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EFFECT OF RESPONSE RATES ON NON-DISTRACTED AND DISTRACTED CONDITIONAL DISCRIMINATION PERFORMANCE

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Toby Gwynne Campbell

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ABSTRACT

Two experiments were carried out in order to see if higher rates of responding during training result in higher stability of accuracy in the face of distraction. In the first experiment hens were exposed to a repeated acquisition procedure where they were taught to peck a number of 3 key combination response sequences (chains). In the first condition hens had the opportunity respond at any rate, in the second condition delays between each correct response were used to reduce response rate. Each session was made up of two periods. During the first period (training), hens learnt to complete chains. The second period was a test period where a stroboscope was used to distract behaviour. Accuracy during each condition and period was measured. The number of trials and rate of reinforcement were held constant. This procedure was repeated in a second experiment in order to test if habituation to the stroboscope was occurring. During both experiments the stroboscope was found to distract behaviour during the test period. During training, accuracy was higher for the no-delay condition than the delay condition. There were no large differences in accuracy between the no-delays condition and the delays condition during the test period, this was the same for both experiments. The second experiment showed that repeated presentation of the stroboscope resulted in higher accuracy meaning that habituation had occurred. The findings showed that when rate of reinforcement and number of practices were controlled, rate of responding alone during training did not change the stability of accuracy during distraction which was unexpected.

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DEDICATION

This thesis is dedicated to my parents. Thank you so much for your incredible encouragement of my goals, believing in me every step of the way. There is no doubt that without your, understanding, love, support, and parenting that this thesis would not have been finished, or started for that matter.

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Introduction

Problem:

Distraction is interference by irrelevant information that competes with information relevant to the task at hand (Lorch, Anderson, & Well, 1984). Distraction often causes problems in the workplace, classroom, while driving and in many other situations.

Work place:

A study of textile workers measured correlations between workplace sound levels in decibels (dB) and worker performance. For 2458 male workers, workplace sound levels were measured and correlated against production efficiency, production incentive, disciplinary actions, absenteeism, accident incidence, accident frequency rate, and severity. The results were split into a high noise group (above 90dB average) and a low noise group (below 90dB average). Findings were that workers in the high noise group had lower efficiency, received fewer production incentives, received more disciplinary action, and had more absenteeism than the low noise group. There were no other large differences between groups (Nowei, 1984). These findings suggest that high amounts of continuous noise distract people from the relevant information required for good performance in the work place.

An experiment by Venetjoki, Kaarlela-Tuomaala, Keskinen, and Hongisto (2006) measured the distractibility of different intelligibility levels of speech in an open plan office. Participants were exposed to three conditions each with a different speech to masking noise ratios, this varied speech intelligibility: a speech condition (high decibel level speech/low decibel level masking noise), a masked speech condition (medium decibel level speech/high decibel level masking noise) and a noise condition (low decibel level speech/high level decibel level masking noise). These conditions were designed to correspond to poor, acceptable and perfect acoustical privacy in an open-plan office, respectively. During each condition participants completed questionnaires' relating to sensitivity to noise and the effect each condition had on them. Participants also carried out computer based tests on reaction time, subtraction, whether presented sentences made sense, the ability to sustain attention and the Stroop test which involves saying the name of the colour of a word regardless of its meaning. Tests on comprehension and proof-reading were also carried out. The results showed that the performance on computer based tasks and reading comprehension were not different during proofreading, performance was significantly worse for the speech condition than the other two conditions, and subjectively the participants rated the speech condition as the most unpleasant and most disturbing and the noise condition as the most pleasant and least disturbing. This experiment shows that intelligible speech is more distracting than noise and impairs performance so is not ideal in the workplace.

In an experiment by Czerwinski, Cutrell, and Horvitz, (2000) on the distracting effects of instant messaging on work related performance, participants were told that they would be receiving notifications throughout the experiment on the computer they were working on from the experimenter. Participants were then asked to find a book title on a spread sheet using the direction arrows on a keyboard. During half the trials participants were given the name of the book title they had to find and in the other half they were given the gist of the book title but not the actual name. In addition, during half of all trials participants were distracted with an instant message which contained a multiplication or division problem as the content. Participants were asked to complete the math question and then return to their previous work. The results showed that when receiving notifications subjects took significantly longer to complete the search trials compared with not receiving notifications with time to complete the notification subtracted from total time. The results of this experiment mean that instant messaging distracts workers from tasks and reduces work performance even when the time taken to answer notifications is taken in to account.

Classroom:

Poor acoustics in the classroom producing long reverberation times have been shown to have a distracting effect on behaviour and learning in the classroom (Klatte, Hellbrück, & Seidel, 2010). Reverberation times for 17 different classrooms were measured and participants from these classrooms were asked to fill out a number of questionnaires and assessment. The questionnaires asked about noise in the classroom, and social and emotional attitudes to the noise. Phonological processing, written language acquisition, and nonverbal intelligence were assessed. Further, parents of the participants completed a questionnaire on socio-demographic circumstance, and their child's reaction to noise. Results showed that participants in classrooms with longer reverberation times performed worse on phonological processing tasks than participants in classrooms with shorter reverberation times and this was not related to any other measure. Participants in classes with longer reverberation times also reported higher burden of noise and had a less positive relations with peers and teachers. This experiment shows us that long reverberation times increase the distractibility of noise in rooms which can cause poor phonological processing and reduce positive social interactions.

In a second experiment by Klatte, Hellbrück and Seidel (2010) participants were tested on matching sounds to pictures and sentence comprehension, this time participants were tested in two settings: their original classroom and a control sound-attenuated room. The results showed that participants from classrooms with long reverberation times showed more improvement on the matching task when moved to the control room compared with participants from classrooms with short reverberation times. No significant differences were found for the sentence comprehension segment. The results suggest that the acoustics in a room can make distractions more prominent and reduce learning ability.

Schools under the flight path of airports are subject to high amounts of noise, which can distract reading acquisition (Evans & Maxwell, 1997). Students at two primary schools were tested on their reading abilities. One of these schools was underneath the middle of a flight path used by a busy airport and was exposed to over an average of 65 decibels in 24 hrs. The other school was not near any airport’s flight path; however, an average decibel level was not provided. Both schools were matched for demographic variables such as average income, ethnicity and percentage of pupils with English as a second language. Results show that pupils in the noisy schools had significant reading deficits compared with those in the quiet school. The results suggest that intermittent loud noise in schools acts as a distracter and can lower reading ability.

Noise can have a negative effect on intellectual performance (Weinstein, 1974). University students were assigned to either a noisy group or quiet group and tested on proof reading accuracy and speed. Participants in the noisy group were subjected to noise from an automatic typewriter which produced noise between 66 and 70 dB at random intervals lasting for 2.5-15-s and totalling 30 s per min. When the typewriter was not typing the motor produced a 50 dB hum. Participants in the quiet group worked in ambient noise of approximately 36 dB. The results showed that there was no significant difference in accuracy when detecting spelling errors or recall of proof reading content. The noisy group had significantly less accuracy when detecting grammatical errors compared to those in the quiet group, and worked significantly more slowly but more accurately during the noise intervals than the intervening quiet periods. The results suggested that comprehension of sentences was disrupted by the distraction of irrelevant noise.

Driving:

Use of phones during driving has been shown to reduce driving ability which can result in accidents Brown, Tickner, and Simmonds (1969) studied the interference between concurrent tasks of driving and phone use. Participants were tested on whether they would take different sized gaps in traffic while talking on a phone or not talking on a phone. The results showed that use of a phone made it more likely that people would make dangerous choices of what size gaps to take. This suggests that use of a cell phone while driving is distracting and reduces decision making ability.

McKnight and McKnight (1993) tested the effect of cellular phone use and age upon driver reaction time. Participants were subjected to five conditions: placing a cell phone call, carrying on a casual cell phone conversation, carrying on an intense cellular phone conversation, tuning a radio, and no distraction while driving using a simulator. There were three age groups: 17-25, 26-45, and 50-80 years old. Drivers 17-25-showed only slightly increased reaction time for placing a call and carrying on a casual conversation. Drivers older than this showed a greater degree of impairment to reaction time. All age groups showed much higher reaction time for intense conversation. Radio tuning showed highest reaction time for the 17-25 group and overall was second most distracting after the intense conversation condition. This shows that older people are more easily distracted by use of phones while driving and by radio tuning but both old and young people have longer reaction times when subjected to these distractions. Cell phone and radio tuning are therefore distracting and dangerous while driving.

Strayer and Johnston (2001) tested performance using a driving simulator to investigate the effect of conversing on a cellular phone while driving in two experiments. During the first experiment, participants carried out a cursor tracking task using a joystick. Included in this task was a light that flashed red or green, when it flashed red participants were asked to press a button on the joystick as a brake. Participants were assigned to radio control, handheld phone, or hands-free phone groups. There were two conditions: single task, and dual task. During the single task there was no distraction during the tracking task and during the dual task the participants were presented with the distraction coinciding with their group during the tracking task. The Participants were measured on percentage of missed red lights and reaction time. No significant difference was found between handheld and hands free groups. Talking on a cell phone made participants significantly more likely to miss a red light and have slower reaction times compared to when no distraction was present and when listening to a radio. There was no significant difference between listening to the radio and having no distraction present. This means that using cell phones reduces reaction times and makes people more likely to miss important cues while driving.

In the second experiment participants were only to carry out the tracking task. There were three groups: shadowing of words spoken to them on phone, generating words starting with the same letter the word spoken to them ended with, and no distraction. The conditions were easy and hard tracking. Results showed that errors increased with tracking difficulty, the word generation condition showed significantly worse accuracy during the difficult tracking conditions than both shadowing and single task conditions. There were no other significant differences. This suggests that phone use whether hands-free or not is distracting to driving performance.

Solutions:

It is clear that distraction causes problems in many aspects of our society within the workplace, the classroom and while driving. Finding ways of reducing the effects of distraction could therefore solve these problems. Removal of distraction, masking, use of drugs, and precision teaching are ways that have been used to make behaviour persist in the face of distraction thus reducing the effects of distraction.

Removal of distraction

Removal of distraction means that there is no longer a distracting stimulus. A number of studies compare distracting conditions to non-distracting conditions. Performance during the non-distracting conditions was significantly better than the distracting conditions in the following studies: Nowei,(1984); Czerwinski, et al. (2000); Klatte, Hellbrück et al. (2010), Evans & Maxwell, (1997); Weinstein, (1974); Brown, Tickner, and Simmonds (1969); McKnight and McKnight (1993); Strayer and Johnston (2001). Removal of distraction however is not always possible as the distraction may be a necessity such as with phone calls during work or machinery noise. This means that other ways of lowering the effectiveness of distracting stimuli need to be found.

Masking

Masking is overlaying a stimulus over a distracting stimulus in order to reduce the effects of the distracting stimulus, thus masking the distracting stimulus. Pink noise has been used effectively to mask irrelevant sound, and increase performance during sound distraction across two experiments by Ellermeier and Hellbrück (1998). During these experiments participant's performance was measured during a serial recall task using a digit sequence by recording the percentage of correct responses. In the first experiment, performance was measured during silence, pink noise, Japanese speech (participants could not speak Japanese) and music to determine distractibility of each condition. There was no significant difference between pink noise and silence; however, speech and music were significantly more distracting than these conditions. In the second experiment during the serial recall task, pink noise to speech ratios were compared to examine how masking affects performance during distraction from irrelevant speech. Higher pink noise to irrelevant speech ratios resulted in fewer errors on the serial recall task. The results of these experiments prove that distraction from irrelevant speech is reduced by masking the sound with pink noise and that masking is an effective way to reduce distraction. Unfortunately masking is not always practical, for example music may be distracting for security workers at a concert but it is not practical to overlay the music with pink noise as it would ruin the concert.

Drugs

Drugs have been used to improve people's ability to perform in the face of distraction. A mental disorder called attention deficit hyperactivity disorder (ADHD) is characterised by a lack of attention, impulsiveness and overactive behaviour (Kerig & Wenar, 2006). Stimulants are used in the treatment of ADHD, a study by Peterson, et al. (2009) tested the effect of stimulant ADHD medication on performance in the face of distraction. Participants with an ADHD diagnosis who respond well to medication and had been using either Methylphenidate Dextro-Amphetamine or Dextro-Amphetamine/Amphetamine were recruited and assigned to either the medicated ADHD group or the non-medicated ADHD group. The medicated group used their preferred medication and the non-medicated group received no medication. Both groups carried out the Stroop test which involves saying the name of the colour of a word regardless of its meaning. Words presented were colours which either matched the colour of the word itself or didn't match the colour of the word. The results showed that the medicated ADHD group was less distracted by the meaning of the word than the non-medicated ADHD group. This shows that methylphenidate can effectively improve performance in the face of distraction in ADHD diagnosed individuals. While Methylphenidate, Dextro-Amphetamine and Dextro-Amphetamine/Amphetamine can reduce distraction, they are not always practical due to adverse reactions or the potential for abuse.

Precision teaching:

Precision teaching is a teaching method used to establish fluent behaviour (Hughes, Beverley, & Whitehead, 2007). This method can reduce the effects of distraction on behaviour by making behaviour fluent in the face of distraction without the problems involved with removal of distraction, masking, and drugs.

At the heart of PT are a group of tenants proposed by Kubina and Morrison (2000) which provide the guiding principles for precision teaching. The first tenant encourages changes to be made to the teaching methods based upon child's performance (i.e., "The child knows best"). This involves choosing interventions or changing learning plans to suit the student's ability. The second tenant states that teachers should use rate of response as the basic datum. This measurement relates to the number of correct responses per min and provides not simply an accuracy measure, but how frequently the correct response is occurring. The third tenant says that precision teachers use a Standard Celeration Chart (SCC) to display frequency data. These charts are useful in making data-based decisions and to guide teachers in how to instruct their students. The final tenant states that only directly observable behaviour will be the focus of change. The behaviour charted must be directly observable, operationally defined and pinpointed.

To carry out the guiding principles of PT, several practical steps are recommended (Hughes, et al. 2007; Lovitt & Fantasia, 2000):

i. Pinpointing a pupil's behaviour

ii. Recording the direct observations on a SCC

iii. Creating an "aim" based on what is considered to be mastery performance or on the individual's performance

iv. Evaluating the teaching methods and making changes based upon the SCC.

The first step in applying PT is to pinpoint a behaviour that needs to be trained, creating a working definition of the behaviour and describing the context under which the behaviour should occur. In a case study carried out by Kerr, Smyth and McDowell (2003) following 'give commands' was pinpointed for increase. Give commands were defined as: "Sean will receptively identify functional objects (e.g., cup, spoon, bag, shoes, video etc.) by giving them upon hearing the instruction Give me——— at a rate of 20 + per min" (p.404).

The next step is to record the rate of correct answers on a SCC for future reference. For example, Kerr et al. instructed teachers to chart the initial number of 'give commands' followed correctly per min.

Aims are made using the occurrences of behaviour per min. Aims are chosen based on the individual's performance or others performance and are set using the occurrences of behaviour per min. Kerr et al. set an aim rate for the amount of 'give' commands at 20 per min. Once this aim was reached this skill was considered to be mastered. This rate was chosen based on the participant's initial performance.

Finally, once data is gathered it can be charted on the SCC to determine whether the teaching methods are having the desired effects and if changes are warranted. The first teaching method used by Kerr et al. was to reduce number of items that could be chosen from. After charting the data on the SCC, researchers decided the first teaching method did not improve Sean's rate of following 'give' commands. It was determined from interviewing and from the SCC that Sean did not have the prerequisite skills to "give items asked for" so the task was altered. The skill he did not have was matching the items to the command and this became the new task. Once Sean was able to match at a higher rate than 25 per min, the previous teaching was reinstated.

Fluency

The ultimate goal of PT is to improve someone's ability at a certain skill or more specifically achieve fluency. Fluency is defined by Binder (1988) as the combination of accuracy plus speed and can be described using the acronym REAPS (Retention, Endurance, Application, Performance standards, and Stability) (Johnson & Layng, 1996). Retention is the ability to remember something or to keep a high response rate after a significant period of time with no practice. Endurance is the ability to keep a high response rate after a long period of time with no rest that is longer than previous training times. Application is the ability to apply the learnt skill in novel situations. Performance standards are aim rates where behaviour is considered fluent. Stability is the ability to continue the target behaviour at a high rate in the face of distraction.

The research on rate-building gives an indication that rate-building exercises improve retention (Olander, 1986; Kessissoglou, & Farrell 1995; Hughes, Beverly & Whitehead 2007), endurance (McDowel & Keenan 2001; Hughes, et al. 2007), application (Kessissoglou & Farrell 1995; Hughes, et al. 2007), performance standards (McDowel & Keenan (2001)), and stability (Hughes, et al. 2007; Kim, Carr, & Templeton, 2001; Cohen, 2005). However a high rate of behaviour alone has not been shown by the research to improve fluency due to confounds. A literature review of 48 articles on fluency (Doughty, Chase , and O'Sheilds 2004) found that 45 of their reviewed articles did not control for number of practices and reinforcers; two variables known to enhance learning. Therefore improved fluency results in the literature could be due to the increased number of practices or reinforcers that tend to follow a high rate of behaviour. McDowel and Keenan, (2001); Olander (1986); Kessissoglou and Farrell, (1995); Hughes et al. (2007) did not keep the amount of reinforcers or practice equal for the experimental group and the control group.

An experiment by Porritt, Wagner, & Poling (2009) studied if high rate alone improves fluency and controlled confounds in the literature. Pigeons were trained to peck different keys in a chained sequence. The sequences the birds responded on most consistently were used for the experiment proper being: RCL LRC and CLR. Throughout the experiment proper, the pigeons were reinforced on a VI 50-s schedule. The first component was retention where the hens had to complete 15 chains of the sequence they previously were trained on. The next component used the same sequences but with a new first link, lasting for 75 chains. This component was used in order to stop the hen from learning the chains based on the first colour position combination. The third component trained the next sequence to be tested at either a high or low rate of responding depending on the condition. Condition 1 was the no-delays condition during this condition no-delays were imposed between each link. The condition ended when 4 consecutive bins of 5 chains were completed. Condition 2 was the within chains delay condition, this condition contained a 5-s blackout where no response could be reinforced between the last correct response and the next link in the chain. This condition ended after subjects completed the same number of responses as they did during Condition 1. The third condition was the delays between chains condition, this condition contained a 15-s delay between the last reinforcement and the start of the next chain. This condition ended after subjects completed the same number of responses as they did during Condition 1. The results showed that reducing the amount of overall delay while controlling for practice and reinforcement improves the accuracy during both training and retention components. From this it can be inferred that high rate behaviour is retained and acquired better than low rate behaviour. Because this method controlled for the number of reinforces and practice, this thesis uses an adaptation of this method with changes made to suit the topic.

Distractibility methodology

Pre-exposure to a stimulus can make it less distracting (Lorch, et al. 1984), (Parmentier & Andres, 2010), this raises concerns about habituation (reduction of the effectiveness of a stimulus) to any kind of distractor making results on distractibility invalid.

Because of how the structure of the method by Porritt et al. (2009) is set out, even if habituation occurs, all conditions will be equally affected by the habituation because the condition alternates every day. Although habituation can occur there are many examples of experiments studying distraction where habituation has not caused problems (Cynx, 1990; Maes & de Groot, 2003; Grueninger & Pribram, 1969). A study by File (1973) showed that shorter inter-stimulus intervals (ISI) resulted in less habituation in a decay curve pattern, and distractor duration did not have a significant effect on habituation. The decay curve pattern meant that ISI of 2.5-min, 3-min, and 24-hrs were roughly similar. Because of this if an ISI of over 2.5-min is ideal as ISI greater than 2.5-min does not have a large effect on habituation. In this case the distracter ISI was 24-hrs because a continuous distracter test period was used and the time between sessions was 24-hrs.

This experiments aim was to discover the relationship between stability and response rate, not retention and response rate so an alteration to the Porritt et al. method was made by replacing the retention phase with a stability test phase. In order to measure stability, a test period with continuous distraction was used. Because a continuous distraction period was used, the ISI between each distracting stimulus onset is the time between sessions.

Distracting stimuli that have been used to test for distraction include: noise (Nowei, 1984; Venetjoki et al. 2006), concurrent irrelevant tasks (Czerwinski, et al. 2000; Brown, et al. 1969), and irrelevant visual information (Peterson, et al. 2009; Lorch, et al. 1984) including stroboscope activation (Cynx, 1990; Fox, 1964). In this case a stroboscope is used as it doesn't require a sound attenuated chamber and responding in the same way as during other phases and conditions is possible during stroboscope distraction. Another change to the Porritt et al. method will be removing the delay between chains condition as this thesis is comparing fast vs. slow responding and it is unnecessary when both the delay within chains and no-delays condition are being used.

Methods

Subjects:

Six experimentally naive domestic laying hens (Gallus Gallus Domesticus) obtained from a free range farm were housed in individual standard wire cages (30 cm wide x 45 cm high) in a room lit on a 12:12-hr light:dark cycle. Water made freely available and grit and vitamins supplied weekly. Hens were weighed daily and provided with supplementary feed if required to maintain their weight at approximately 80% (+/- 5%) of their free-feeding body weights. The principles of laboratory animal care were followed and all procedures were approved by the University of Waikato Animal Ethics Committee.

Apparatus:

The experimental chamber measured 53cm high, by 53cm wide, by 47cm deep. In this chamber, three response keys on a working panel were positioned 40 cm above the floor; the centre key was centred 22cm from each side of the chamber, the left key was 10cm to the left of the centre of the middle key, and the right was 10cm to the right of the centre of the middle key. These keys measured 3cm in diameter and could be illuminated with red, white or green light emitting diodes (LED). A stroboscope was positioned in the centre of the ceiling inside the chamber, set to 11,000-15,000 lux illumination and to flash at approximately 10 flashes per second when turned on. A square was cut out of the working panel 115mm up from the base, centred 20cm from each side, measuring 70mm wide by 100mm high. This square provided access to a grain hopper which could be tilted forward to provide access to wheat and tilted back to remove access.

Procedures

Key Peck Training

Hens learned to peck keys using an auto shaping procedure similar to methods described by Picker and Poling (1984). The hens were placed into the chamber where, on a random time (RT) 45-schedule, one of the three keys were lit red, white or green, determined at random. After either a response to the lit key, or six s of no responding, wheat was presented for 2.5-s during which the key light is turned off (reinforcement). These sessions lasted for 45 grain presentations. All subjects moved onto the next condition when reliably pecking all keys illuminated with all possible colours.

Repeated acquisition training

*Phase 1.*This phase was the same as Key Peck Training with the exception that reinforcement was available after any peck to a lighted key (CRF). Between trials there was a 5-s Inter-trial blackout where the key was not illuminated and no reinforcement could be received by the hen. Each session in this phase lasted for 45 trials or 45 mins, whichever came first. Once the hen was reliably responding on each colour and key the next phase could start.

Phase 2. This procedure was Identical to Phase 1 except that another key was illuminated (distracter key). This key was the same colour as the key that provided a reinforcer (the correct key), when pecked no reinforcement was given. This key turned off when the correct key was pecked, and turned on when the next correct key turned on. Once the hen was reliably responding on each colour and key the next phase could start.

*Phase 3.*This was Identical to Phase 2 except that there was a second distracter key. Once the hen was reliably responding on each colour and key the next phase could start.

Phase 4. In this phase hens had to complete a chain, consisting of three correct key pecks, to access reinforcement. The hens were first exposed to three keys lit in red, known as the first link. A link was completed with a peck in the correct position, which immediately turned off the key light and advanced the schedule to the next link. The second link was the same except the keys were lit white and the correct key position was changed. During the third link the keys were lit green, the correct key position was changed, following a correct response, the hopper was raised. Magazine time was reduced to .9 s on 3 out of 4 trials selected at random. The reduced magazine time resulted in a light flash and clicking sound, but did not allow subjects to consume any wheat. A correct response on the third link completed the chain and advanced the schedule to the first link of the next chain. A distracter key peck during any link resulted in a 1 s darkening of key lights followed by representation of that link. The correct key for each colour position combination remained the same throughout the experiment. No key position was correct over two consecutive links, and no colour-position combination was repeated across consecutive sessions. During the first series each session finished following 2800-s. For the remainder of the phase each session finished following either 2800-s, or 80 reinforcement, this was done to control the weight of the hens. The first series ended when the 12 possible different chains were presented to the hen. The six most accurate chains were then selected and the remaining chains were no longer presented in the following series. This phase ended after six series were completed. During this phase a rate criterion was determined for use in the repeated acquisition procedure. The criterion was established by taking the 15^{th} % of the median rates from the last three sessions with the limitation that no rate could be slower than 3.4 chains per min.

Repeated acquisition procedure:

Component 1: high rate condition. The three most accurate chains during training were used during this component. Reinforcement was made on a VI-50 schedule where reinforcement was delivered after the first response following a variable amount of time which averaged 50-s. This reinforcement schedule was used for the high rate condition and the low rate condition. Each experimental session consisted of a training and test period. The training period ended when the rate criterion determined in Phase 4 was met. During the training period the rate was measured by grouping the chains into bins of five chains each and measuring the time taken for completion of each bin. For the criterion to be met subjects had to complete four consecutive bins at the given rate. Once met, 10 chain completions were required in the presence of an activated stroboscope (e.g. test period) in order to test distractibility. Two new chains are trained and tested in a similar manner across Sessions 2 and 3 respectively.

Component 2: Low rate condition. Experimental sessions 4, 5, and 6 were conducted in a similar manner to 1, 2, and 3 with two exceptions. A 5-s blackout was imposed between each link of every chain. During the blackout, key lights were darkened and key pecks did not produce a consequence. A rate criterion was not utilized during the training phase. Instead, the number of links the hen was exposed to before meeting the rate criterion for sessions 1, 2, and 3 was used to determine how many links the hen was exposed to during sessions 4, 5, and 6 respectively during the test period (known as a yoking procedure). This yoking procedure ensured the number of practices was constant across both high rate and low rate conditions. After meeting the rate criterion 10 test trials were carried out in the same manner as in the high rate condition test trials (test period). Table 1 shows how the Repeated Acquisition Procedure is structured.

For one series				
Session:	Chain:	Components:	Stroboscope	Delay between links
Session 1:	Chain 1	Training (ends after criterion is reached)	No	No
		10 chain completions	Yes	No
		session ends		
Session 2:	Chain 2	Training (ends after criterion is reached)	No	No
		10 chain completions	Yes	No
		session ends		
Session 3:	Chain 3	Training (ends after criterion is reached)	No	No
		10 chain completions	Yes	No
		session ends		
Session 4:	Chain 1	Training (ends after same number of responses made in session 1 training)	No	5-s
		10 chain completions	Yes	No
		session ends		
Session 5:	Chain 2	Training (ends after same number of responses made in session 2 training)	No	5-s
		10 chain completions	Yes	No
		session ends		
Session 6:	Chain 3	Training (ends after same number of responses made in session 3 training)	No	5-s
		10 chain completions	Yes	No
		session ends		

Table 1: experimental conditions during repeated acquisition procedure for one series

Results:

Figure 1 shows the number of errors made (defined as a peck to a key that was not lit during the presentation of a lit key) for each hen across sessions, split into Key Peck Training, Phase 1, Phase 2, and Phase 3 using phase breaks. During Key Peck Training there was a steep downward trend in the number of errors made for all hens. All hens finished this phase producing 0 errors for their last session. Hens reliably received all available reinforcers, and were therefore reliably responding on each colour and key so were moved on to the next phase. Hen 12.6 underwent shorter training periods to catch up to the other hens as it started later. During Phase 1 the number of errors was low across hens, with the exception of Hen 12.4 which had an increase in errors. All hens were reliably receiving all reinforcements by the end of the session and therefore reliably responding on each colour and key so were moved on to the next phase. In Phase 2 there was a high amount of variation in the number of errors between hens to begin with which decreased throughout this phase. After approximately the 30th session responding across hens was relatively stable. Each hen was reliably responding on each colour and key so were moved on to the next phase. In Phase 3 the number of errors became irrelevant because all three keys were lit during presentation.

Figure 2 shows the number of ISI pecks made (key pecks made during the inter-stimulus interval) for each hen across sessions, split into Key Peck Training, Phase 1, Phase 2, and Phase 3 using phase breaks. During Key Peck Training there was a steep downward trend in the number of ISI pecks made for all hens. During Phase 1 there was a downward trend in the number of ISI pecks, with the exception of Hen 12.4 which had a gradual increase. During Phase 2 and 3 there was a low and stable level of ISI pecks for all hens.

During Phase 2 and 3, distracter keys or lit keys that when pecked did not provide reinforcement or advance the schedule were introduced. Figure 3 shows the number of

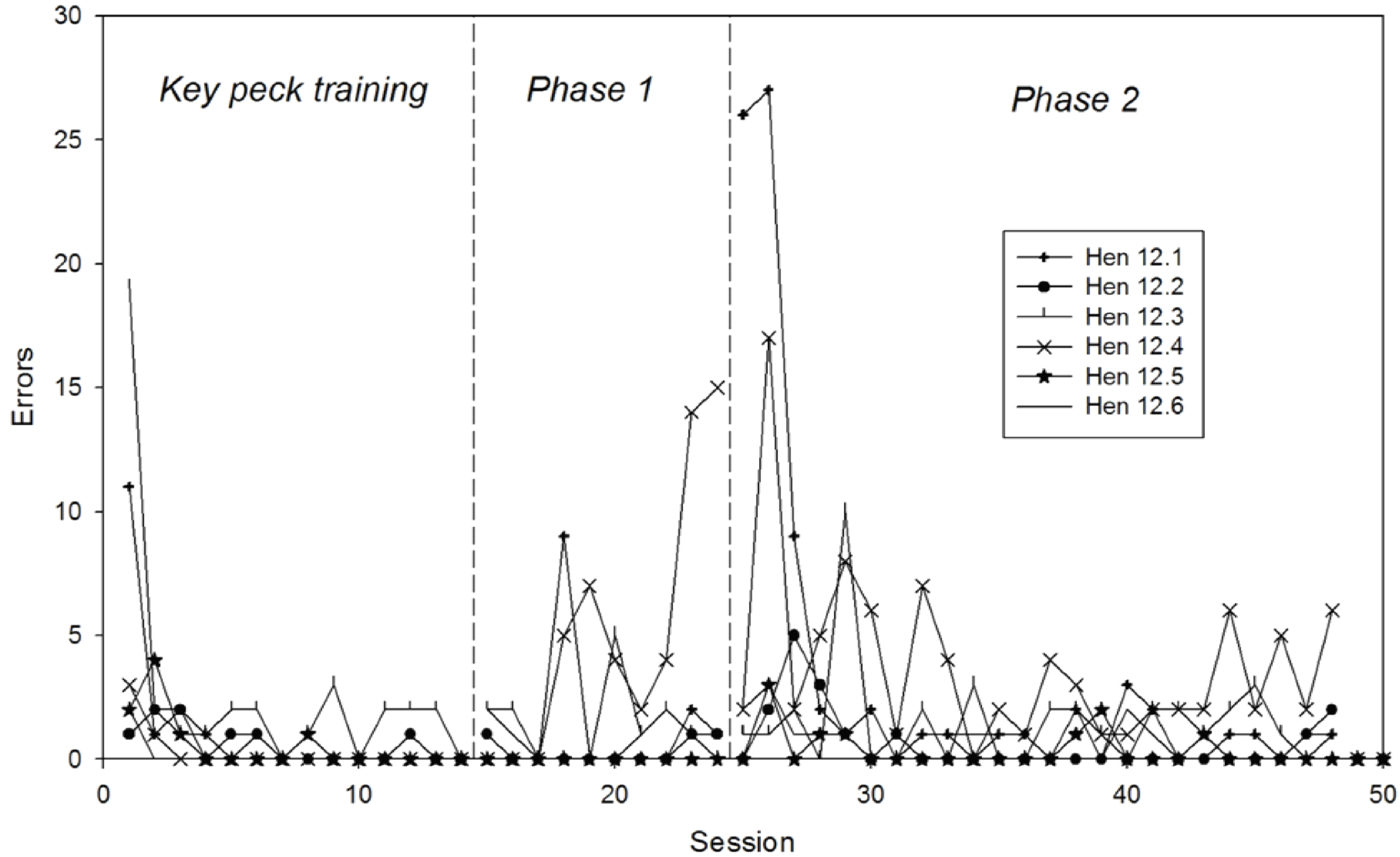

Figure 1: Errors across sessions for each hen during Key Peck Training, Phase 1, and Phase 2

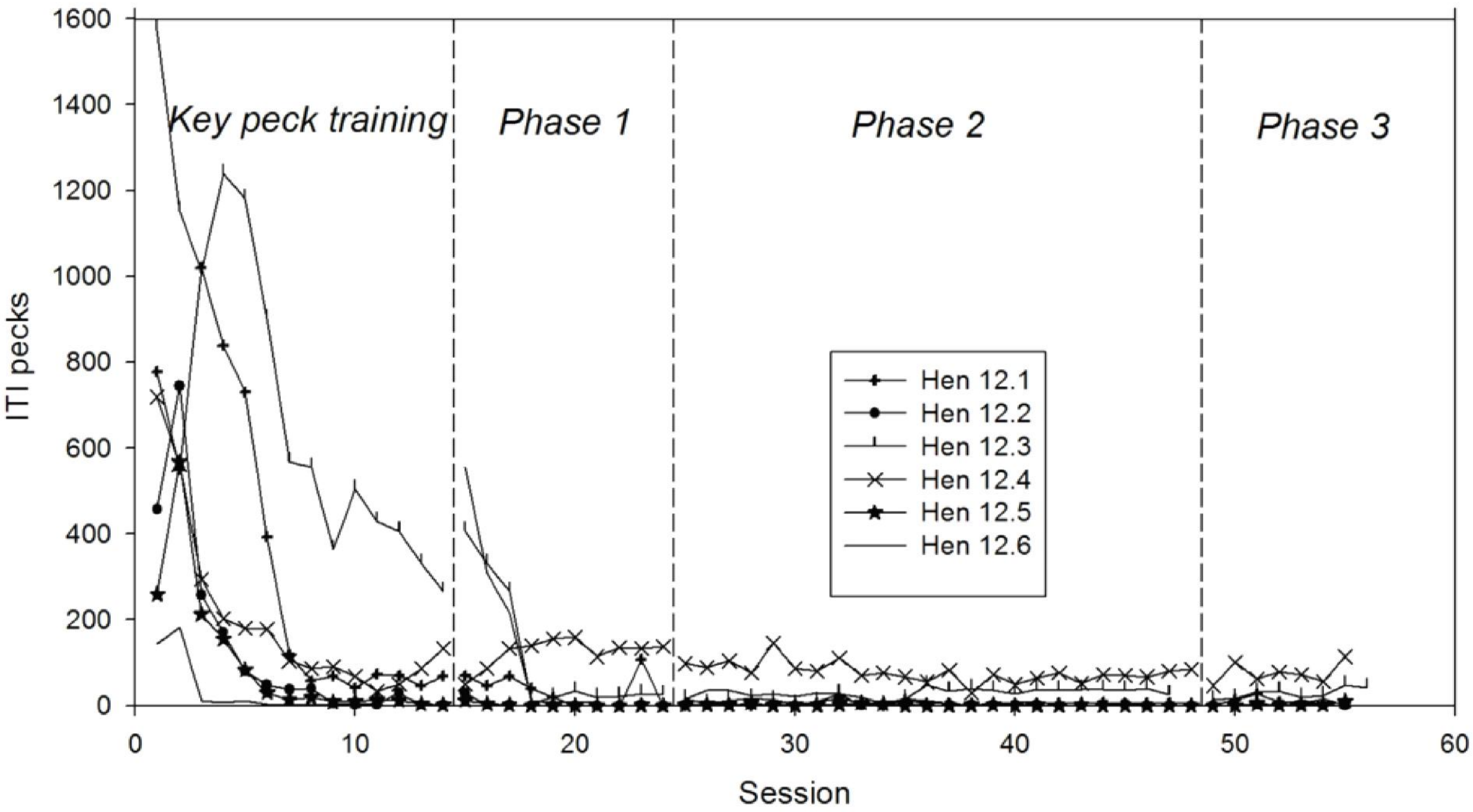

Figure 2: Inter-stimulus interval pecks (ITI pecks) across sessions for each hen during Key Peck Training, Phase 1, Phase 2, and Phase 3

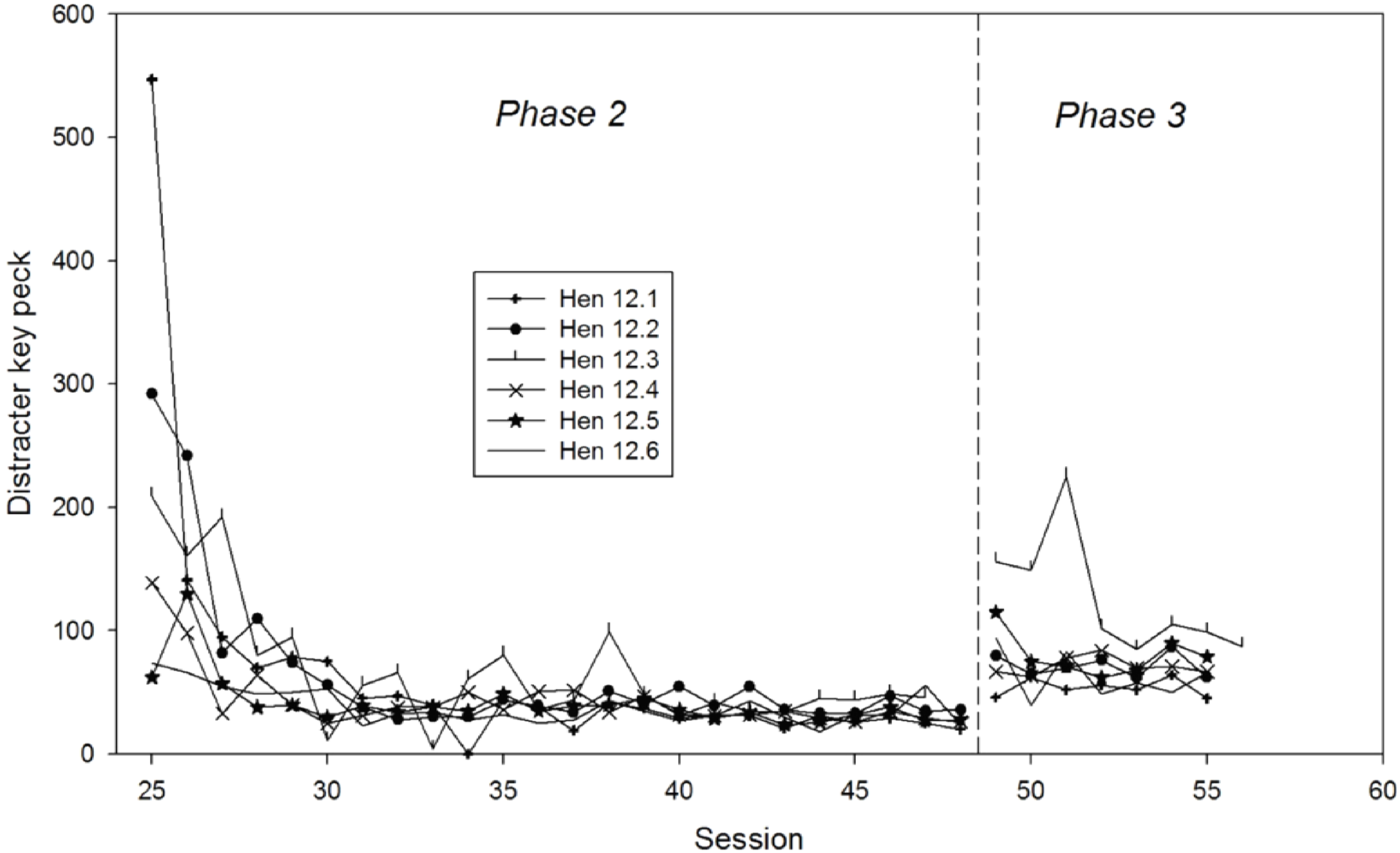

Figure 3: Distracter key pecks across sessions for each hen during Phase 2 and Phase 3

distracter key pecks made for each hen across sessions, split into Phase 2, and Phase 3 using a phase break. During Phase 2 there was a downward decay trend in the number of distracter key pecks which levelled off. During Phase 3 the number of distracter key pecks started slightly higher than in the previous session and stayed relatively constant except for hen 12.3 which had a higher number of distracter key pecks than the other hens and then dropped to a level closer to the number of distracter key pecks the other hens were making. Each hen was reliably responding on each colour and key so were moved on to the next phase.

During Phase 4 the percentage of correct responses was recorded across the last 3 series of Phase 4 to pick the three chains used in Phase 5. The three most accurate chains on which all hens responded and with over 75% accuracy were selected for use in the next phase. Figure 4 shows the percentage of correct responses for each chain averaged during the last three series for each hen. Only the chains: RCL, RLR and CLC had accuracy over 75% across all hens so these chains were selected for Phase 5.

Figure 5-shows the accuracy averaged across hens during the last three sessions across all chains. The order of highest to lowest accuracy was RLR, RLC, RCL, CLC, CLR, followed by CRL. While it shows RLC having a greater accuracy than CLC when averaged, it was not over 75% accuracy across all hens so was not selected for use during Phase 5.

Figure 6 shows the interquartile range and mean proportion of correct responses for the training period and the test period for each hen during Phase 5. The proportion of correct responses was measured during the last five chains of each training period, and during the first five chains of each test period. Conditions and periods were then compared. The average accuracy during the no-delay training period was 74.39%, this dropped by 33.61% in the test period. During the 5-s delay condition, the accuracy reduced only slightly from training to the test period for all hens except for 12.4 and 12.6, for which there was only a slight increase.

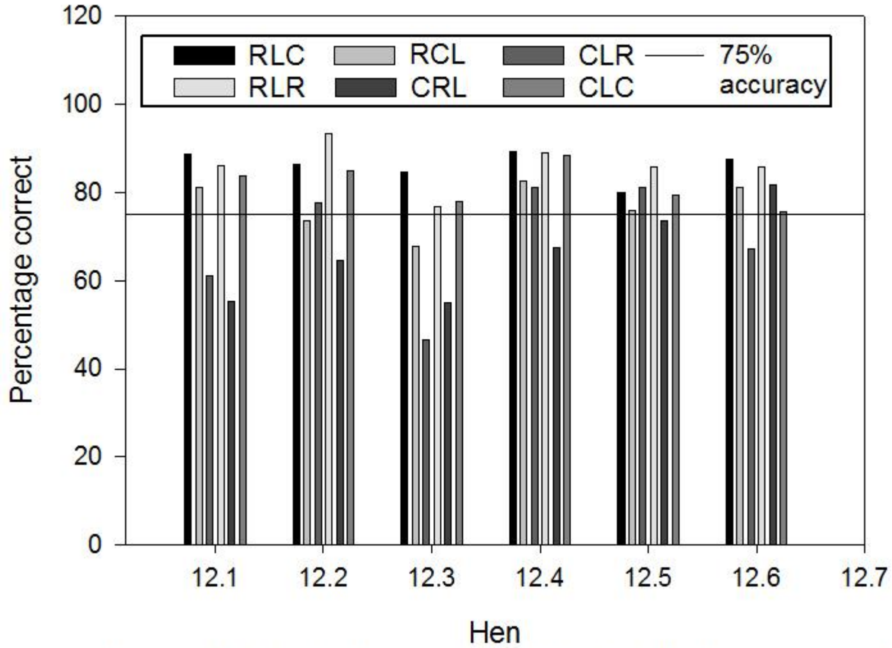

Figure 4: Percentage correct for each chain across hens during Phase 4.

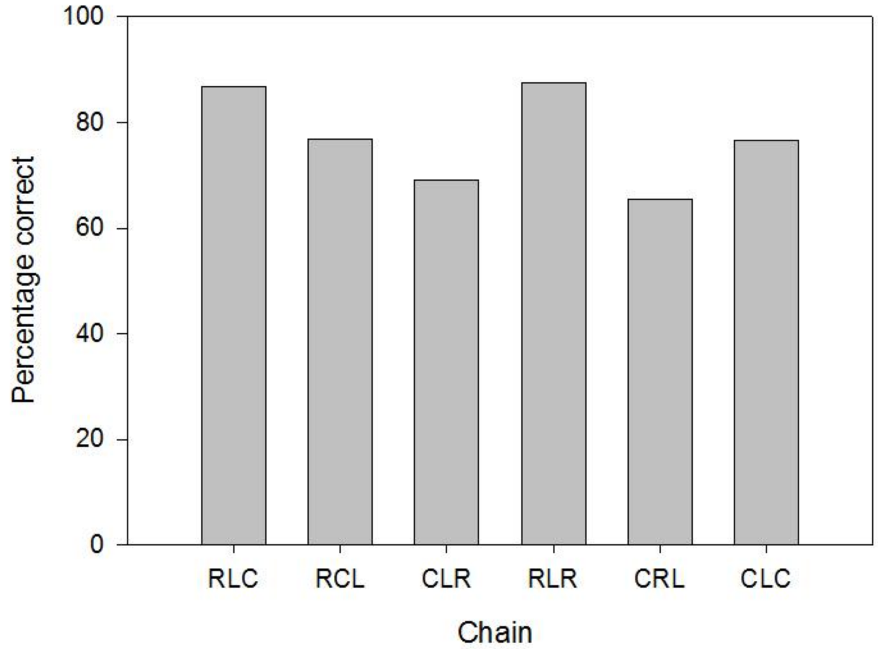

Figure 5: Overall chain accuracy during Phase 4 averaged for all hens over the last three sessions

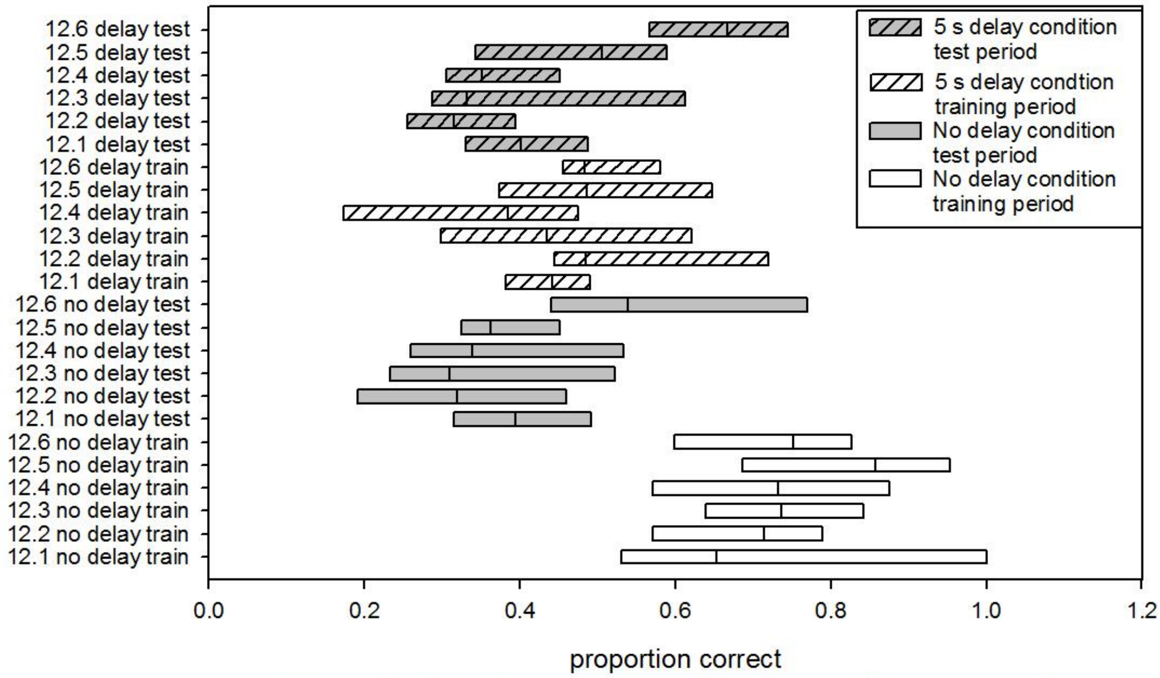

Figure 6: Experiment 1 Phase 5 interquartile range and mean proportion correct across conditions for each hen

The average accuracy during the training period for the 5-s delay period was 47.08%, this dropped by 2.85% in the test period. On average, responding during the no-delay condition training period was more accurate than the 5-s delay condition training period and there were no large differences in the data from the two conditions during the test period.

Discussion

Previous results have shown that accuracy during retention is better when hen behaviour is free to occur at any time during training (no-delay condition) compared to when there is a delay imposed between responses during training (Porrit, et al. 2009). Thus, it is possible that free operant responding would result in better performance than spaced responding for other measures of fluency. The current study examined the effect of stroboscope distraction periods and response spacing on stability of accuracy using a modified version of the method used by Porritt, et al.

Figure 6 shows that for the no-delay condition's accuracy from the training period to the test period reduced by 33.61%. This reduction in accuracy suggests that the stroboscope was successful as a distracter. This is in line with research by Cynx (1990) which showed that using a stroboscope disrupted finches during singing. Finding out that the stroboscope acted as a distracter was important to the current study because, as previously explained in the introduction, this experiment was testing stability and was to be measured by testing accuracy in the face of a legitimate distracter.

The results of this study show that during the training period, the hens were much more accurate on the last 5 chains in the no-delay condition than the last 5 chains in the 5-s delay condition. This meant that faster responding during acquisition resulted in higher accuracy. This is the same result as the Porritt, et al. (2009) study. This information is important to the current study because it shows that the results of the no-delay condition replicated the findings of Porritt, et al. that there was a positive relation between response rate and accuracy during acquisition.

Higher response rates have been shown to result in greater retention than lower response rates when reinforcement and number of practices are controlled for (Porritt, et al. 2009). Following a review of literature on fluency it was suggested that all aspects of fluency are improved by an increase in rate of behaviour during training (Olander, 1986; Kessissoglou, & Farrell 1995; Hughes, Beverly & Whitehead 2007, McDowel & Keenan 2001; Hughes, et al., 2007; Kim, et al., 2001; Cohen, 2005). It was also suggested that stability of performance in the face of distraction would be improved by a higher rate during training (Hughes, et al. 2007; Kim, et al., 2001; Cohen, 2005). This was shown not to be the case when tested using the current procedure. During the test period there was only a small difference in accuracy between conditions. During the no-delay condition accuracy was 40.79% and during the 5-s delay condition it was 44.23%. Thus the hens were distracted by the stroboscope by the same amount for both conditions. This was not expected based on the literature, because the literature suggested that a higher rate of behaviour during training would have higher accuracy or ‘stability’ in the face of distraction. From these findings it is suggested that training response rate alone is not responsible for any increase in stability during rate-building exercises.

There was no real difference between accuracy in the training and test periods during the 5-s delay condition. During this condition, accuracy levels were low enough to suggest that there was a floor effect (accuracy was so low that it was governed by chance). This could mean that there was no difference between periods because accuracy was too low during training to drop any further during the test period. Also results showed there was not a large difference in the accuracy across the two conditions during the test period and that the no-delay condition showed higher accuracy than that from the 5-s delay condition during the training period. These results it suggested that no matter how high the accuracy was during the training period accuracy would be reduced by the distraction down to a common level. This will be referred to as a “common level of distraction”.

In order to test if there was a common level of distraction, and to get rid of any floor effect, the accuracy in the delay condition during the training period would need to be raised. This would then test if the stroboscope had a common level of distraction because if the accuracy was raised in the training period and yet still dropped to similar levels during the test period (as it did during phase 5) then this effect would be presumed consistent. An increase in accuracy would also mean that accuracy would be above any floor level (where accuracy would be based on chance) and a reduction across periods would be possible. Because the relationship between accuracy and response rate showed that as response rate increased so did accuracy, the accuracy during training was raised by a reduction in the delay for the delay condition. Experiment 2 reduced this delay in order to find if a stroboscope produced common level of distraction and reduced accuracy to the same level as in the present experiment and in order to get rid of any floor effect.

EXPERIMENT 2

Introduction:

In Experiment 1 the accuracy for the training period and test period during the 5-s delay condition were not very different. It was expected that the stroboscope presentation during the test period would produce lower accuracy. Accuracy during the delay condition was so low, that it was possible that there was a floor effect. This meant that accuracy was too low during training for accuracy to be any lower during the test period. If any effect on accuracy between periods was to be seen, then accuracy would need to be raised above chance during the training period.

During the test period, accuracy between conditions was similar even though the no-delay condition had higher accuracy than the delay condition during training. This raised the possibility that there was a common level of distraction. Raising accuracy during the training period would show if there was. This would show a common level of distraction because if compared to Experiment 1, accuracy was higher during training and the same during the test period, then this would show that the stroboscope distracted accuracy down to the same level regardless of how high it was during training.

Because accuracy during the training period was greater for the no-delay condition it can be said that as response rate increased so did accuracy. From this it is logical that reducing the delay during the delay condition would result in higher accuracy during training. This would remove any floor effect and show if there was a common level of distraction. Because of this, the current experiment will use the same repeated acquisition procedure used in Experiment 1 but with a shorter delay.

In Experiment 1, hens were subjected to a number of stroboscope presentations. Because pre-exposure to a stimulus can make it less distracting (Lorch, et al. 1984), this means that hens may be less distracted by the stroboscope going in to the second experiment. To see if there was any increase in accuracy due to stroboscope pre-exposure, the repeated acquisition procedure was carried out again using both a 5-s delay and the shorter delay already used, in that order.

Methods

Phase 1

Phase 1 of this experiment was identical Experiment 1 except during the low rate condition the delay between links was reduced to 2.5-s.

Phase 2

In order to test if habituation had occurred from Experiment 1 to Experiment 2, Phase 2 was identical to Experiment 1.

Phase 3

In order to further test the effects of habituation phase two is identical to Phase 1.

Results

Figure 7 shows the interquartile range and mean proportion of correct responses for the training period and the test period for each hen during Experiment 2, Phase 1. The proportion of correct responses was measured during the last five chains of each training period, and during the first five chains of each test period. Conditions and periods were then compared. During the no-delay condition each hen's accuracy was lower in the test period than in the training period. The average accuracy during the no-delay condition training period was 71.92%, which dropped by 19.92% in the test period. During the 2.5-s delay condition, the accuracy was lower in the test period than in the training period for all hens except for 12.6 (this then increased in accuracy by 12.73%), Hen 12.1 only showed a slight decrease of 2.84%. The average accuracy during the 2.5-s delay condition training period was 62.85%, which dropped by 8.98% in the test period. On average responding during the no-delay condition training period was more accurate than in the 2.5-s delay condition training period and there were no large differences in accuracy between conditions for the test period.

Figure 8 shows the interquartile range and mean proportion of correct responses for the training period and the test period for each hen during Experiment 2, Phase 2. The proportion of correct responses was measured during the last five chains of each training period, and during the first five chains of each test period. Conditions and periods were then

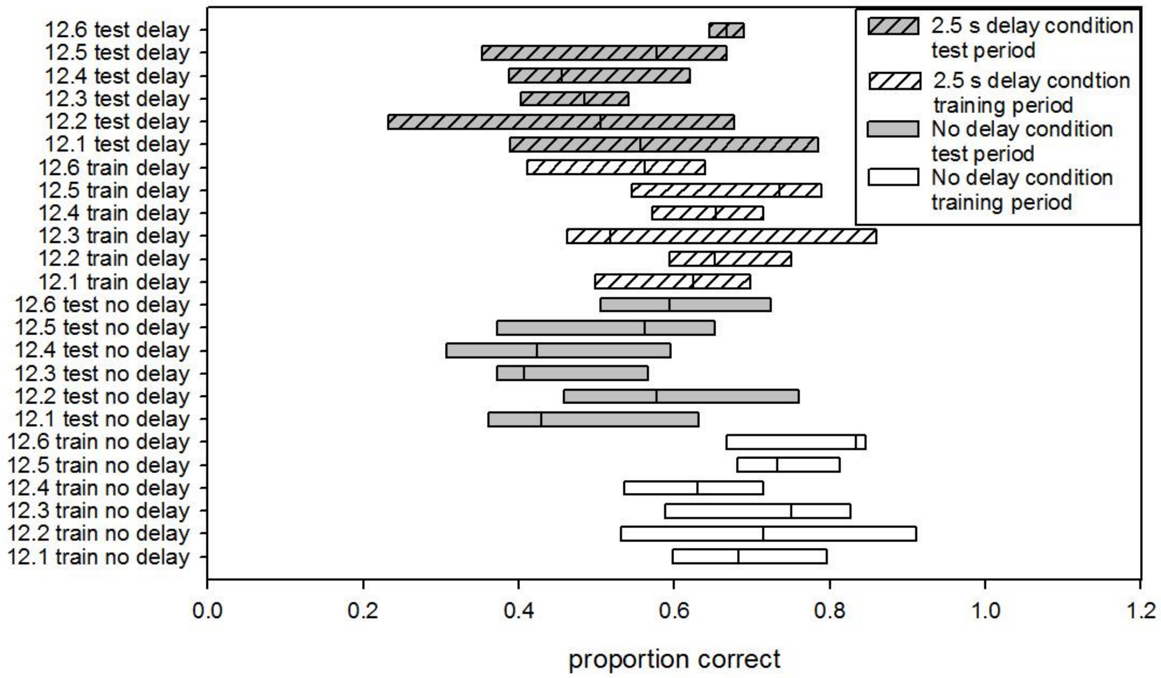

Figure 7: Experiment 2 Phase 1interquartile range and mean proportion correct across hens and conditions

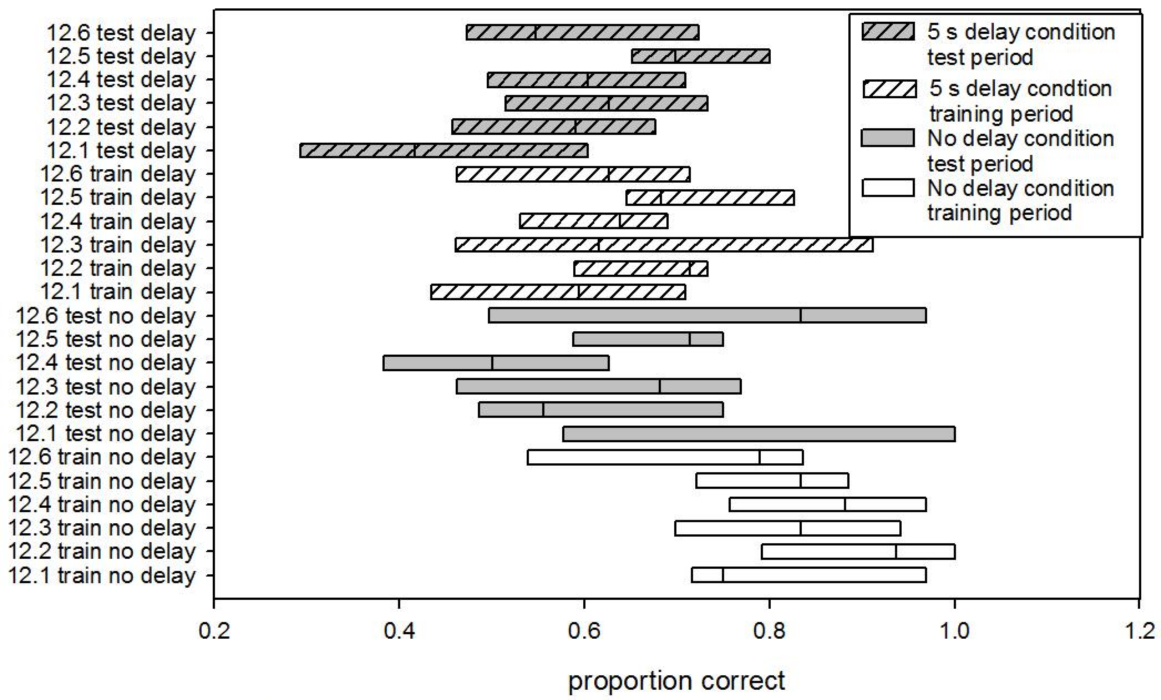

Figure 8: Experiment 2 Phase 2 interquartile range and mean proportion correct across hens and conditions

compared. During the no-delay condition each hen's accuracy reduced from the training period to the test period except for 12.6 which had a slight increase. The average accuracy during the training period of the no-delay condition was 82.2%, which dropped by 15.5% in the test period. During the 5-s delay condition, the accuracy reduced if only slightly from the training period to the test period for all hens except for 12.3 and 12.5 which had slight increases in accuracy. The average accuracy during the 5-s delay condition training period was 64.5%, which dropped by 5.5% in the test period. On average responding during the no-delay condition training period was more accurate than the 5-s delay condition training period and there was only a slight difference between conditions during the test period.

Figure 9 shows the interquartile range and mean proportion of correct responses for the training period and the test period for each hen during Experiment 2, Phase 3. The proportion of correct responses was measured during the last five chains of each training period, and during the first five chains of each test period. During the no-delay condition each hen's accuracy reduced from the training period to the test period except for 12.6, which had a slight increase. The average accuracy during the training period of the no-delay condition was 80.8%, this dropped by 12.1% reduction from the training period to the test period. During the 2.5-s delay condition, the accuracy reduced if only slightly from the training period to the test period for all hens except for 12.3, 12.5 and 12.6 which had slight increases in accuracy except for 12.6 which increased from 53.9% to 58.8%. The average accuracy during the 2.5-s delay training period was 66.6%, which dropped by 3.2% in the test period. On average responding during the no-delay condition training period was more accurate than in the 2.5-s delay condition training period and there were only slight differences in accuracy between conditions during the test period.

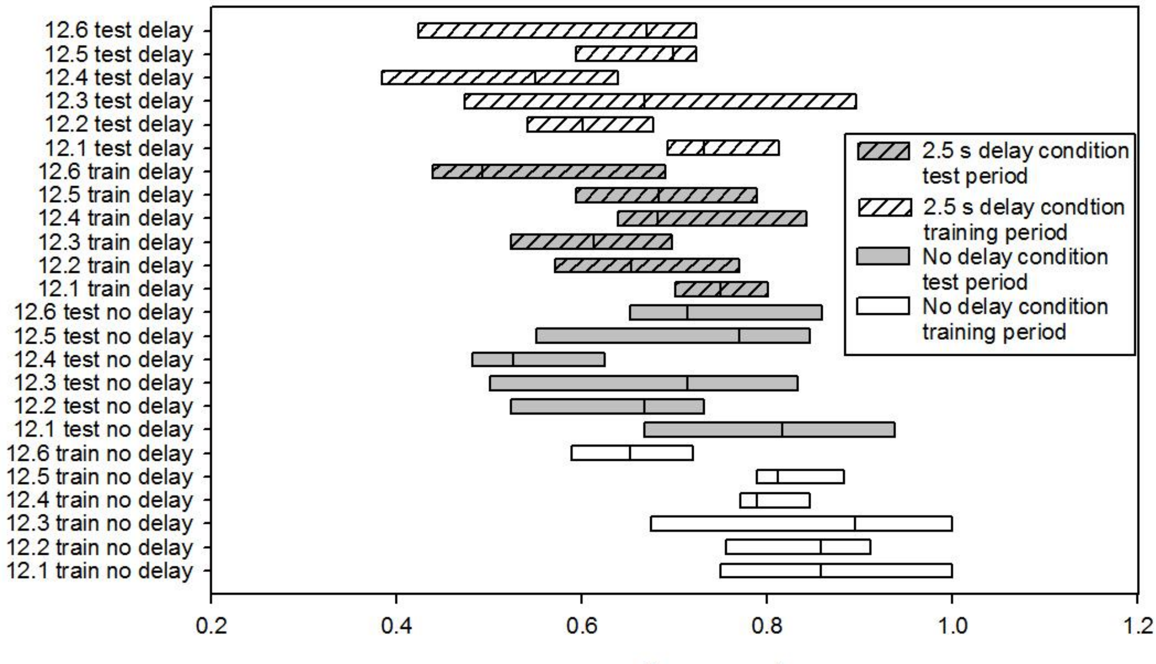

Figure 9: Experiment 2 Phase 3 *interquartile range and mean proportion correct across hens and conditions*

Figure 10 shows the summary of accuracy for Experiment 1 Phase 5 and Experiment 2. Each box represents the distribution of each condition's proportion of correct responses during each phase. Each condition showed a positive trend in accuracy as each phase took place. The no-delay condition during the training period had the highest accuracy for each phase of any other period or condition. There was a reduction in accuracy from the training period to the test period during the no-delay condition for each phase. This was not the same during the delay condition as there were no large differences between the training and test period's accuracy for each phase. The test periods had no great difference in accuracy between conditions for each phase.

Discussion

Following Phase 1 of Experiment 2 it was determined that increased response rate resulted in higher accuracy during the no-delay training period. This is because the accuracy in the 2.5-s delay condition during training was lower than that in the no-delay condition. This suggests that rate-building teaching techniques were successful in improving accuracy during acquisition. A higher rate of responding during acquisition has been shown in this experiment to result in higher accuracy. Rate-building teaching techniques increase rate of behaviour during acquisition and therefore should increase accuracy during acquisition.

During the test period, there was no large difference in accuracy between the 2.5-s delay and no-delay conditions. This was in line with results in Experiment 1 and provided further evidence that greater rates of responding do not maintain in the face of distraction.

During Experiment 1 accuracy in the 5-s delay condition was low enough for a floor effect to be possible. Experiment 2 reduced the delay to 2.5-s in order to increase accuracy

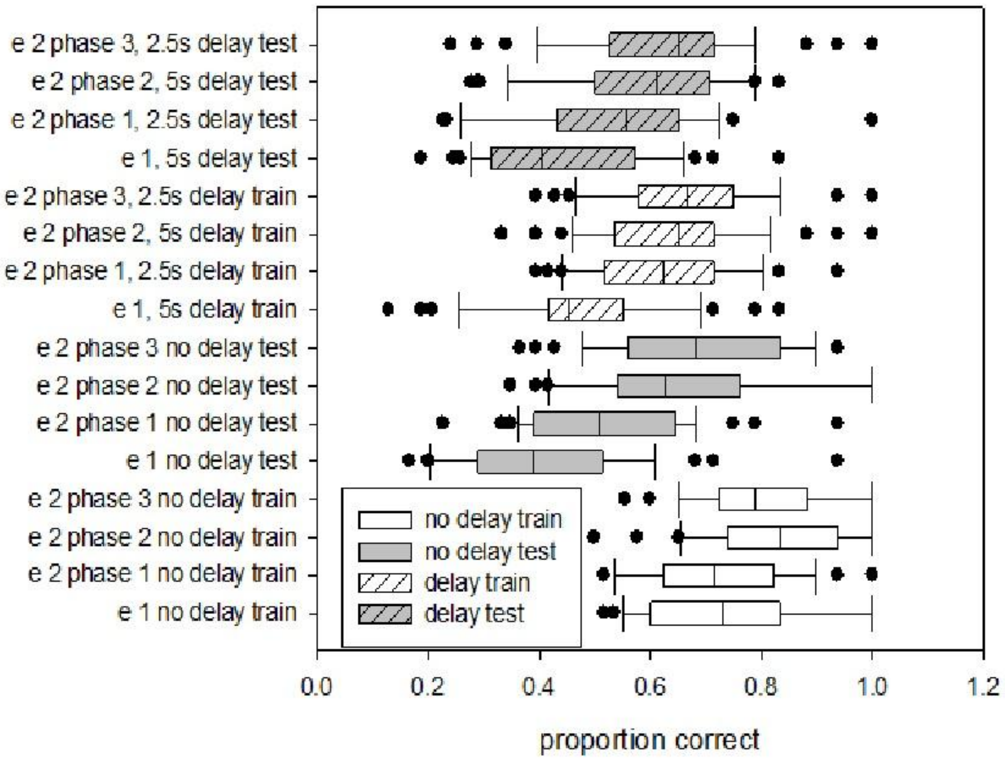

Figure 10: Interquartile range and mean proportion correct across conditions and phases

and get rid of any floor effect. The reduction in delay was successful at increasing accuracy thus getting rid of the floor effect.

Results from Experiment 1 raised the possibility of a common level of distraction where the strobe light distracted behaviour the same amount for every condition down to a common level. This was tested by seeing if the accuracy during the test periods was constant across all conditions and experiments. When comparing the test periods of the 5-s delay condition from Experiment 1 with the 2.5-s delay condition from Experiment 2 Phase 1, the 2.5-s delay condition gave higher accuracy. Higher accuracy during the 2.5-s delay condition appeared to show that a shorter delay or higher rate resulted in higher accuracy meaning the stroboscope did not have a common level of distraction. This may not be the case however because Experiment 2 Phase 1 gave higher test period accuracy during both conditions when compared with Experiment 1. This suggested that the higher accuracy during the 2.5-s delay condition may have been because of a reduction in the distractibility of the stroboscope to the hens due to repeated stimulus presentations (habituation). The following phases of Experiment 2 determined whether this was due to habituation or not.

Phase 2 of Experiment 2 was identical to Experiment 1. No large differences between the test periods accuracy during the fast condition during Experiment 1 and Experiment 2 would mean that there was no common level of distraction and habituation was not occurring. If there was an increase in accuracy, it would mean that habituation was evident. The results from Phase 2 of Experiment 2 showed an increase in accuracy for the training and test periods for both the no-delay and 5-s delay conditions when compared with both Experiment 1 and Experiment 2 Phase 1. Because accuracy during the test period increases from Experiment 1 to Experiment 2 Phase 2 where all things were held equal, this suggests that habituation was occurring. This is important to the current study because when comparisons between phases are made, any habituation needs to be taken in to account. Any habituation makes it hard to determine if there is a relationship between length of delay and accuracy and if a common level of distraction was occurring or not.

Phase 3 of Experiment 2 showed an increase in accuracy in both fast and slow conditions when test periods were compared with Phase 1 of Experiment 2. This result reinforces the notion that habituation occurred.

GENERAL DISCUSSION

Overall the results suggest that, while holding reinforcement rate and number of practices constant, performance is disrupted in a similar manner regardless of rate of responding. Because there was no big difference in accuracy between the no-delay and delay conditions during the test period in Experiment 1 and each phase of Experiment 2, there was no effect of training rate on accuracy in the face of distraction. This result was unexpected because previous research has shown that higher rates of responding produce greater accuracies in retention measures than lower rates of responding (Porritt et al. 2009; Olander, 1986; Kessissoglou, & Farrell 1995; Hughes, et al. 2007). As mentioned previously, stability, like retention, is said to be an outcome of fluency and because of this a higher accuracy was expected during the test period for the no-delay condition. Reasons for these unexpected results could be that only the published research by Kim, et al. (2001); Cohen, (2005); and Hughes, et al. (2007) was on stability and none of this research controlled for rate of reinforcement and number of practices. Another possibility is that fast responding alone does not ensure “stable” responding. In short the prior theory is wrong. The higher rates of behaviour used in rate-building procedures with humans are often governed by instruction and generally have higher rates of reinforcement than traditional teaching methods. The motivating factors of instruction such as accountability to someone to reach a goal or the added reinforcement of seeing a goal becoming nearer on a celeration chart, could improve accuracy. The higher rates of reinforcement that normally go along with higher rates of behaviour especially for ratio reinforcement schedules could be responsible for the improvement in accuracy. Because of this more research is required to determine what procedures are best to use, to produce stable accurate performance in the face of distraction. If speed of responding is to be investigated, a rate-building procedure, altering reinforcement density, or a combination of both can be attempted. Otherwise, future research can manipulate the number of practices in an attempt to produce behaviour that maintains during distraction.

A drawback to this research is that to compare the effects of different rates of behaviour while controlling number of practices, a response spacing procedure must be used. The response spacing procedure supresses behaviour by adding a delay between each response and does not allow for free operant responding. Because the response spacing procedure does not allow for free operant responding; making comparisons to the literature difficult. The applied literature on stability (Kim, et al., 2001; Cohen, 2005; and Hughes, et al., 2007) uses free operant responding to raise rate rather than spacing responses. Because this study did not use different aim rates, as the applied literature has, comparisons between the current research and literature cannot be made. In order to make this research comparable to the literature, a procedure that holds practices constant while building two different rates of behaviour would necessary. This could show if the effects of systematically increasing aim rates are responsible for improved stability in the face of distraction.

Consider this as a comparison with Porritt et al. (2009): The present data show that accuracy differed during the two types of training conditions. That is, placing a delay between each link during the delay condition decreased accuracy during training. This finding is in line with the research by Porritt, et al. which had similar results. This is important because the training results from this study and Porritt et al. suggest that higher rates of responding increase accuracy during training. This provides evidence for the benefits of using rate-building teaching techniques.

The present data suggests that a stroboscope is a successful distractor as found by Cynx (1990). This is because during the no-delay condition there was a decrease in accuracy from the training to the test period. In future a comparison could be carried out with other distracters that have been previously used to distract behaviour such as noise (Nowei, 1984; Venetjoki et al. 2006), concurrent irrelevant tasks (Czerwinski, et. al, 2000; Brown, et al. 1969), and irrelevant visual information (Peterson, et al. 2009; Lorch, et al. 1984). This would help establish the generalizability of this finding.

Although within each phase the stroboscope served as a distractor, each subject's accuracy improved with repeated exposure to the stroboscope across test phases. This shows that as each subject was exposed to the test condition, the stroboscope had less of an effect on accuracy. The structure of the experiment means that habituation will not interfere with results between conditions. Unfortunately the habituation has interfered with results between phases and experiments. This habituation is shown by the increase in accuracy for the test periods from the first 5-s and 2.5-s delay phases to the second 5-s and 2.5-s delay phases. Learning across phases also occurred as can be seen by the increase in accuracy for the training periods from the first 5-s and 2.5-s delay phases to the second 5-s and 2.5-s delay phases. These results are not surprising based on previous research (Lorch et al. 1984; Parmentier & Andres, 2010). This suggests that the more exposures to distractions in applied situations such as in the classroom, workplace or while driving reduces the effect of the distractions on behaviour. This presents a case for introducing distractions during training that are likely to occur when carrying out the tasks being trained.

These results meant that it was difficult to have a precise idea of whether there was a common level of distraction from the stroboscope. If habituation hadn't occurred and there were no large differences between the test periods for Experiment 1 and Experiment 2 Phase 2, then whether or not the stroboscope gave a common level of distraction would be obvious based on whether the accuracy in the 2.5-s delay condition was the same or higher than that in the 5-second delay. However in this case the increase may be solely due to habituation.

In order to get rid of this problem Experiment 2's procedures could be incorporated into Experiment 1. To do this each chain would be presented during separate sessions with no-delay, this would be repeated with a 2.5-s delay, a 5-s delay, and a 2.5-s delay again with the number of practices for the no-delay condition yoked to all delay conditions. This means that the number of stimulus presentations between the different delays would be negligible.

Knowing what components within a technology, such as Precision Teaching or rate-building teaching techniques, lead towards fluent responding decreases the time, energy, and cost of teaching new skills and ensuring they maintain in the face of distraction. Since, to date, there is no published research suggesting that speed alone, combined with accuracy, produces stable behaviour, the present research can be used to begin a systematic investigation into what procedures account for behaviour that is stable in the face of distraction. Reducing distractibility is of great importance because it has been shown to cause workplace disciplinary action, and absenteeism (Nowei, 1984), poor reading task performance (Venetjoki, et al. 2006; Weinstein, 1974), poor mathematic reasoning by (Czerwinski , Cutrell, & Horvitz., 2000), difficulty with phonological processing tasks (Klatte, Hellbrück, & Seidel, 2010), reading deficits (Evans & Maxwell, 1997) poor decision making while driving (Brown, Tickner, & Simmonds, 1969), and lower reaction times (McKnight & McKnight (1993); Strayer & Johnston (2001). Continuing research into what procedures account for behaviour that is stable in the face of distraction could result in solutions to these problems and would clearly be beneficial to workplace, classroom and driving settings.

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