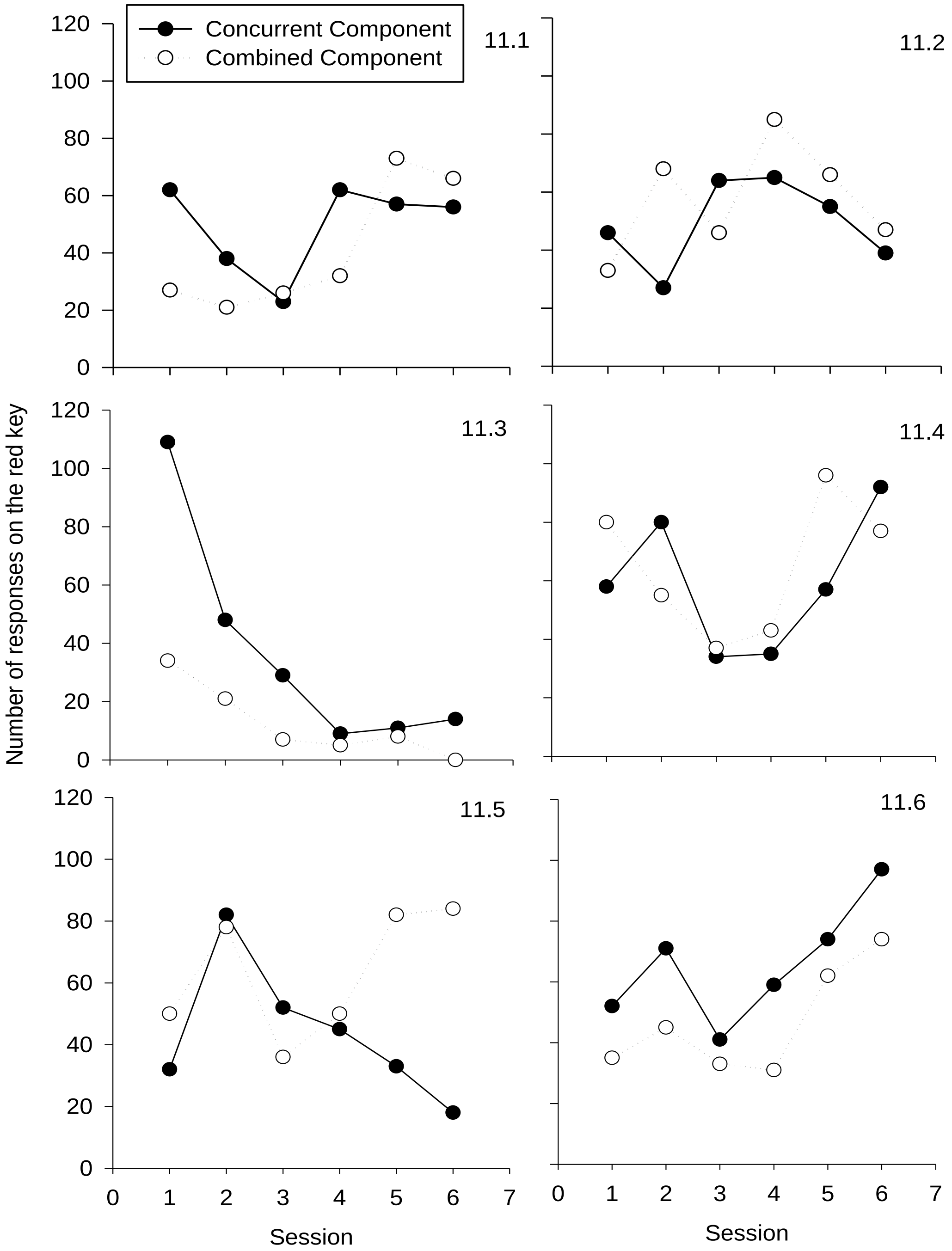


Figure 10.11. Number of responses on the red key for all Group 2 Hens during the disruptor test. The filled circles show red key responding when it was presented with the Concurrent Component (both yellow keys), and the open circles show red key responding when it was presented with the Combined Component.

Discussion

Aims and Overall Findings

This experiment investigated the effects of training a target behaviour in one context, and an alternative behaviour in a separate context, on persistence of that target behaviour. Persistence of target responding that had been trained in a separate context to the alternative behaviour was compared to the persistence of responding to a target behaviour that had been trained in the same context as an alternative behaviour. Unlike previous experiments, context was defined by using completely separate operant chambers, painted a different colour.

Overall, responding was less persistent to the Combined Target (right blue) key compared to responding to the DRA Target (right yellow key), and these findings were statistically significant. The results were the same for both groups of hens, one of which had a long experimental history (Group 2 Hens) and one that did not (Group 1 Hens). Group 1 Hens did, however, show an increase in responding on the right blue key, as shown in the response rate data, as sessions progressed, for Hens 5.1, 5.2 and 5.5 in particular. Although it was not for all hens, an increase in the target, or problem behaviour, is exactly what this procedure was aiming to prevent. Using two separate chambers to define the separate context was successful at reducing the persistence of the target behaviour. This suggests that it is possible to expand on the current findings by investigating the effects of separate contexts beyond that of individual key sides and colours.

Somewhat surprisingly, there were few differences in responding between the two groups of hens despite the differences in their previous experience, with the exception of a greater variability in right blue key responding for Group 1. Left green key responding was continually higher than responding elsewhere for most of the hens during baseline (see Figures 10.4 and 10.5), and whilst this reduced slightly more for some of the 5 group during the disruptor test, it remained high throughout. Left green key responses were comparable to other experiments in which the contexts did not change beyond that of an additional key light or colour. Left yellow key responding on the other hand, was slightly higher for Group 1 throughout both baseline and the disruptor test. This is quite possibly because Group 2 Hens had previously experienced a reduction in the reinforcement schedule associated with the left yellow key (see Experiment 8), however, the same reduction in schedule had also applied to the left green key, and aside from the first session, responding on this key continued at a high rate for all of Group 2.

Right yellow key responding remained quite similar across both groups of hens, although possibly slightly lower during baseline for some of Group 1. Right blue key responding on the other hand changed more for the Group 1 Hens during the disruptor test, with responding here generally lower than Group 2 responding on the same key. For several sessions, responding stopped on this key completely for most hens at varying times. Once again, previous experience could be responsible here, as responding on the right blue key had increased for Group 2 Hens when the schedule associated with the left yellow and left green key reduced, so it could be a carryover effect from their previous experiment. Another replication with another set of naïve hens could support this conclusion. As for red key responding, there was generally less responding on the red key for Group 2 than there was for Group 1, potentially because Group 2 Hens were less sensitive to the red key having experienced it before.

General Discussion of Experiment 10

Results of this experiment can be compared to previous experiments throughout this series using the red key as a disruptor. The red key was found to be effective at disrupting responding overall (so reducing the persistence of responding in its presence compared to baseline levels) in Experiments 2, 8 (for Group 1 hens) and 9, and for both groups of hens in the present experiment. In the present experiment however, the reduction in responding overall during the disruptor test was not as great as with previous experiments, and a greater reduction was observed on the left green and right blue keys. However, this reduction was still significant.

While there were differences in procedure prior to exposure to the red key over these four experiments, there was consistency in that reinforcement continued for alternative and target responding during the disruptor tests. The findings are consistent; not only did the persistence of responding overall reduce in the presence of the red key, but right blue (Combined Target) key responding, was less persistent than right yellow (DRA Target) key responding. This was also shown over the varying methodologies, including the two defined contexts in the present experiment.

Experiment 2 and the present investigation can be directly compared as both used the red key disruptor (note that only Disruptor Test 1 of Experiment 2 is being referred to here, as only one disruptor test took place in this experiment). Persistence of target responding was investigated in both experiments, one in which target behaviour was trained in separate components to define two different contexts (Experiment 2), and one in which the contexts were two separate operant chambers (the present experiment). Interestingly, there was a larger reduction, in terms of effect size (Cohen’s D), in the mean of the proportions of the number of baseline responses on the right blue key during Experiment 2, than there was for both groups in the present experiment (Experiment 2 d = 2.049, Experiment 10 Group 1 d = 1.503, Group 2 d = 1.935). Red key responding, however, was generally similar between the hens during Disruptor Test 1 of Experiment 2 and Group 2 hens during Disruptor Test 1 of Experiment 10. Although there was a greater number of red key responses for Group 1 hens in Experiment 10, this increased responding does not clearly explain why combining stimuli trained in separate components, rather than chambers, produced a greater disrupting effect. These findings could be investigated in the future by exposing the same subjects to both procedures, across more disruptor tests, and in clearly defined separate contexts.

The finding that the persistence of the target behaviour was reduced following training of the alternative behaviour in a separate context has clinical implications. It suggests that, if implemented in an applied setting, training an alternative behaviour in a separate environment to the one in which the problem behaviour was occurring, before combining it at a later stage, would result in less persistence of the problem behaviour. This was found when persistence of responding on the Combined Contexts Target key was compared to the persistence of responding using the traditional DRA methodology (i.e., introducing an alternative behaviour into the same context as the target behaviour from the start).

Previous research highlights the implications of this particular experiment using explicitly different contexts, due to the fact that the alternative and target stimuli were visually separated. Podlesnik and Bai (2015) compared the effects of combining alternative and target stimuli on different keys, with combining alternative and target stimuli on the same key in a series of extinction tests. Responding was less persistent in general for the target behaviour that had been trained in on a separate key to the alternative behaviour, than for the target behaviour when both behaviours were trained on the same key (Podlesnik & Bai, 2015). Their results suggest that the combination of stimuli that have been trained spacially separately will produce greater disruption to target responding, rather than training the two behaviours associated with the same key.

The visual separation of two different key stimuli is far greater when the target and alternative behaviours are trained in separate locations, such as in the present experiment. Podlesnik and Bai (2015) suggested that target responding would be less persistent following greater spacial separation from the alternative stimulus, than if the target and alternative were trained in the same location. One might expect then, that target responding in the present experiment, where the two contexts involve completely separate locations, to be even less persistent, than in previous methodology that has defined the contexts as separate components via different key light association within the same chamber. This is not what was found when the persistence of target responding in Experiment 10 (different chambers) was compared with the persistence of target responding in Experiment 2 (same chamber, different components), as shown by the reduction in responding compared above.

Limitations and Conclusions

There were limitations to this methodology, both in terms of the subjects used and the differentiation of the two contexts. Firstly, the previous experience of the Group 2 Hens (particularly in the thinning schedules) may have led to different responding on both the left and right keys due to this experimental history. Secondly, although the chambers were created to be different, it is still possible this was not enough to define two or three separate contexts. Nevin (2015) describes the possibility that the entire experimental chamber could be one context, and it was possible that this was the case during the present experiment. It could also be possible that applied settings are viewed as one context as well. DeLeon et al. (2015), likewise, question if separate classrooms actually function as two contextually different environments, or if, to the student, school is just one big stimulus context in which problem behaviour occurs.

However, the present findings do go some way toward showing that it is possible to create two separate contexts beyond that of key colour and location, to train target and alternative behaviour, by using separate chambers to do so. Reduced persistence of target behaviour was demonstrated, compared to the persistence of the target behaviour that had been trained in the same context as the alternative behaviour.

Chapter 8: Overall Summary and General Discussion

Summary

These experiments set out to explore potential solutions to the persistence-strengthening effects of DRA procedures. The first experiment was a replication of Podlesnik et al. (2012) who had expanded on a possible solution to the persistence-strengthening effects of DRA proposed by Mace et al. (2010). Using extinction as a disruptor, training an alternative behaviour in a separate context to that in which a target behaviour was occurring was successful at reducing the persistence of that target behaviour, when compared to two behaviours trained in the same context. Not only did this method prove successful at reducing the persistence of target responding, but extinction bursts to this target key in the Combined Component were reduced, a finding also shown by Podlesnik et al. (2012). The possibility of removing extinction bursts has strong clinical significance, due to the challenges associated with using extinction in certain environments (Athens & Vollmer, 2010), and where problem behaviour is too violent to risk an extinction burst (Lerman et al., 1999)**.**

The second experiment expanded these findings. A red centre key that provided reinforcement at a low rate was used as a disruptor, and reinforcement for the alternative and target behaviours continued throughout the disruptor test. Training the target, or right blue key, responding in a separate context to the alternative, or left green key, responding reduced the persistence of target responding, compared to that seen where the alternative behaviour had been trained alongside the target. This reduced persistence was shown when assessed as the proportion of baseline responding as this measure is used to assess persistence in the literature (Nevin, 1974). However, a reduction in the average number of responses on the Combined Target key, compared to the DRA Target key was also observed, and this reduction was also evident when responses on both target keys were compared to baseline levels. These findings expanded on Experiment 1 by successfully replicating the procedures used but without withholding reinforcement for responses to the alternative and target stimuli. The experiment showed that it was possible to generate results similar to that of Experiment 1, and the previous literature, whilst maintaining reinforcement and using different disruptors. This was an important first step in evaluating the persistence of behaviour with the use of disruptors that do not involve extinction.

In the next experiment the effects of increasing the reinforcement schedule on the centre key, on the persistence of the target behaviour, were examined. There appeared to be little effect on responding overall in the disruptor tests when this reinforcement schedule was increased, but the persistence reducing effects of training an alternative behaviour in a separate context to the target behaviour were still seen with both reinforcement rates. The main effect of increasing the reinforcement rate on the centre key was increased responding to this centre key. It was possible that this increased responding could cause a confound by altering responding on the other keys. Therefore, as discussed in Chapter 3, it was decided that a disruptor that could not itself be responded to, might reduce this confound and so provide a better measure of persistence of the responses of interest.

Although the use of a centre key as a disruptor had allowed alternative and target reinforcement to be maintained throughout, one downside of this disruptor was that more reinforcement was added to the environment, or context, in which the alternative and target behaviours were occurring. The persistence-strengthening effects of DRA interventions are hypothesised to be because of additional reinforcement in the environment when the alternative behaviour is trained in the same context as the target behaviour. Therefore, in hindsight adding even more reinforcement to this context, even to examine its effect as a disruptor, seemed a little counter-intuitive.

In addition, the effect of combining the two stimuli trained alone (the left green and right blue key of the Combined Component), without any external influence from a disruptor, was not known. Podlesnik and DeLeon (2015) suggested that combining two stimuli could actually be a disruptor in and of itself.

Experiment 4 therefore examined the effects of combining the alternative and target behaviours trained separately without any disruption. Target responding was then compared to the target responding in the Concurrent Component. As measured by the proportion of baseline data, the Combined Target (right blue) key responding continued to be less persistent than responding on the DRA Target (right yellow) key. In many ways this was not surprising because the target response that had been trained alone was now paired with an alternative response option, so one might expect target responses to drop. This is especially likely given that DRA Target responding had always been part of a concurrent, so it is not really clear if the reduction in Combined Target responding was due to a disrupting effect, or simply due to introducing a response option when one did previously not exist.

When the response rates on both of these keys was analysed, responding on the Combined Target key was greater than that on the DRA Target key. This finding raised the challenges of the use of proportion of baseline data as a measure of a persistence if studies are investigating the procedures for an applied setting. It also questioned the effectiveness of the Combined Contexts procedure if the Combined Target, or right blue key responding, was not actually reducing. Furthermore, during the No Disruptor Test there was no reduction in the response rates to the left and right yellow keys and the left green and right blue keys compared to baseline levels of responding. As discussed in the discussion section of Experiment 4, it was difficult to compare the DRA/Concurrent and Combined components, and the disrupting effects, as a potential disruptor had not been applied equally to both components.

Therefore, it was proposed to try disruptors that could be applied equally to both components to measure the persistence of both types of target behaviour. The idea was that such disruptors would not add any further reinforcement to the context and would reduce responding towards the disruptor itself.

The first disruptor used was a flashing centre key with no reinforcement, and no other consequences, for responding on the key. The persistence of target behaviour once again reduced in the component in which it had been trained separately to the alternative, but hens responded to the flashing centre key. This was particular noticeable during the individual stimulus disruptor test, a result similar to that seen with the active centre key.

The use of the flashing centre key as a disruptor did not show the same reduction in responding to each of the keys between baseline and the disruptor tests, as observed with the use of the centre key when it did provide reinforcement. During the earlier disruptor tests with the centre key disruptor, responding on both yellow keys and on the left green and right blue keys had generally decreased compared to baseline levels of responding. This had also been observed in previous research that provided an additional response option on a centre key and a reinforcement for that response (Nevin et al., 1981). Possibly this was due to the behaviour being allocated to the centre key when it was providing reinforcement that was taking time away from the left and right key responses. Behaviour was still allocated to the flashing centre key in this experiment, even though no reinforcement was provided for this.

What was needed was a disruptor that the hens could not physically access or respond to in any way. Therefore, in the next experiment the sound of a hen room at feeding time (on a repeating loop) was used as the disruptor (see Experiment 6 Introduction for rationale behind selecting this particular sound). This was successful at preventing the hens from responding to the stimuli intended as a disruptor, as it was not possible for them to access or peck anything to do with the sound. Persistence of target (right blue key) responding reduced compared to right yellow key responding. However, responding overall during the disruptor test (on both yellow keys and on the left green and right blue key), did not reduce in the presence of the sound, compared to baseline levels of responding.

The use of sound as a disruptor avoided the possible confound caused by disruptors that the hens could respond to. Despite this, persistence of responding was not vastly different to that when investigated using the flashing centre key as a disruptor. Still, the fact that the hens could not respond to the sound removes any potential impact on the other responses that was likely with the other disruptors. The findings suggested that sound could be a potential disruptor in future studies investigating the persistence of responding whilst avoiding the use of extinction.

In Experiment 7, hens were placed in a Perspex operant chamber during the disruptor test in an attempt to completely change the context from that in which baseline training had taken place. The data here supported previous findings, responding was less persistent to the right blue (Combined Target) key than the right yellow (DRA Target) key. There was also no reduction in the average responding on the left and right yellow keys and the left green keys during the disruptor test in the Perspex box, compared to baseline levels of responding on these keys. Interestingly, even though right blue key responding decreased, left green key responding didn’t. This showed that responding was more likely to continue towards the richer alternative, following training in separate contexts, than to the leaner target response option. The persistence reducing effects of training an alternative behaviour in a separate context to a target behaviour were shown when the responses rates, taken as a proportion of baseline response rates, were assessed. As with Experiment 4 (No Disruptor) though, the response rates were greater on the Combined Target (right blue) key when compared to the DRA Target (right yellow key).

The next experiments examined thinning the reinforcement schedules associated with the alternative behaviour (Sweeney & Shahan, 2013) and the use of low-rate DRA (Pritchard, Hoerger, Mace, et al., 2014; Sweeney & Shahan, 2013). The procedure involved thinning the reinforcement schedules associated with both of the alternative behaviours. These were the left yellow key (DRA Alternative) and the left green key. For one group of hens, the stimuli were presented as in the previous baseline procedure while these schedules were being thinned. For another group of hens, the left green key was combined with the right blue key during schedule thinning.

Experiment 8 aimed to combine two possible procedures for decreasing the persistence-strengthening effects of DRA interventions; thinning the reinforcement schedules associated with the alternative behaviour, and training that alternative behaviour in a separate context. This procedure was more successful for the group of hens who were exposed to the schedule thinning process during the original baseline exposure, responding on the Combined Target (right blue) key was less persistent than responding on the DRA Target (right yellow) key. These findings provided support for the use of both procedures together, rather than just thinning schedules or Combined Contexts Training alone.

There were, however, some concerning results for the group of hens who had been exposed to the Combined Component while the schedules were thinned. Some of the group demonstrated increased persistence of responding on the Combined Target key when compared to baseline, possibly because of the additional amount of time they had been exposed to the Combined Alternative and Target stimuli compared to the other group. Previous, unpublished research, discussed by Podlesnik and DeLeon (2015), suggested that longer term exposure to the Combined Context procedure produces no less persistent responding than traditional DRA interventions.

Throughout the previous experiments, there were difficulties in determining exactly what caused the reduced persistence of responding on the right blue key when it was presented as part of the Combined Component. It seemed unequal that the right blue key was always presented alone initially, whereas the right yellow key was always paired with a richer reinforcement schedule available on the left yellow key. In particular, this part of the baseline procedure was not aligned with how a DRA intervention might be implemented in an applied setting. It seems very unlikely that in a clinical model of this procedure, the alternative behaviour paired with a source of reinforcement would be introduced at the same time as the target behaviour, regardless of whether this in the same context (traditional DRA) or a separate context (Combined Contexts DRA), (see Experiment 9 Introduction for a more detailed explanation).

This confound was also considered as a possible cause for the increase of responding compared to baseline levels on the right yellow key during the presence of a disruptor, because the right yellow key was continually associated with the left yellow key which offered a richer source of reinforcement. This increase in responding to the right yellow key was observed throughout all experiments, in particular when the right yellow key was presented as an individual stimulus during the second disruptor test of each experiment that ran this specific disruptor test.

When the responses rates were analysed during disruptor tests there were greater amounts of responding to the right blue key than to the right yellow key (Experiments 4 and 7). However, the proportion of baseline data from these same disruptor tests almost always showed less persistence of responding to the right blue key compared to the right yellow key. Given that these experiments aimed to investigate both persistence of target responding, but also examined the effectiveness of the Combined Contexts DRA procedure as an intervention, the use of both response rates and proportion of baseline measures are important. The increased response rates to the right blue key in previous experiments however, raised concerns about the effectiveness of this procedure as an intervention.

A potential solution to this was to train both yellow and blue target keys initially, in separate contexts, alone. This phase closely resembled ‘true baseline’, or a baseline situation analogue to an applied setting where target behaviour would be occurring before an alternative was introduced. Then, the right yellow, or DRA Target key would be presented with an alternative key, to resemble a DRA intervention (as has occurred in previous experiment baselines in this thesis). The right blue key would remain separate to the alternative, or left green key, before being presented together in the Combined Component during disruption.

This experiment showed reduced persistence of responding to the Combined Target (right blue) key compared to the DRA Target (right yellow) key when measured under disruption, even though responding on both target keys had started out equally. This was found when the proportion of baseline was calculated on the number of responses during the initial baseline phase, and during the intervention phase. Furthermore, response rates were lower in the disruptor test on the Combined Target (right blue) key than on the DRA Target (right yellow) key, an opposite of the findings found when this measure had been assessed in Experiments 4 and 7. This was important, as it meant that both the response rates, and the persistence, reduced on the Combined Target key during the disruptor test. This suggests the method of training the alternative behaviour in a separate context to the target behaviour is successful at reducing the persistence of target responding when measured from a true baseline phase.

If a model based on these experiments was to be examined as a clinical trial, then gathering data on the initial rate of target behaviour to compare the effects of both types of intervention would be essential, as discussed in Experiment 9, to analysing the effects of each intervention. These initial data suggest that such a model could be effective at reducing the persistence of target behaviour. One limitation to applying this model however, is that the start of the disrupter test is the start of the Combined Contexts DRA, but not the start of the DRA intervention. This begins during the earlier intervention phase (or the other baseline procedures used in the previous experiments). Although this experiment improves the initial baseline procedure, there was no comparison of which DRA procedure (traditional or Combined) actually produced lower target response rates compared to their corresponding alternative responding.

As discussed in the Introduction and Experiment 7, there is difficulty in defining exactly what constituted a “context”. More specifically, it was not clear whether or not two separate stimuli in a multiple component schedule clearly signal two separate contexts (see Experiment 10 Introduction for further discussion). Therefore, the final experiment aimed to create two clearly separate contexts in which the alternative and target response could be trained. This was analogous to an applied setting where a problem behaviour may be occurring in a classroom, but then a therapist, or similar, trains an alternative behaviour outside of the classroom environment before introducing it into the classroom once it is established. The outcome of this procedure was then compared to that from training an alternative behaviour in the same context in which the target behaviour was already occurring, just as in a traditional DRA. The results supported previous findings; the target behaviour trained separately was less persistent than that which had been trained in the same context as the alternative. Interestingly, as discussed in Experiment 10, there was actually less persistence of responding on the Combined Target key when it was assessed using the red key disruptor during Experiment 2 (same chamber) rather than Experiment 10 (different chambers). Although Experiment 10 supported the previous findings then, it still raises questions about how to accurately define, and then separate, a context.

General Discussion

The latter experiments in this series raised several issues in translating the Combined Contexts DRA procedure to the intervention it is designed to replicate. This series of experiments started off to investigate persistence of target responding in the presence of disruptors, as measured through proportion of baseline responding. As the hens were exposed to different ‘baselines’ (i.e., baseline after thinning schedules in Experiment 8, baseline using both target keys in Experiment 9), the proportion of baseline measure becomes more difficult to interpret because one needs to be clear about what should be used as the baseline in the first place. Of the experiments carried out, the baseline that used the two types of target responding (Experiment 9) seemed like the most appropriate analogy to a true baseline, such as used in an applied setting, and therefore the most appropriate measure for proportion of baseline. There is no known research analysing the best representation of baselines for these measures.

Another issue was the comparison of the two types of procedures examined (traditional DRA and Combined Contexts DRA). What started as an investigation into persistence, led to comparisons between these two methods during disruptor tests. Whilst this is in line with previous literature that has used the investigation of such procedures to examine the effectiveness of interventions (for example, Mace et al. (2010), and those who have investigated similar procedures with this aim, e.g., Podlesnik and Kelley (2014)) there may be better ways of comparing these types of procedures than used in the current analysis. For example, comparison between the two procedures to determine the most effective method for an intervention would require more detailed analysis of the response rates to see which procedure reduced response rates to a greater degree compared to baseline.

In applied settings, behaviour that is continuing after an intervention is unlikely to be measured through proportion of baseline. Instead, it is more likely to be analysed, and for interventions to be determined as effective, through frequency of responding or response rate data. Although persistence is defined as responding relative to baseline levels (see Introduction for full discussion), responding can still be compared to baseline without using proportions. For example, a problem behaviour occurring 10 times during baseline but five times following the intervention is still behaviour occurring relative to baseline levels. The main concern for practitioners is the continuation of problem behaviour after an intervention ends (Nevin, 1996), and this should be able to be measured through any appropriate means of data necessary.

The two issues discussed above are related to one another, because in order to compare the effectiveness of the two procedures in relation to the most effective intervention, the pre-intervention baseline would need to be clearly defined. In the present procedures (with the exception of Experiment 9), this is not the case, as the intervention for the traditional DRA procedure typically starts prior to the intervention for the Combined Contexts procedure.

One of the key implications of this research however, is the finding that the Combined Contexts procedure can reduce the persistence of target responding when both types of target responding started out equally (Experiment 9), resembling a baseline procedure in an applied setting. Further investigation into this use of this baseline procedure is essential to draw clear links to the potential applications of the Combined Contexts procedure. In Experiment 9, persistence was evaluated using the red key disruptor, which was done so that reinforcement could be maintained for the alternative and target behaviours. Evaluating persistence following this initial baseline procedure, with the use of other disruptors, and with more disruptor tests than used in the present study, to see if these findings can be replicated, would be beneficial to the translational literature. If a greater body of experimental evidence using and supporting this procedure, then evaluating persistence of target responding as part of a clinical trial to see if this method translates effectively, would be worthwhile further research.

This research examined the effects of a variety of different disruptors that to the best of the author’s knowledge, have not been used previously to assess the persistence of responding in their presence. As stated previously, the use of disruptors that did not require removal of reinforcement for the alternative or target behaviours of interest was a fundamental aspect of this research. Extinction has been used in much of the research in this area, but these data show it is possible to examine persistence without the use of extinction. Extinction has been an integral part of research on resurgence, and Lattal et al. (2017) also suggested that it extinction may not be as essential as previously thought to the understanding of resurgence. Although the behavioural processes underlining resurgence differ slightly from the processes examined in this series of experiments, research on both aims at further understanding, and ultimately reducing, the persistence of problematic behaviour. These experiments show that response persistence can be investigated without eliminating reinforcement for the behaviours of interest entirely, and future research will hopefully continue in the same way.

There were limitations to the experiments in this series, and these have been discussed in each of the relevant chapters. In addition to those previously discussed, hens received six sessions of exposure to the centre key prior to all of the experiments in which the centre key was used as a disruptor (Experiments 2, 3, 8, 9 and 10). While this provided an association between the centre key and the reinforcement schedule it was paired with, this initial exposure could have altered its effects as a disruptor, compared to a novel stimulus. It is not possible to know if the prior exposure and the association with reinforcers had any effect as none of the hens in these experiments were ever exposed to the centre key as a disruptor without prior exposure to it initially. If these experiments were to be replicated with the use of a centre key as a disruptor, having two groups of subjects, one exposed to the centre key with reinforcement initially, and one not, would help to evaluate the impact this initial exposure has on the effects of a centre key as a disruptor.

Throughout most of these experiments (excluding Experiments 1 and 2), the third disruptor test was always a repeat of the first disruptor test. This was partly due to trying to keep similar exposure to the stimuli as in Experiment 1, but with modifications, necessary when extinction was no longer used as a disruptor. Although presenting the same disruptor test twice allowed for useful investigation as to the effects of that disruptor, and the persistence of behaviour in its presence, it is possible that the repeated exposure also compromised these results. This is because the hens would have had previous experience with the stimuli presented, the disruptor presented, and the reinforcement schedules associated with each. Not only that, but the same subjects were used for multiple experiments within this thesis, so in addition to the same disruptor tests within experiments, the same stimuli were also used across experiments with different disruptors. Whilst there is research suggesting the effects of repeated extinction tests on results are minimal (see Bai and Podlesnik (2017) for a recent example), there is no known research analysing the effects of repeated disruptor tests that maintain reinforcement. Again, it is unclear what impact this repeated exposure may have had on the subjects. Future research might consider either changing the order in which the disruptor tests are presented, or withholding some subjects from this repeated exposure to analyse any differences in responding.

In the translation of these findings into clinical application, the length of time that the separately trained alternative and target stimuli are combined in the presence of the disruptor could impact the success of the intervention, as discussed in more detail in Experiment 8. This is because longer term exposure to both alternative and target stimuli as one combined component suggest that behaviour is no less persistent than a traditional DRA procedure. Long term investigation of persistence is something that limits this basic methodology from further application.

Many applied studies do not report the long-term removal of problem behaviour following DRA interventions (see Petscher et al. (2009) for a review), and others experimental studies, including the ones in this series of experiments, do not examine persistence beyond six, nine or 12 sessions. This is likely to be fewer than required for a successful intervention in an applied setting. These experiments were not designed to investigate the long-term persistence-reducing effects of the proposed solutions, but additional research examining these effects should be considered. It is hard to investigate these long-term effects in both experimental and applied settings. In both areas, repeated disruptor tests, and repeated presentations of the target stimuli over extended periods of time could provide some answers. Comparison to the persistence of responding in the initial stages after baseline, and again at a later time, could then give a measure of the persistence-reducing effects.

Context is particularly difficult to define, with the definition outlined in the Introduction referring to the wider environment surrounding a response and its association with a particular stimulus and/or reinforcement contingency. Bouton (2014) states that contexts are “made up of many stimulus elements” (p. 32), and it is well known that operant behaviours are influenced by various discriminative stimuli within, and often specific to, a particular context. Without analysing the function of a specific behaviour, controlling the reinforcement, and evaluating the controlling discriminative stimuli within a particular context, it is difficult, at best, to determine which part of the context is the part influencing behaviour. Only if that is achieved, can the contexts, or specific discriminative stimuli, be separated completely as attempted in Experiment 10. If behaviour is influenced by several variables, or stimuli, within a context, which seems likely if not certain, then clearly ensuring each one of those variables are not present in a context, so as not to inadvertently provide an antecedent for that behaviour to occur, remains a great challenge. Greater understanding of the influence of specific discriminative stimuli within a context or the problem behaviour occurring in that context would be ideal, before implementing training in separate contexts in order to change long-term persistence of problem behaviour.

Future research is paramount to continue to explore these findings, and others, into the most effective ways to reduce the persistence of problem behaviour, particularly problem behaviour caused as a side effect of DRA interventions. One possibility could be the use of signalled alternative reinforcement in combination with the methodology of combining behaviours trained in separate contexts. Findings from Nevin et al. (2016) showed strong support for reducing the persistence of target behaviour by signalling the availability of the alternative reinforcer in DRA procedures with both pigeons and children, while the current findings, and others, provide support for the combined contexts procedure. As suggested previously, it is possible that a combination of methodologies, such as signalling the availability of alternative reinforcement with Combined Contexts Training, will provide not only the best understanding of the processes influencing persistence, but also the best options to reducing the persistence of problem behaviour in clinical application.

Whilst combining methodologies known to reduce persistence in an experimental setting is useful for further investigation, one downside of potentially combining those methodologies in applied settings is the time it takes to implement. For example, using both thinning schedules and combining the stimuli trained separately in the present investigation took over 40 sessions of daily exposure, which in an experimental setting is completely feasible. However, not all interventions have this luxury with time or resource. A further possibility for reducing the persistence of a problem behaviour is to do so over a longer period of time than typically happens using extinction, for example, to reduce the amount of relapse (Lit & Mace, 2015; Schieltz et al., 2017). Whilst it seems that there are definite benefits to removing the problem behaviour more slowly to combat both resurgence, and the long-term persistence, practically this may not be possible if a behaviour is particularly problematic, or if there is not the time or resources to implement such a strategy.

There are benefits from translational research, but before the implications of these findings can be fully understood and applied, clinical trials would need to take place to ensure they were actually replicable and successful with humans. Whilst there have been several attempts to do this (for example; Mace et al. (2010), Kelley et al. (2015), Nevin et al. (2016)), none of the methods explored have maintained reinforcement for the alternative and target behaviours, nor have they investigated the combination of some of the procedures such as those done here.

Conclusions

Despite the need for further investigation into the persistence-strengthening effects of DRA interventions, there are clinical implications from the present findings. Findings from translational research, such as this series of experiments, allow interventions to be guided in such a way that unwanted side effects can be reduced (Lit & Mace, 2015) and the most effective interventions implemented (Podlesnik & Kelley, 2015).

These studies undertaken in thesis have shown that there is potential for training an alternative behaviour in a separate context to the one in which the target, or problem behaviour, is occurring to reduce the persistence-strengthening effects of DRA interventions. Using several disruptors other than extinction allowed reinforcement to be maintained for the alternative and target behaviours. This meant that these responses did not reduce entirely as they would with extinction, so the persistence of responding in the presence of the disruptor could be evaluated in terms of a reduction or an increase in responding compared to baseline. The use of the different disruptors allowed for evaluation of the effects of this range of disruptors on the persistence of responding in their presence. An alternative baseline procedure was also examined for comparing the traditional DRA method with the Combined Contexts DRA method, and this involved training the two types of target responding initially before introducing the alternative response option. The translational implications of this procedure provided a direct comparison to problem behaviour, and subsequent DRA interventions, occurring in an applied setting. Finally, examining the wider notion of context, beyond that of a single stimulus, allowed greater support of this procedure as a possibility to reduce the persistence of problem behaviour. The procedures evaluated here further the understanding of persistence and the use of disruptors to measure persistence, and contribute to the translational research aiming to experimentally investigate matters of applied significance.

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