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The Effects of Punishment on Resistance to Change and Reinstatement

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REINSTATEMENT

by

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. Resistance to change (RTC) refers to the persistence of behavior when environmental changes disrupt responding. Studies have shown that RTC varies as a function of the reinforcement associated with the context, with higher rates and magnitudes of reinforcement generating greater response persistence. Resistance to change has been shown to be related to reinstatement, or the increase in responding during extinction when responses are followed by noncontingent reinforcement. Little research has investigated whether punishers have equivalent yet opposite effects as reinforcers on response persistence and reinstatement. The present study investigated the effects of electric shock punishment on resistance to change and reinstatement in rats. Six rats were exposed to a multiple reinforcement schedule in which lever pressing was reinforced with food in one component, and reinforced with food and intermittently punished with electric shock during the other component. Punishment conditions were followed by RTC probes during which responding was extinguished. Two types of probes were investigated, one in which punishment was discontinued and one in which punishment remained in effect. Each RTC probe was followed by a reinstatement probe with the same punishment or no-punishment conditions in effect. In the RTC probes with no punishment, there was greater response persistence in the punishment component than in the no-punishment component. During the reinstatement probe with no punishment, greater rates of responding occurred in the component previously associated with punishment. Conversely, during RTC probes with punishment,

response rates quickly decreased and response rates in four rats showed no differential effects across components. Two rats showed less resistance to change in components previously associated with punishment. During reinstatement with punishment probes, only one rat less responding in component associated with punishment; the others showed no clear difference across components. Although data from the RTC and reinstatement probes without punishment suggest that punishers increase resistance to change and reinstatement, the results are more likely attributable to the temporary recovery from punishment that occurred when punishers were removed. The varied results with RTC with punishment probes may be attributable to sequence effects, but data from two rats provide some evidence that punishers decrease resistance to change. This finding, if replicated, would support theoretical interpretations of punishment that suggest that punishment has equivalent but opposite effects of reinforcement. Future research investigating RTC and reinstatement with noncontingent electric shock, or research with different RTC probe types, is needed to better examine the effects of aversive stimuli on resistance to change and reinstatement without the interactions caused by removing or sustaining punishment during extinction.

ACKNOWLEDGEMENTS

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INTRODUCTION

Behavior analysts in applied settings are often faced with the task of reducing problem behavior, such as aggression, noncompliance, or substance abuse, but problem behavior often persists, even during extinction when the reinforcement is eliminated. One area of research that might inform attempts to eliminate problem behavior is resistance to change (RTC). Resistance to change refers to the persistence of behavior when environmental changes disrupt responding. Research on RTC has shown that behavior tends to persist more in the presence of stimuli associated with greater rates or magnitudes of reinforcement. Research on RTC suggests that the stimulus conditions present when problem behavior is extinguished may be important, because the presence of stimuli associated with high rates of reinforcement can enhance the persistence of problem behavior (e.g., DeLeon, Gregory, & Peter, 2013; DeLeon, Podlesnik, & Miller, 2015; Nevin & Shahan, 2011; Podlesnik & Shahan, 2010).

Punishment is the process by which behavior decreases as a result of a response contingent presentation of an aversive (punishing) stimulus (e.g., electric shock) or the response contingent removal of a reinforcing stimulus (e. g., food). Because punishers have opposite effects on behavior as reinforcers, it is possible that stimuli associated with punisher delivery may reduce the persistence of problem behavior. However, very little research has investigated punishment as a method to decrease resistance to change.

Another treatment challenge that arises in applied settings is the reappearance of problem behavior after it has been eliminated. Problem behavior may re-appear for various reasons, including treatment providers accidentally reinforcing a few instances of the problem behavior, or because providers deliver reinforcers that maintain problem behavior response-independently

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(reinstatement). These accidental deviations from treatment plans are known as treatment integrity failures. Although research on staff and parent training is needed to determine how to prevent such deviations from the treatment plans, research is also needed to discover methods for reducing the return of problematic behavior during treatment integrity failures. Below, literature on resistance to change, reinstatement, and punishment are reviewed.

Behavior momentum

Behavior momentum is a theoretical account that argues that persistence of responding when environmental contingencies change (i.e., resistance to change, RTC), is a better measure of response strength than response frequency (Nevin, 1974). Behavior momentum is based on two laws of motion developed by Isaac Newton. As summarized by Plaud, Gaither, and Lawrence (1997), "Newton's first law states that when an object is in motion, it remains in motion unless acted on by an external force. Newton's second law states that whenever an external force acts upon an object, it produces an acceleration in the direction of the force that is directly proportional to the force and inversely proportional to the mass of the object" (pg. 169). Newton's Second law is formulated as, $\Delta V = f/m$, where V is velocity, f is the force, and m is mass of the object. According to Nevin, Mandell and Atak (1983) the persistence of behavior can be viewed as analogous to the momentum of physical objects (Nevin, 1992). Thus, response rate may be conceptualized as (V) velocity, response strength (resistance to change) may be conceptualized as (m) mass, and changes in contingencies for behavior may be conceptualized as (f) force (Nevin et al., 1983; Plaud et al., 1997).

According to behavior momentum theory, frequency of responding and response strength are controlled by different contingencies. The frequency of a response is determined by reinforcement contingencies, with higher reinforcement rates producing higher frequencies of

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responding. Thus, frequency of responding is determined by the reinforcer-response relationship (Herrnstein, 1970; Podlesnik & Shahan, 2009; Pyszczynski & Shahan, 2011). The strength of a response is determined by contextual stimuli (Nevin, et al., 1983; Nevin, Tota, Torquato, & Shull, 1990). Stimuli associated with higher rates or higher magnitude of reinforcement will exert greater control over behavior than stimuli associated with lower rates or lower magnitudes of reinforcement. In support of this, research has shown that behavior is more resistant to change when it occurs in a context that signals a high frequency or magnitude of reinforcement than when it occurs in a context that signals a lower frequency or magnitude of reinforcement (Dube & McIlvane, 2001; Grace, McLean & Nevin, 2003; Mace, et al., 1990; Mace, et al., 2010; Nevin, 1974; Nevin, et al., 1983; Plaud & Gaither, 1996; Plaud, Gaither & Lawrence, 1997; J. Plaud, D. Plaud & Duvillard, 1999). Stimuli that signal greater reinforcement are assumed to make behavior more resistant to change through Pavlovian stimulus-reinforcer relationship (Nevin, et al., 1983; Nevin, et al., 1990). Thus, when environmental contingencies are disrupted, such as during extinction, responding in the presence of a stimulus paired with higher rates of reinforcement results in a slower decrease than responding in the presence of the stimulus paired with lower rates of reinforcement (Nevin, 1974).

Many studies with rats (Cohen, Riley, & Weigle, 1993) and pigeons (Bell, 1999; Grace, McLean, & Nevin, 2003; Harper, 1996; Nevin, 1974; Nevin, et al., 1983; Nevin, Smith, Roberts, 1987; Nevin, et al., 1990; Podlesnik & Shahan, 2009; Podlesnik, Jimenez-Gomez, Thrailkill, & Shahan, 2011) have found support for the predictions of the theory. For example, a study conducted by Nevin (1974) examined resistance to change by exposing pigeons to a multiple variable-interval (VI) VI schedule, which included a rich VI component (i.e., VI 2 min), and a lean VI component (i.e., VI 6 min). Red and green keylights alternated throughout the session

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with the red keylights signaling the VI 6 min schedule, and the green light signaling the VI 2 min schedule. Following the last training session, extinction was implemented. Response rates declined less rapidly in the presence of the stimuli associated with the richer rate of reinforcement (i.e., green keylight).

Resistance to change appears to be solely determined by the stimulus-reinforcer relationship. Nevin, Tota, Torquato, and Shull (1990) conducted two studies designed to examine the effects of alternative reinforcement on response rate and response persistence. Pigeons were exposed to a two component multiple variable interval schedule of reinforcement. Each component was signaled by a distinct stimulus. The variable-interval schedule (VI 60 s) was the same in both components. However, in one component, a variable-time (VT) schedule was implemented which provided non-contingent (response-independent) reinforcer presentations. The purpose of adding response-independent food deliveries was to weaken the response-reinforcer relationship. Following baseline, resistance-to-change probes were introduced via pre-feeding and extinction. Results showed that greater response persistence occurred in the presence of the stimulus associated with greater rates of reinforcement, which was in this study the component with response-independent food deliveries. These findings suggest that response persistence depends on the stimulus-reinforcer relationship prior to the disruption of environmental contingences. Thus, although non-contingent reinforcer deliveries decreased responding, those additional reinforcers also caused a greater rate of reinforcement and resulted in greater response persistence when environmental contingencies were manipulated.

Several research studies have investigated resistance to change in humans. Mace et al. (1990) study examined response persistence in adults meeting criteria for various forms of mental retardation. During Part 1 of the study, participants were asked to sort silverware

according to color, and responding was reinforced on a multiple variable-interval (VI) 60 s variable-interval (VI) 240 s schedule. One VI schedule produced a lean rate of reinforcement, and the other a richer rate of reinforcement. A video program was introduced as the disruptor. Results indicated that behavior maintained by the higher rate of reinforcement was more resistant to the effects of the disruptor. During Part 2, reinforcers were delivered both contingently (dependent on behavior) and non-contingently according to a VI 60 s schedule in one component and a VI (60 s) and a variable time (VT 30 s) schedule in the second component. Results demonstrated that when the video disruptor was presented concurrently with the sorting task, responding decreased under both VI schedules. However, response rates were higher for the schedule that yielded higher reinforcement rates (i.e., VI 60 s) than the schedule with lower reinforcements rates (i.e., VI 240 s). Also, resistance to the video disruptor was greater when reinforcers were delivered non-contingently and schedules with higher rates of reinforcement (i.e., VI 60 s VT 30 s). This is consistent with previous resistance to change literature in that it demonstrates that behavior is more resistant to change when reinforcement densities are higher.

A study conducted by Plaud and Gaither (1996) extended the investigation of human behavioral momentum to typical adults. In this study, participants were asked to press keys on a computer keyboard and responding was reinforced on a two-component multiple VI 45 s VI 45 s schedule. A green stimulus signified a higher reinforcer magnitude (i.e., 10 point token) (i.e., rich component) and the red stimulus a lower reinforcer magnitude (i.e., 1 point token) (i.e., lean component). After baseline, participants were randomly assigned to experimental conditions to assess resistance to change. Resistance to change conditions existed of: extinction, decreases in the schedule of reinforcement (i.e., VI 30 s), increases in the schedule of reinforcement (i.e., VI 60 s), and two response-independent reinforcement schedules (i.e., VT 30 and VT 60s). Once

experimental conditions were implemented, the schedule for each condition was equated across components (e.g., multiple schedule VT 30 s VT 30 s) during RTC probes. More specifically the baseline schedule of reinforcement was a multiple VI 45 a VI 45 s, but during the RTC probes the reinforcement schedule changed depending on the probe (VT 30s VT 30s). The schedule was the same across conditions; however the difference in reinforcer magnitude remained the same (e.g., 1 point and 10 points) in the presence of the previously assigned stimulus. Results demonstrated that in the extinction condition responding was more resistant to change in the presence of the stimulus that signaled a higher reinforcer magnitude. Resistance to change was also greater in the rich component during response-independent reinforcement when the response-independent schedule was VT 30 s or VT 60 s. When the reinforcement schedule was lowered to VI 30 s from baseline of VI 45 s, making the schedule richer, data yielded mixed results. However, when the reinforcement schedule was increased to VI 60 s from baseline of VI45 s, making the schedule leaner, greater responding occurred greater in the rich component. The results of the Plaud and Gaither (1996) were therefore consistent with previous behavioral momentum research findings.

Plaud, Gaither, and Lawrence (1997) conducted a systematic replication of the Plaud and Gaither (1996) study. The main difference was that reinforcement density and key-pressing behavior was manipulated across participants. For half of the participants the stimulus signaling a rich schedule of reinforcement was green and participants were instructed to the press the key F1, and the stimulus signaling the lean schedule of reinforcement was red and participants were instructed to press the key F12. For the other half of the participants the stimulus signaling the rich and lean component remained consistent, but the associated key press was alternated.

Results also demonstrated that responding was more resistant to change under the stimulus that signaled a higher reinforcer magnitude.

Although the results of the Plaud and Gaither (1996, 1997) studies are consistent with predictions of behavioral momentum theory, there are some interpretive problems with their studies. Their studies examined response rates and not response rates as a proportion to baseline. One would expect higher response rates in a higher reinforcer-magnitude condition. Resistance to change literature typically involves assessing the change in response rate in relation to baseline. Response rate data from Plaud and Gaither, (1996) was not provided for baseline conditions therefore, it is difficult to interpret their data. Plaud et al. (1997) did provide baseline response rate data, which can be plotted as a proportion to baseline allowing researchers to re-interpret their data by plotting response rates as a proportion to baseline.

Although research has indicated that resistance to change is caused by the stimulus-reinforcer relationship, several studies have examined the role of the response-reinforcer contingency (Fath, 1983, Lattal, 1989; Nevin, 1974). In these studies, reinforcement rates are equated and response requirements are manipulated. More specifically, these studies programmed a multiple schedule with two components that yielded the same reinforcement rate but generated different response rates. For instance, one component might have had a response criterion that resulted in low response rates, and the other component had a response criterion that resulted in high response rate (e.g., DRH or DRL). Resistance to change probes were implemented by providing response-independent food deliveries during the inter-component intervals. The duration of each response-independent food presentation varied. These studies found that higher response rates were less resistant to change and lower response rates were more resistant to change. Behavior momentum theory suggests that both the response-reinforcer

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(Operant) relationship and the stimulus-reinforcer relationship (Pavlovian) is important. The response-reinforcer relationship helps establish response strength during baseline conditions; however RTC is only measured by the rate of responding, which is the result of the stimulus-reinforcer relationship (Podlesnik & Shahan, 2008).

One behavioral phenomenon that seems to contract predictions of RTC is the partial reinforcement extinction effect (PREE). The PREE is the finding that behavior maintained by continuous reinforcement (CRF), in which reinforcement presentation occurs after each response, shows less RTC than intermittent reinforcement (INT), in which reinforcement presentation occurs after a variable number of responses or a response after a variable amount of time. The rate of reinforcement is greater under CRF schedules of reinforcement than INT schedules of reinforcement. Thus, RTC would predict that once environmental contingencies change, greater response persistence should occur in the presence of the stimulus associated with the CRF schedule of reinforcement than the INT schedule of reinforcement (Nevin, 1988). However, data show that responding is more persistent during extinction after INT reinforcement (Nevin, 2012). One interpretation of this effect is that research measuring response persistence with CRF and INT have involved between group designs. When CRF and INT were examined using a within-subjects design, greater response persistence occurred during CRF (Nevin, 1989; Pavlik & Peter, 1965). Researchers also suggest PREE to be a discrimination issue (Quick & Shahan, 2009). When extinction is implemented following CRF and INT, there is more of a discriminable difference between CRF and extinction. Subjects exposed to CRF receive reinforcement for every response emitted and then are transitioned to a phase where responding no longer produced reinforcement. This results in a more immediate decrease in response rates. In contrast, subjects exposed to INT receive reinforcers after a variable number of responses or

after the first response after a amount of time or response, thus the transition to extinction is less discriminable (Quick & Shahan, 2009). This suggests that accounts of behavior based on RTC need to take into account the discrimination of extinction.

In summary, response persistence occurs in the presence of stimuli associated with greater rates of reinforcement and/or higher magnitude of reinforcement. The predictions of BMT have been replicated across a number of species, including humans. Understanding the processes that determine behavioral momentum is useful in that is provides researchers with a new way to conceptualize effects of reinforcement on behavior; and it may aid in the development of effective methods to modify response persistence. Understanding the conditions under which behavior is more or less likely to persist allows behavior analyst to modify environmental contingencies to strengthen appropriate behaviors, or to weaken persistence of problem behaviors.

Little research has investigated how to effectively decrease the persistence of unwanted behavior. The contingent delivery of aversive stimuli has been shown to equivalent yet opposite effects of reinforcement resulting in the response contingent decrease of behavior. This suggests that the presentation of punishers may have opposite effects of reinforcement and reduce resistance to change. Further discussion on the effects of punishment on RTC is addressed below.

Reinstatement

Reinstatement is a process by which extinguished behavior is recovered (Reid, 1958). Specifically, reinstatement occurs when the reinforcer used to maintain responding prior to extinction is delivered response-independently, which causes the previously extinguished behavior to reemerge. Reid (1958) was among the first to investigate the re-occurrence of an

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extinguished behavior. Reid examined behavior in a variety of subjects (i.e., pigeons, humans, and rats) to determine how various stimuli and reinforcers presented during extinction affected the reappearance of a previously extinguished behavior. In Experiment 1, lever pressing of six rats was reinforced with food delivery using a continuous reinforcement schedule (CRF) for 20 sessions across two consecutive days. Following a steady baseline, extinction was implemented. After behavior was extinguished, subjects were presented a variety of different stimuli (i.e., sounding of a buzzer, taping the box, flickering of the light) to examine whether they caused the re-appearance of the previously extinguished behavior. None of the stimuli affected behavior. Next, food pellets were delivered non-contingently, and responding re-appeared in all subjects. Reid interpreted the finding by suggesting that the reinforcer functioned as a discriminative stimulus which resulted in occurrence of the extinguished response. Reid (1958) replicated the aforementioned study using pigeons. In Experiment 2, key pecking of six pigeons was reinforced with food delivery using a CRF schedule across 50 sessions across two consecutive days. Following baseline, extinction was introduced for a period of 30 minutes across three consecutive days. During the second day of extinction, several stimuli were presented (i.e., the sound of rattling maple peas) which caused only a slight effect on behavior. Towards the end of the third extinction day, non-continent reinforcer delivery occurred. The previously extinguished behavior (i.e., key pecking) re-appeared in five of the subjects.

Falcomata, Hoffman, Muething, and Fienup (2013) examined the occurrence of reinstatement of destructive behavior by individuals with autism. Three individuals diagnosed with autism who also engaged in destructive behaviors (e.g., tantrums, self-injurious behaviors) were participants. Access to an iPad functioned as the reinforcer throughout the study. The study consisted of three phases. During the first phase, baseline, a fixed ratio (FR 1) schedule was

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implemented. During this component, the iPad was visible, and participants were granted 30-s

access to the iPad contingent on each occurrence of destructive behavior. Participants then

experienced an extinction condition. The iPad was present and visible to the participants, but

destructive behavior did not result in its access. Following extinction, reinstatement was

implemented. During this condition, a fixed time (FT) 2 min schedule of reinforcement was

implemented. Participants were given 30-s access to the iPad every 2 minutes. Destructive

behavior was ignored. A momentary differential reinforcement of other behavior (MDRO)

procedure was co-implemented along with the FT 2 min schedule to prevent accidental

reinforcement of destructive behavior. During MDRO procedures, reinforcer delivery is withheld

if problem behavior occurs within a specific time interval prior to scheduled reinforcer delivery.

Results showed that during the reinstatement condition the previously extinguished response re-

appeared in all three participants.

Podlesnik and Shahan (2009) have argued that the degree of reinstatement may be related

to resistance to change. Podlesnik and Shahan (2009, Experiment 1) investigated the effect of

rates of reinforcement on both response persistence and reinstatement of extinguished behavior.

During baseline, 10 pigeons were exposed to equal rates of response dependent reinforcement in

a two component variable interval (VI) 120 multiple schedule of reinforcement. Each

component was signaled by a distinct stimulus. Response independent food delivery was added

to only one component on a variable time (VT) 20 s schedule of reinforcement. The component

containing response independent food deliveries was defined as the "rich" component. The

component without the response independent food deliveries was defined as the "lean"

component. Following baseline, extinction was implemented. Once responding during

extinction was below 10% of baseline for two consecutive sessions, reinstatement was

implemented. During reinstatement, food reinforcers were delivered response independently or response dependently in separate blocks across sessions. Each response dependent and response independent block was separated by approximately five extinction sessions. During response-independent presentations, food reinforcers were delivered 2 s and 8 s into each component. During response-dependent presentations, the first two responses in each component resulted in reinforcement. Extinction continued after each presentation. Results showed that the free-food generated more responding during the rich component than in the lean component during extinction. Reinstatement occurred at a greater rate in the rich component than in the lean component. Furthermore, reinstatement was greater with response dependent food deliveries than response independent food deliveries. Responding decreased across all reinstatement sessions as extinction continued. These data suggest that resistance to change and reinstatement vary as a function of the density of reinforcement and its associated context.

Although nearly all RTC and reinstatement research has been conducted with positive reinforcers, at least one study has shown that rate negative reinforcement can also affect response persistence and reinstatement. Alessandri, Lattal, and Cancado (2015) investigated the effects of negative reinforcement on resurgence, renewal, and reinstatement. In this study, human participants received timeout from pressing a force cell contingent on key pressing. Experiment 1 investigated the occurrence of resurgence while Experiment 2 investigated the occurrence of renewal. Experiment 3 investigated the occurrence of reinstatement. In Experiment 3, the computer screen remained gray throughout the study. During baseline, three male participants were exposed to a variable ratio (VR) 23 schedule of reinforcement for key pressing while simultaneously pressing the force cell. Reinforcers were a 3-s timeout from pressing the force cell. The baseline conditions lasted for three, 10-min sessions. Following baseline, extinction

was implemented. During extinction, key pressing no longer resulted in breaks from pressing the force cell. After extinction, reinstatement was implemented. During this time, timeout from pressing the force cell occurred response-independently. Results showed a decrease in responding during extinction; however, reappearance of behavior occurred only slightly during reinstatement. These findings are inconsistent with previous reinstatement literature.

Understanding the conditions affecting RTC is therefore relevant to understanding reinstatement. To the author's knowledge little to no research has examined whether aversive stimuli can mitigate reinstatement. If reinforcer presentations increase reinstatement, then it is possible that the presentation of punishers may reduce reinstatement.

Punishment

Punishment is defined as the decrease in behavior following the response-contingent presentation of an aversive stimulus or the removal of a reinforcing stimulus (Azrin & Holz, 1966). Much research has shown the rate-decreasing effects of stimuli such as shock (Azrin, 1956), noise (Charlop, Burgio, Iwata, & Ivancic, 1988), water mist (Dorsey, Iwata, Ong, & McSween, 1980), and money loss (Pietras, Brandt, & Searcy, 2010). If reinforcer presentations can increase RTC and reinstatement, then it is possible that punishers may decrease RTC and reinstatement. However, whether punishers actually function in a similar (but opposite) way to reinforcers is not clear.

Researchers have debated whether punishment has a direct suppressive effect on responding (i.e., is functional equivalent but opposite in direction as reinforcement), or whether punishment decreases behavior via indirect means (Critchfield, Paletz, MacAleese, & Newland, 2003; Deluty, 1976; de Villiers, 1980; Dunham, 1971; Mowrers, 1947; Schuster & Rachlin, 1968). There are two leading theories of punishment, as defined by Skinner, that correspond to

these two interpretations. One-Factor Theory of punishment (i.e., the direct-suppression model) suggests that punishment contingencies directly affect reinforced responding by decreasing response strength (de Villers, 1980). More specifically, One-Factor Theory suggests that punishment contingencies have a direct suppressive effect on behavior. Thus, this theory suggests that reinforcement and punishment and comparable but opposite processes. Two-Factory Theory of Punishment (i.e., the competitive-suppression model) suggests that punishment decreases behavior indirectly (Deluty, 1976). Punishment operates to negatively reinforce behavior that competes with the response that produces punishment. Thus, the punishing stimulus acts as a negative reinforcer for the alternative behavior (see Critchfield et al., 2003). Engaging in the alternative behavior decreases or prevents the occurrence of the aversive stimulus (Arbuckle & Lattal, 1987; Schuster & Rachlin, 1968). Two-Factor Theory of Punishment (Dinsmoor, 1954; Dunham, 1971; Schuster & Rachlin, 1968; Skinner, 1953) assumes that both Pavlovian and operant processes are responsible for the response suppression during punishment and the development and maintenance of an alternative response. Classical (Pavlovian) conditioning occurs when the stimulus paired with the punisher, including the response that produced it, becomes the conditioned aversive stimulus (Skinner, 1953). Operant conditioning occurs when a behavior that results in the decrease of the conditioned aversive stimulus increases in frequency.

Skinner, a two-factor theorist, originally argued that the effects of punishment were indirect and temporary, and thus not equivalent to reinforcement (Skinner, 1953). Once punishment contingencies were removed, previously punished behavior reemerges. Data from various studies on punishment, particularly those by Azrin and colleagues, however, have led researchers to conclude that punishment is a process comparable but opposite to reinforcement,

and thus punishment is better interpreted in terms of One Factor Theory (Azrin, 1956; Azrin, 1960; Azrin & Holz, 1961; Azrin, Holz, & Hake, 1963; Holz & Azrin, 1963). These studies have shown that the same variables that alter the efficacy of reinforcement also alter the efficacy of punishment (i.e., immediacy of punishment, schedule of punishment, magnitude of punishment).

For example, Azrin, (1960) examined the effects of punishment magnitude on response frequency. Responding was maintained on a VI reinforcement schedule and a FR punishment schedule was introduced at various shock intensities (i.e., 0 V. to 160 V.). Results from the study showed greater response suppression at higher shock intensities. These results are equivalent but opposite to studies on reinforcement that have shown that greater reinforcer magnitudes result in higher response rates (e.g., Jenkins & Clayton, 1949).

Baron, Kaufman, and Fazzini (1969) examined the effects of punishment density and punishment delay on free operant shock avoidance behavior in rats. Data showed that the more immediate the delivery of the aversive stimulus (electric shock), the greater the decrease in response frequency. Data also showed a greater decrease in responding as the reinforcer density increased. This finding is similar but opposite to studies using reinforcement that have shown that the more immediate the reinforcer the delivery and the more frequent the reinforcer deliver, the greater the increase in responding (e.g., Chung & Herrnstein, 1967).

Studies have also examined the effects of punishment on patterns of responding. Azrin (1956) examined a conjoint fixed-interval (FI) 60-s shock delivery variable-interval (VI) 3-min food schedule of reinforcement. The subject's rate of responding decreased towards the end of the FI 60-s interval producing a decelerating pattern of responding. This pattern of responding is opposite of that of reinforcement which shows an increase in rate of responding towards the end

of the reinforcement interval, producing an accelerated pattern of responding (e.g., Fry, Kelleher, & Cook, 1960).

Researchers have also implemented quantitative models to test different theoretical interpretations of punishment, specifically models based on the Matching Law (e.g., Delutey, 1976; de Villiers, 1980). The Matching Law is a model that has been used to describe response allocation in concurrent schedules of reinforcement. It has been shown to describe response allocation on concurrent schedules across various species (Catania, 1963; Herrnstein, 1970), and across a various forms of behavior (Borrero & Vollmer, 2002; Vollmer & Bourret, 2000). The Matching Law (Herrnstein, 1970) states that:

$$\frac{R_1}{R_1 + R_2} = \frac{r_1}{r_1 + r_2}$$

(1)

where R_1 and R_2 are the response rate for two concurrent schedules and r_1 and r_2 are the reinforcement frequencies associated with each schedule. The matching equation states that response rates on each alternative should match the rate of reinforcement. Many studies have shown that performance on concurrent schedules is generally consistent with these predictions (e.g., Catania, 1963; Critchfield, Paletz, MacAleese, & Newland, 2003; Deluty, 1976; de Villiers, 1980).

Deluty (1976) investigated the effects of punishment rates (electric shock) on concurrent schedules of reinforcement. Three male rats were exposed to concurrent RI 1.5 min RI 1.5 min schedule of reinforcement. Each schedule also had a punishment contingency in place. For one schedule, the punishment schedule remained constant (RI 6 min), for the other schedule, the punishment schedule varied. Results showed that as the punishment rate increased, responding on the lever decreased, while responding on the alternative key increased despite the rate of

punishment remaining constant. To account for the data, Deluty (1976) tested the following

version of the matching equation. Equation 2 demonstrates that as the rate of one response

decreases under punishment, the rate of the other concurrently punished response increases. Here

p_1 and p_2 represent punishment rates.

$$\frac{R_1}{R_1 + R_2} = \frac{r_1 + p_2}{r_1 + p_2 + r_2 + p_1} \quad (2)$$

Deluty's data and equation therefore assumed that punishers function not to directly

suppress behavior but rather to increase alternative behaviors. More specifically, when one

response is punished, alternative unpunished responses increase (Deluty, 1976; de Villiers, 1980)

Conversely, de Villiers (1980) suggested that punishers directly reduce the occurrence of

behavior. The following equation developed by Estes (1969) suggests there to be a subtractive

interaction between reinforcement and punishment. More specifically, Equation 3 demonstrates

how punishers directly subtract from the reinforcer value.

$$\frac{R_1}{R_1 + R_2} = \frac{r_1 - p_1}{r_1 - p_1 + r_2 - p_2} \quad (3)$$

Perhaps the most extensive evaluation of the two punishment versions of the Matching

Law (i.e., Deluty's competitive suppressive model and de Villiers' direct suppression model)

was conducted by Critchfield et al., (2003).Human participants were exposed to concurrent VI

VI schedule of reinforcement in which mouse clicking was reinforced with money. The punisher

consisted of money loss. Two experiments were conducted. Experiment 1 was designed to

determine the effectiveness of money loss as a punisher. Experiment 2 was separated into two

parts in order to compare the two punishment models (i.e., the competitive suppression and

direct suppression). Experiment 2 Part A was designed to test the direct-suppression model (i.e.,

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de Villiers' equation). During Part A, participants were exposed to a concurrent VI 15 s VI 30 s schedule of reinforcement while simultaneously exposed to a concurrent punishment contingency programmed at 50% and 100% of the programmed reinforcement rate of the leaner schedule. Part B was designed to test the competitive suppression model. During Part B, participants were exposed to a concurrent VI 12 s VI 60s schedule of reinforcement while simultaneously exposed to a punishment contingency programmed at 25%, 50%, and 75% of the reinforcement rate for each response option. Results for Experiment 2 Part A and Part B showed that there was consistent evidence for the direct suppression model as supported by the one factor theorist. According to Critchfield et al., (2003), the de Villiers (1980) model better predicted behavior under punishment.

Punishment and resistance to change

As described above, RTC poses that stimuli associated with higher reinforcement rates or higher magnitude of reinforcement enhance response persistence. Various studies have supported this view. Little is known about how punishers affect resistance to change. If punishment is effective because the punisher strengthens alternative behaviors via negative reinforcement, then one might predict that the added negative reinforcement generated by punishment may result in *greater* response persistence in the presence of punishment stimuli. In other words, the Pavlovian association of the added negative reinforcers and the environment may result in more response persistence in the punishment context. Alternatively, if punishment reduces behavior because aversive stimuli directly weaken responding (i.e., punishment is an equivalent but opposite process to reinforcement), then one might predict that the aversive stimulus generates by punishment may result in *less* response persistence in the presence of the

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stimuli associated with punishment. In other words, the association of the added punisher and the environmental context may result in less response persistence in the punishment context.

To date, there is only one study, not yet published, that has examined the effects of punishment on resistance to change (Hall, Cook, & Lattal, 2015). Hall et al. conducted two experiments to examine the effects of timeout-punishment on resistance to extinction in pigeons. In Experiment 1, eight male pigeons were exposed to three phases: Baseline, Punishment, and Extinction. During baseline, subjects were exposed to multiple VI 45 s 45 s schedule of reinforcement. Each component was signaled by a distinct stimulus (i.e., red and white keylights). Each component lasted 10 min and inter-component intervals were 30 s. A yoking procedure that equated reinforcement rates across components was used to control for reduced reinforcement rate during the punishment phase. This was important to ensure that any effects on response persistence could be attributed to the punishment contingency and not to decreases in reinforcement. During the punishment phase, subjects were exposed to a multiple conjoint VI 45 s VR 2 (punishment) VI 45 s schedule of reinforcement. During the punishment component, responses resulted in food delivery, or 20 s of timeout. Punishment conditions were followed by one of two extinction phases. In one extinction phase, timeouts continued to occur, and in the other they did not. Results showed that during extinction with timeout punishment, responding in the punishment component did not appear less resistant to extinction. During extinction without timeout, responding in the component previously associated with punishment appeared *more* resistant to extinction than responding in the unpunished component.

Although the results appear to contradict predictions of one factor views of punishment, the greater resistance to change in the component associated with punishment may have occurred because the punishment contingency was removed. That is, the removal of the punishment

contingency may have resulted in an increase in responding although responding did not produce reinforcement (i.e., recovery from punishment). Thus, the removal of the aversive stimulus caused response rates to recover to levels similar to baseline levels.

In a second follow-up study, Hall et al., (2015) examined the effects of response-independent punishment on resistance to extinction. Six male pigeons were exposed to baseline, variable time (VT) timeout, and extinction. Baseline procedures were the same as those in Experiment 1 (i.e., multiple VI 45 s 45-s schedule of reinforcement. During the punishment component, subjects were exposed to a multiple, conjoint VI 45 s VT 5 s (punishment) VI 45 s schedule of reinforcement. During the punishment component, responses resulted in food delivery and 20-s of timeout was delivered independent of responding. A red keylight signaled the VT-timeout (i.e., VI 45 s and VT 5 s) component and a white keylight signaled the reinforcement (VI 45 s) component. Extinction phases were conducted in the same manner as Experiment 1, however the VT-timeout schedule continued from the previous punishment phase. Results from experiment two showed that during the VT-timeout phase there was little difference in response rates between the two components. However, during extinction, behavior in the component associated with VT timeout appeared to be less resistant to extinction. This may have occurred because the stimulus context paired with timeout generated less resistance to change. These data provide some additional support for the one-factory theory of punishment, in that punishment appeared to have an equivalent but opposite effect on responding as reinforcement. Additional research examining the reliability of this effect would be valuable.

Experimental purpose

Only one study has investigated whether an aversive stimulus can reduce the occurrence of response persistence. The prior study conducted by Hall et al., (2015) used timeout as an

aversive stimulus. Although timeout is a commonly used punisher outside the laboratory, timeout is a negative punisher. A positive punisher (i.e., eclectic shock) may have different effects on response persistence. Thus, the main purpose of the present experiment was to further examine the effects of punishment on resistance to change. Specifically, the current study examined the effects of electric shock punishment on resistance to change. This was accomplished by examining resistance to change in a multiple schedule with punishment and no-punishment components. Although an actual contingency between responding and the presentation of the aversive stimulus should not be necessary to see effects on resistance of change, a punishment procedure was used to ensure that the stimulus was indeed aversive (punishing).

Because punishers decrease response rate, they may also decrease reinforcement rates. The decrease in reinforcement rate may confound the analysis of the independent effects of aversive stimuli on resistance to change. Thus, it was necessary to examine resistance to change under punishment while controlling for reduced reinforcement rate. Reinforcement rate was controlled through the use of a yoking procedure. In one component of the multiple schedule behavior was reinforced and punished, and in another component behavior was reinforced with food at a rate yoked to the rate of reinforcement obtained under the punishment component.

Resistance to change was investigated using extinction probes. As in the study by Hall et al. (2015), two types of extinction probes were utilized: Resistance to Change with no Punishment (RTC) and Resistance to Change with Punishment (RTC-P). During Reinforcement Extinction with no Punishment, responding in both components (Punishment and No Punishment) did not produce food deliveries or shock. During Reinforcement Extinction with Punishment, responses in the Punishment component continued to produce shock delivery only.

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During probe sessions, the punishment schedule (i.e., RI-5s) and shock intensity was the same as the preceding punishment condition with duration of 0.5s. Responding in both components did not produce food deliveries.

A second goal of this experiment was to examine the effects of punishment on reinstatement to investigate whether punishment would be effective at decreasing the reappearance of behavior. Reinstatement was introduced following each extinction probe. During Reinstatement Probes, response independent food deliveries occurred at the start of each component. There were two reinstatement probe types. The reinstatement probes had the same punishment (REINST-P) or no punishment (REINST) conditions in effect. It was expected that the effects of punishment on resistance to change should parallel the effects on reinstatement.

Potential clinical significance

It is possible that the results of this study would contribute to clinical practice by suggesting alternative strategies to decrease and shorten response persistence, and reduce reinstatement. Results from this study have the potential to provide effective strategies to prevent persistence of aggressive behavior during extinction, persistence of substance abuse during therapy (Pritchard, Hoerger, & Mace, 2014), or persistence of problem behavior for individuals with developmental disabilities (DeLeon, Podlesnik, & Miller, (2015). Van Houten et al. (1988), state that "an individual has the right to the most effective treatment procedures available (pg. 383)."   If aversive stimuli can decrease resistance to change, then it may be possible to reduce the persistence of problem behavior by introducing aversive stimuli into the context in which problem behavior occurs prior to extinction. The relationship between RTC and reinstatement suggests that punishers may also decrease the reappearance of behavior.

METHODS

Subjects

Six male Sprague-Dawley rats approximately one year old were used as subjects. Rats were individually housed in a colony room maintained on a reversed 12-hour light/dark cycle. The rats were maintained at 85% (+/- 5 grams) of free-feeding weight. Post-session feeding was utilized to maintain target weights and rats had free access to water in their home cages. All rats had previous histories responding for water reinforcers in an undergraduate-learning lab. Specifically, these rats had experience responding under fixed ratio (FR), fixed interval (FI), variable (VR) schedules of water reinforcement in which lever lights signaled the availability of water for lever pressing.

Apparatus

Behavior testing was conducted in three Med PC ® operant chambers. Each operant chamber was housed in a sound attenuating shell equipped with a ventilation fan and a white noise generator to mask extraneous noise. Each chamber was 29 cm long, 24 cm wide, and 21 cm high. A light affixed to the ceiling was used to illuminate the chamber. Two retractable levers were located on the front wall of each chamber; however, only the right lever was used for the present study. Between the levers was a 5 cm x 5 cm opening where 45 mg Bio-Serv purified rodent food pellets were dispensed. Stimulus lights were located above each lever. On the opposite wall there were two circular openings (2.25 cm diameter x 2 cm deep) for nose-poke responses; however, nose poke responses were not recorded in this study. All lights were extinguished and contingencies were suspended for 3 s following each reinforcer (food pellet) delivery. The floors of the operant chambers consisted of metal bars through which scrambled

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electric shocks were delivered by a Med-PC dual range, constant current, aversive stimulation module version ENV-410B. Experimental events and data collection was controlled by a computer equipped with MED-PC® software. Experimental procedures were in compliance with Western Michigan University Institutional Animal Care and Use Committee.

Procedure

The experiment consisted of seven conditions: Pre-training, Baseline (BL), Punishment (PUN), Resistance to Change Extinction Probe without punishment (RTC), Reinstatement without punishment (REINST) Resistance to Change Extinction Probe with punishment (RTC-P), and Reinstatement with punishment (REINST-P). Baseline and Punishment conditions separated each extinction probe, and the order of exposure to extinction probes was counterbalanced across subjects.

Pre-training

Because rats had previous experience lever pressing, no lever-press training was needed. Thus, rats were immediately exposed to a random-interval (RI) 1 s schedule of pellet delivery. During training sessions, the light above the right (operative) response lever was not illuminated. Rats were exposed to the pre-training reinforcement schedule for approximately 100 reinforcer deliveries or 32 minutes. Across approximately 5 subsequent sessions the schedule value was gradually increased to 20-s.

Baseline (BL)

Table 1 shows the sequence of conditions and number of sessions per condition for each rat. During baseline, a two component multiple [RI 20 s food] [RI Yoked food] reinforcement schedule was in place for 20 sessions and until responding was stable for 10 consecutive sessions with no increasing or decreasing trends. However, the RI schedule was adjusted for A2 due to a

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decrease in responding during the second baseline phase. Each session consisted of eight 4-min components. Components were separated by a 10-s inter-component interval (ICI) during which all lights within the chamber were extinguished. The first component of each day was randomly determined, and then components followed in an alternating sequence for the rest of the session. If the first component was a yoked component, then reinforcers were delivered according to the rate obtained in the last experienced non-yoked component from the preceding day's session. Each component was signaled by a unique stimulus: a flashing light located above the lever signaled the RI component and a steady illuminated light signaled the yoked component and was consistent across rats.

Punishment (PUN)

During the punishment condition responding was maintained on a two component multiple [Conjoint RI 20 s food RI 5 s shock] [RI yoked food] schedule. During the punishment component, responses produced food after an average of 20 s and shock after an average of 5 s. During the yoked component, responses produced food at the same rate as that obtained in the preceding punishment component and no shocks occurred. Specifically, the number of obtained food deliveries in punishment component was used to create a RI schedule for food deliveries in the yoked component such that the reinforcement rate in the yoked component was equal to that in the punishment component. A flashing lever light signaled the punishment component and a steady illuminated lever light signaled the yoked component.

During punishment sessions, the initial shock intensity was set at 0.4 mA with duration of 0.5 s. Shock intensity was adjusted with the goal of decreasing response rates under punishment to 25-75% percent of baseline rates. Stability was defined as ten consecutive sessions in which the rate of responding was consistently lower during the punishment than the yoked component, and

responding during the punishment component was approximately to 25-75% of baseline

responses.

Table 1

Sequence of conditions, electric shock intensity, and number of sessions per condition for each rat.

Subject	Phase	Number of Sessions
K1	BL	40
	PUN (.6mA)	4
	PUN (.3mA)	6
	PUN (.5mA)	11
	PUN (.6mA)	21
	PUN (.7mA)	3
	PUN (.6mA)	2
	PUN (.5mA)	10
	RTC	10
	BL	10
	PUN (.4mA)	1
	PUN (.5mA)	15
	PUN (.6mA)	5
	PUN (.7mA)	27
	RTC-P (.7mA)	10
	REINST-P (.7mA)	4
K3	BL	40
	PUN (.6mA)	7
	PUN (.3mA)	3
	PUN (.5mA)	6
	PUN (.4mA)	13
	PUN (.5mA)	34
	BL PROBE	11
	PUN (.3mA)	1
	PUN (.4mA)	2
	PUN (.5mA)	5
	RTC-P (.5mA)	10
	REINST-P (.5mA)	4
K4	BL	36
	PUN (.4mA)	4
	PUN (.5mA)	19
	RTC-P(.5mA)	10
	REINST-P (.5mA)	4

	BL	10
	PUN (.5mA)	9
	PUN (.6mA)	20
	RTC	10
	REINST	4
	BL	21
K8	PUN (.4mA)	20
	RTC	10
	BL	10
	PUN (.4mA)	20
	RTC-P (.4mA)	10
	REINST-P (.4mA)	4
	BL	21
A1	PUN (.4mA)	2
	PUN (.3mA)	4
	PUN (.4mA)	15
	RTC-P (.4mA)	10
	REINST-P (.4mA)	4
	BL	10
	PUN (.4mA)	22
	RTC	10
	REINST	4
	BL	23
A2	PUN (.4mA)	20
	RTC	10
	REINST	4
	BL (RI-10)	34
	PUN (.4mA)	11
	PUN (.5mA)	16
	RTC-P (.5mA)	10
	REINST-P (.5mA)	4

Notes: RTC=Resistance to Change, REINST= Reinstatement, PUN=Punishment, and BL=Baseline. Any condition with current (mA) in parentheses used shocks in the punishment component while conditions without parentheses did not employ shocks in the punishment component. Rat A2 had a BL phase with a higher frequency RI-10 schedule than the standard RI-20 schedule.

Resistance to change probes (RTC)

Resistances to Change (RTC) probe sessions were implemented for ten sessions. Two types of RTC probes were programmed. Procedures were similar to the Punishment phase, with the exceptions described below:

Reinforcement extinction with no punishment (RTC)

In the Reinforcement Extinction with No Punishment (RTC) probe, responding in both components (punishment and yoked) did not produce food deliveries or shock.

Reinforcement extinction with punishment (RTC-P)

In the Reinforcement Extinction with Punishment probe (RTC-P), responding in both components did not produce food deliveries; however, responses in the punishment component continued to produce shock delivery. The punishment schedule (i.e., RI 5 s) and shock intensity were the same as in the preceding punishment condition, and the duration remained at 0.5 s.

Reinstatement probes (REINST)

Reinstatement probes were modeled after those used by Podlesnik and Shahan (2009) and were implemented after the ten RTC extinction sessions. Reinstatement probes lasted for four sessions. There were two types of reinstatement probes, corresponding to the RTC probe conditions: Reinstatement with Punishment (REINST-P) and Reinstatement without Punishment (REINST). REINST-P probes followed RTC-P conditions and extinction sessions. During Reinstatement Probes, response independent food deliveries (one pellet) occurred 2 s and 8 s into each component. Thus, rats received a total of 8 pellets per session during reinstatement. All other contingencies were the same as in the preceding RTC probe conditions.

RESULTS

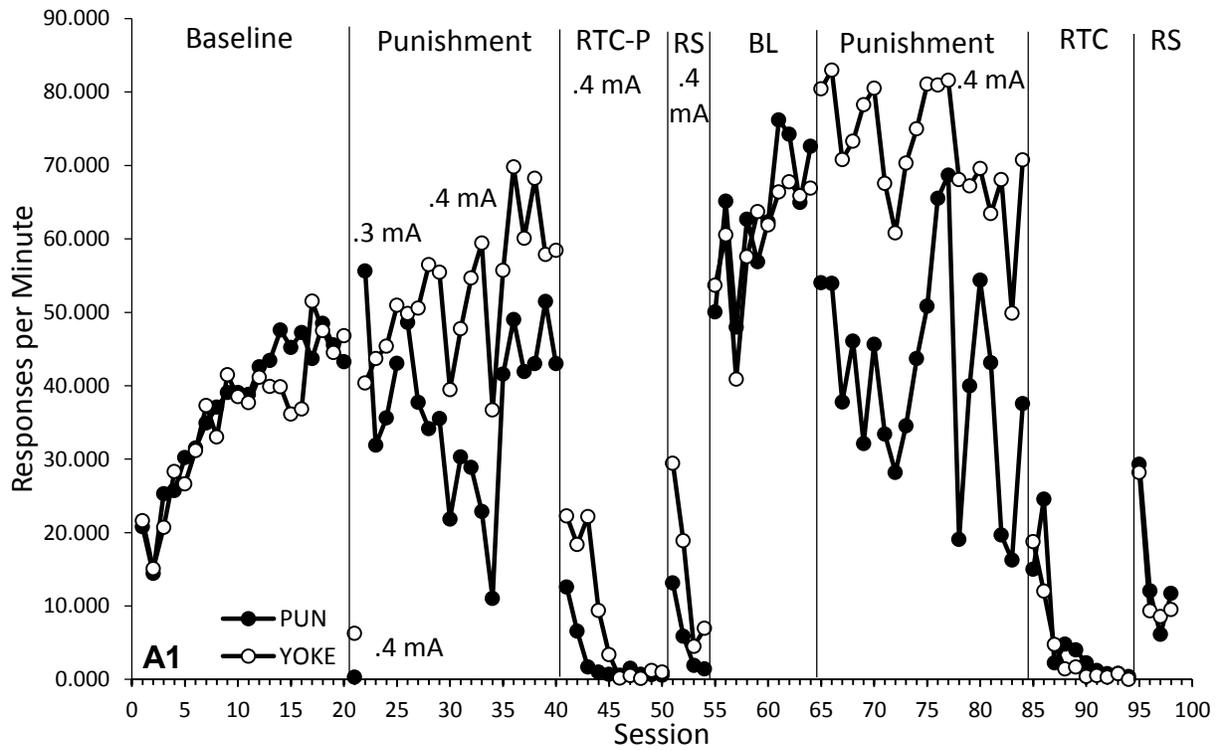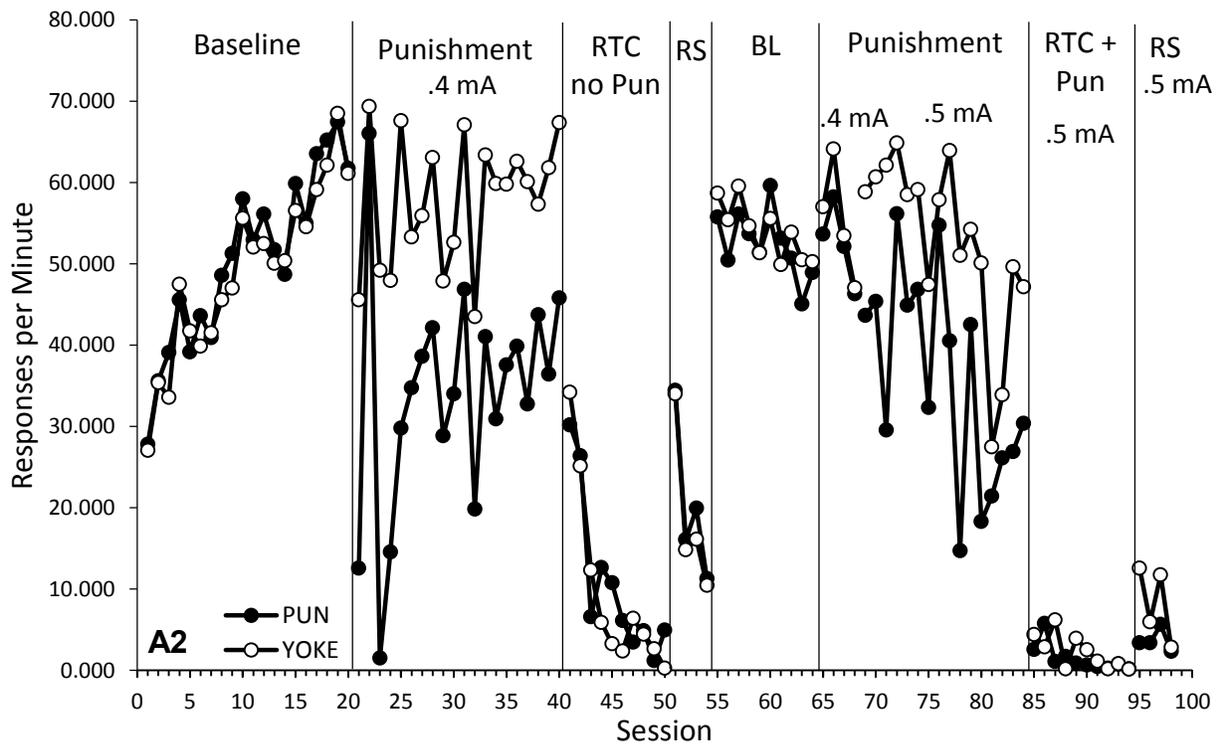## Mean baseline and punishment response rates

Figure 1 shows response rates for all rats across all experimental conditions, and Figure 2 shows average response rates across the last ten sessions for each Baseline and Punishment phase. Response rates during the first Baseline phase stabilized between 16 and 67 responses per minute ($M = 46.28$, $SD = 21.17$). Response rate during the second Baseline phase stabilized between 37 and 90 responses per minute ($M = 56.27$, $SD = 20.03$). When punishment was introduced after each Baseline phase, response rates in the punishment component decreased and became slightly more variable within subjects (see Figure 2), but were slightly lower in variability between subjects ($M_{PUN1} = 25.61$, $SD_{PUN1} = 13.84$; $M_{PUN2} = 27.83$, $SD_{PUN2} = 19.89$). Some rats (i.e., K4, A2, K8) showed an immediate decrease in responding when punishment was introduced, but responding gradually increased across sessions until the shock magnitude was increased. The terminal shock magnitude required to obtain a moderate punishment effect ranged from .4mA-.7mA. Under these intensities, there were clear differences in responding between the punishment and yoked components, with average punishment component responses rates in the last ten sessions being 37-51% lower in the first exposure ($M = 43\%$, $SD = 9\%$) and 36-72% lower in the second exposure ($M = 49\%$, $SD = 15\%$). During the second Punishment condition, in three of the six subjects, the shock intensity required to suppress responding was slightly higher than that in the first Punishment condition. Rats exposed to the same shock intensities in both Punishment phases showed a slightly higher response rates during the second Punishment phase, whereas rats exposed to higher shock intensity during the second Punishment phase showed slightly lower rates in the second Punishment phase.

Average reinforcement rates

Figure 3 shows the average reinforcement rate across Baseline and Punishment phases in each experimental condition in each component. Reinforcement rates were similar in both the punishment and yoked components in each condition, indicating that the yoking procedure was effective in equating rates of reinforcement. Subject A2 had a BL phase with a higher frequency RI-10 schedule than the standard RI-20 schedule in order to maintain responding in the subsequent Punishment phase. Average reinforcement rates between subjects hereafter do not include the reinforcement rates of Subject A2. There was a decrease in reinforcement rates from Baseline ($M = 2.22$, $SD = 0.76$) in both components when Punishment ($M = 1.58$, $SD = 0.78$) was introduced. When Baseline conditions were reintroduced, reinforcement rates increased ($M = 3.04$, $SD = 0.55$) and were higher than the preceding Baseline phase. When the Punishment phase was reintroduced, reinforcement rates ($M = 1.51$, $SD = 0.80$) again decreased.

Punishment phase response rates as a proportion to baseline

Figure 4 illustrates average response rates for each punishment and yoke component for each Punishment phase plotted as a proportion of the preceding Baseline (last 10 stable sessions). Average response rates in the punishment component compared with Baseline were 39 to 81% in the first phase ($M = 61\%$, $SD = 35\%$) and 37 to 75% in the second phase ($M = 52\%$, $SD = 31\%$). In the yoked component, average response rates compared to Baseline were 81 to 123% in the first phase ($M = 103\%$, $SD = 31\%$) and 77 to 119% in the second phase ($M = 94\%$, $SD = 28\%$).
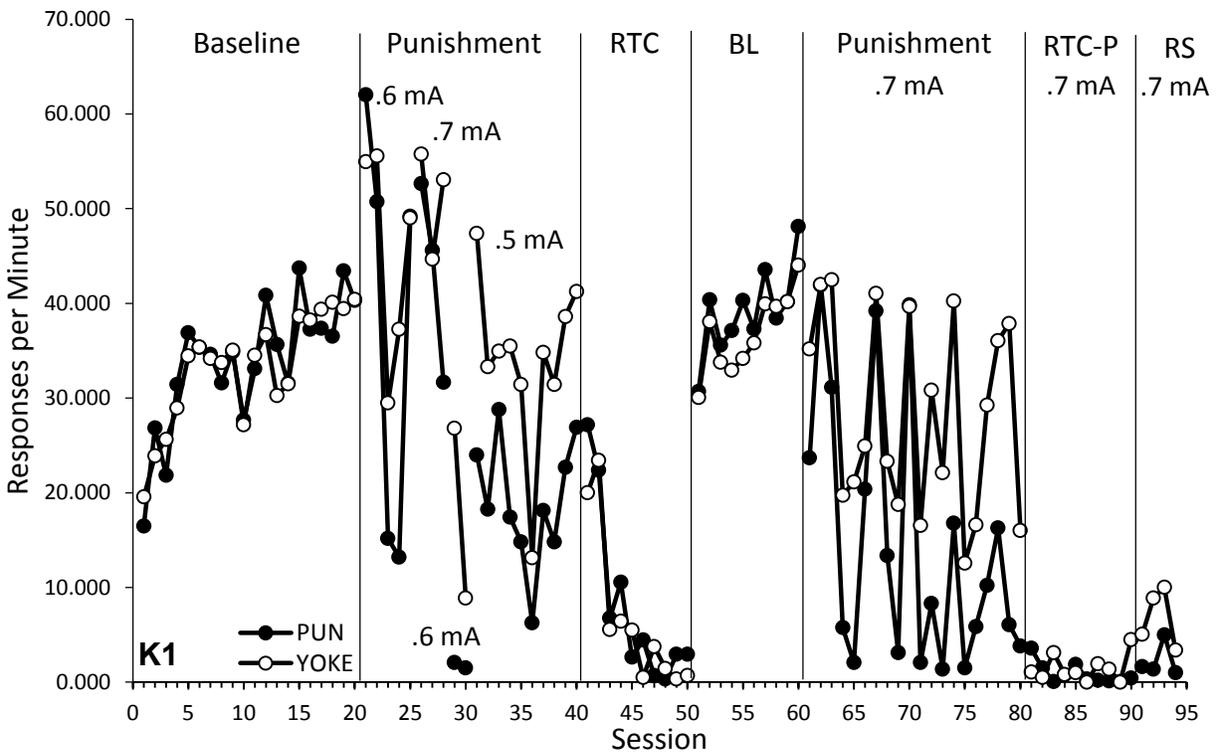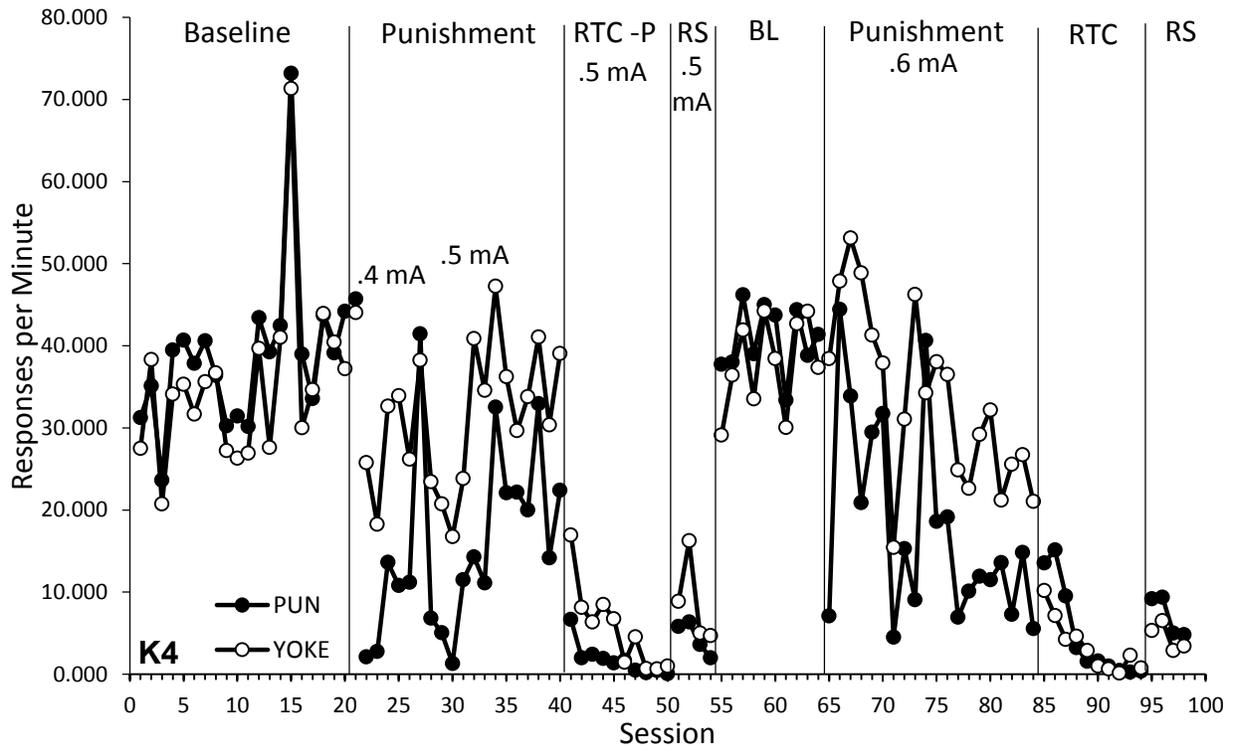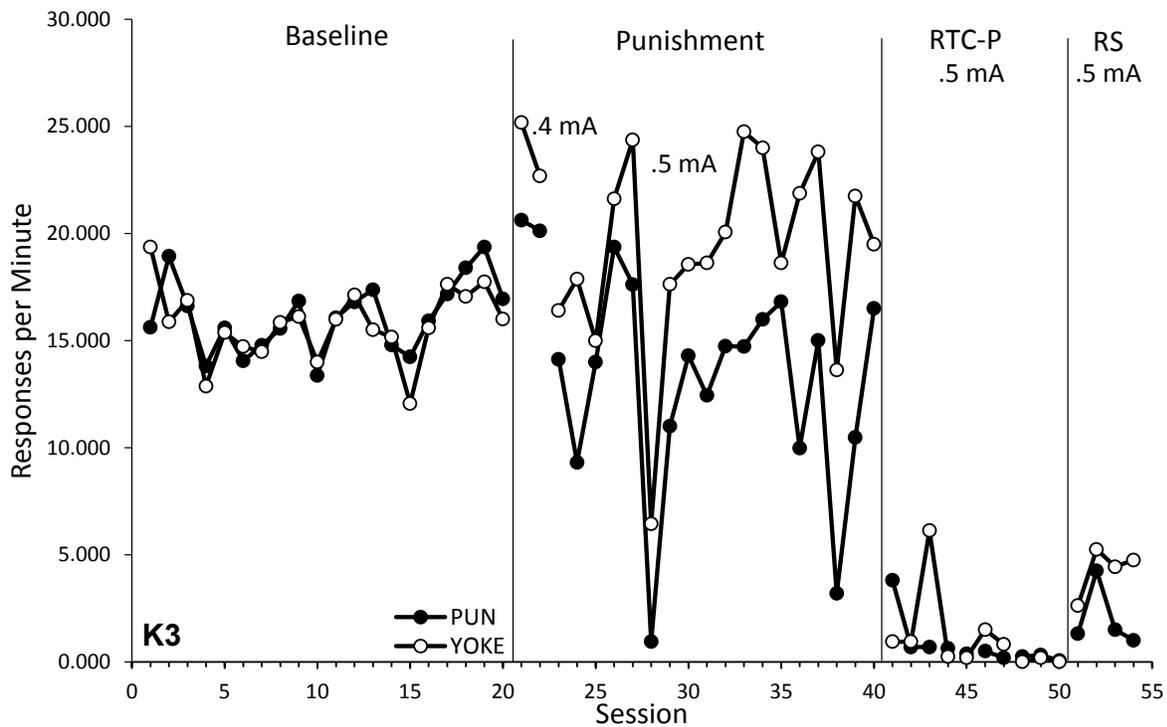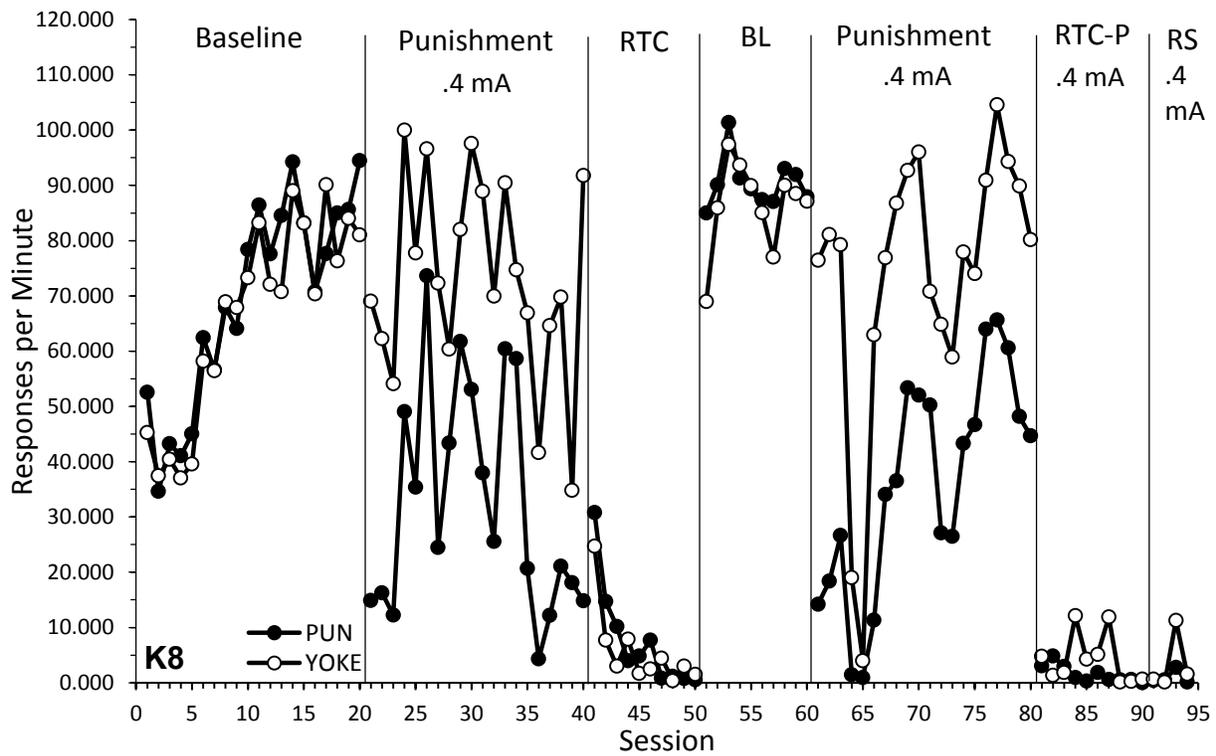
Figure 1. Rate of responding across sessions in all experimental conditions. BL=Baseline RTC=Resistance to Change without punishment, RTC-P=Resistance to Change with punishment, RS=Reinstatement (any RS with shock intensity that follows RTC-P is REINST with punishment)
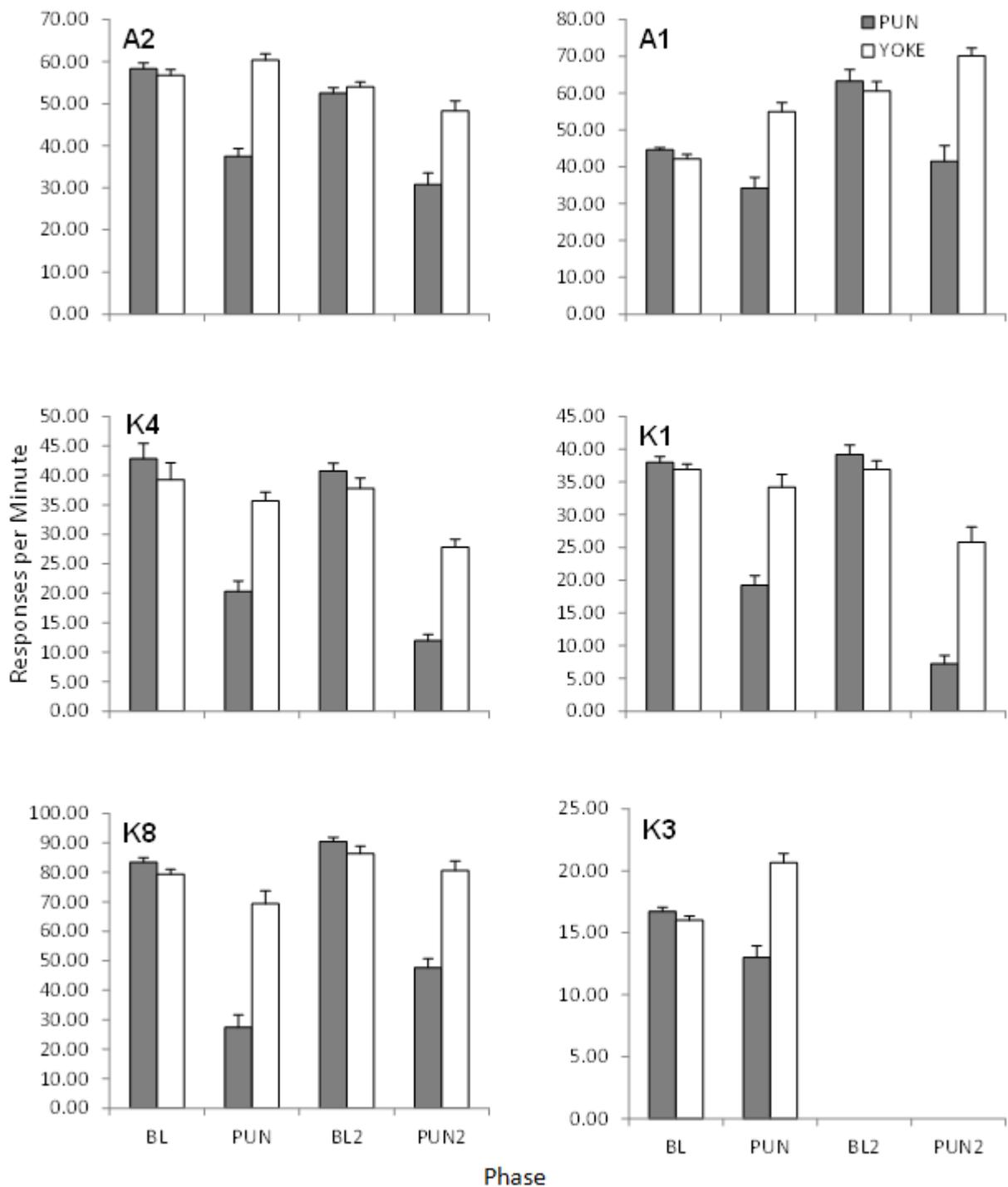
Figure 2. Average response rates across the last ten session of each Baseline and Punishment phase. Error bars show standard error of the mean. BL=Baseline and PUN=Punishment. Empty sections represent conditions the rat did not complete.
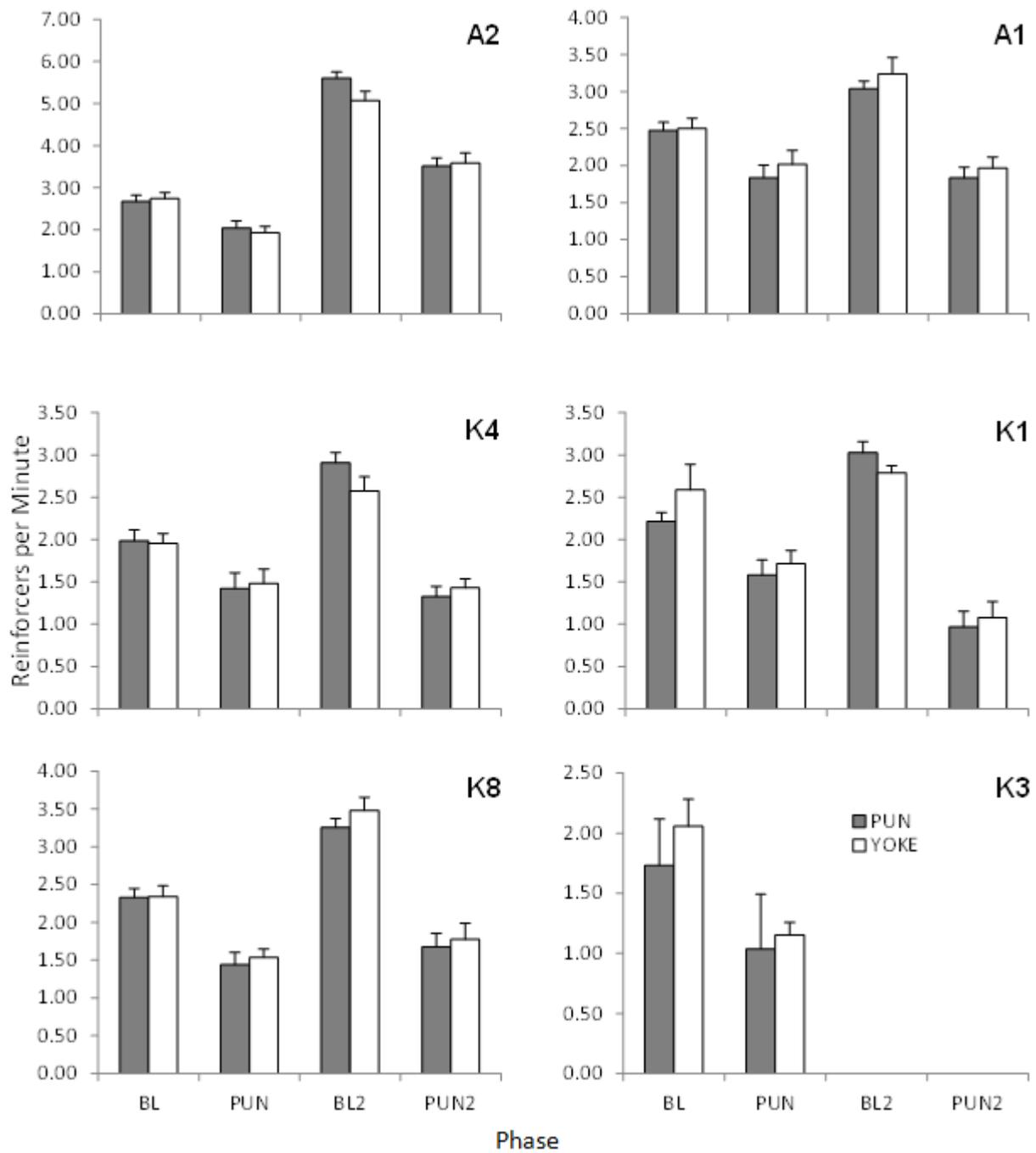
Figure 3. Mean reinforcement rates from all sessions across each experimental phase. Error bars show standard error of the mean. PUN = Punishment, and BL = Baseline. Empty sections represent conditions the rat did not complete.
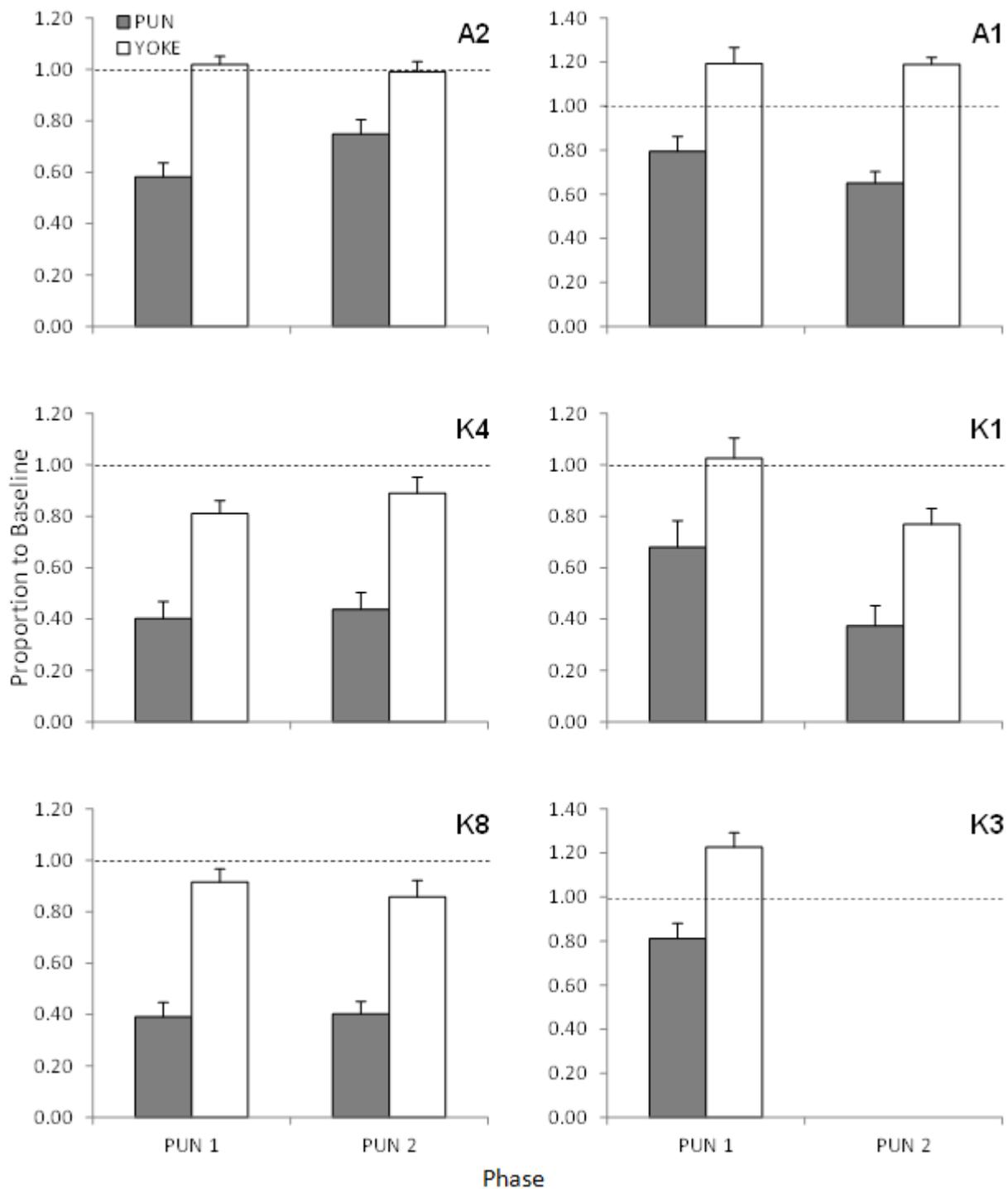
Figure 4. Response rates during each the punishment and yoke component during each Punishment phase plotted as a proportion of the mean of the last ten Baseline sessions. PUN = Punishment. Empty sections represent conditions the rat did not complete.
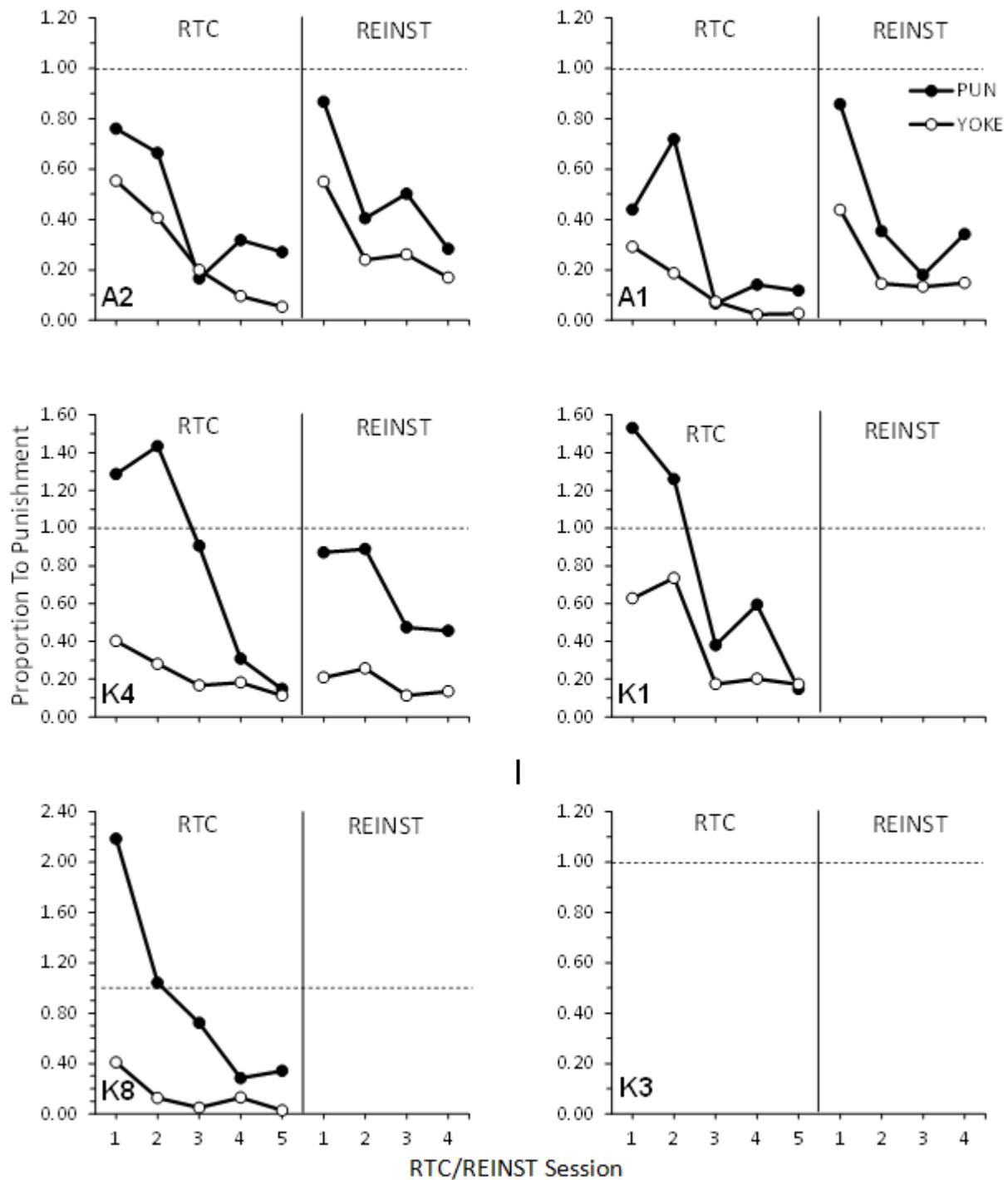
Figure 5. Resistance to Change and Reinstatement without punishment. Response rates of first five RTC sessions and all four REINST sessions are plotted as a proportion of the mean of the last five sessions of the preceding Punishment condition. Empty sections represent conditions the rat did not complete.

Response proportions in RTC and reinstatement probes

Figure 5 shows the rate of responding during each RTC probe and REINST probes plotted as a proportion of the mean response rate of the last five sessions of Punishment. The last five sessions of Punishment were used because those were the most stable. During the first five sessions of the RTC probe, average response rates in the punishment component ($M = 0.52$, $SD = 0.42$) were approximately 144% higher than the yoked component ($M = 0.21$, $SD = 0.18$) for all rats. Eventually responding in both components decreased by the 10th session. During REINST, average response rates in the punishment component ($M = 0.50$, $SD = 0.24$) were approximately 122% higher than in the yoke component ($M = 0.22$, $SD = 0.14$). During reinstatement, four rats showed greater responding in the component previously associated with punishment (see Figure 5).

Resistance to change and reinstatement with punishment

Figure 6 shows responding during the Resistance to Change with punishment (RTC-P) extinction probe and Reinstatement with punishment (REINST-P) plotted as a proportion of the mean response rates of the last five sessions preceding Punishment condition. During the RTC-P probe, average response rates in the punishment component of the first five sessions ($M = 0.12$, $SD = 0.12$) were 11% lower than yoke ($M = 0.13$, $SD = 0.13$).Two rats showed lower response rates in the punishment component during the RTC-P probe (see Figure 6). During REINST-P, response rates increased in five rats. Average response rates during punishment ($M = 0.16$, $SD = 0.15$) were 18% lower than yoke ($M = 0.20$, $SD = 0.14$). Only one rat, though, showed reliably lower rates in the punishment component during the REINST-P probe across all reinstatement sessions
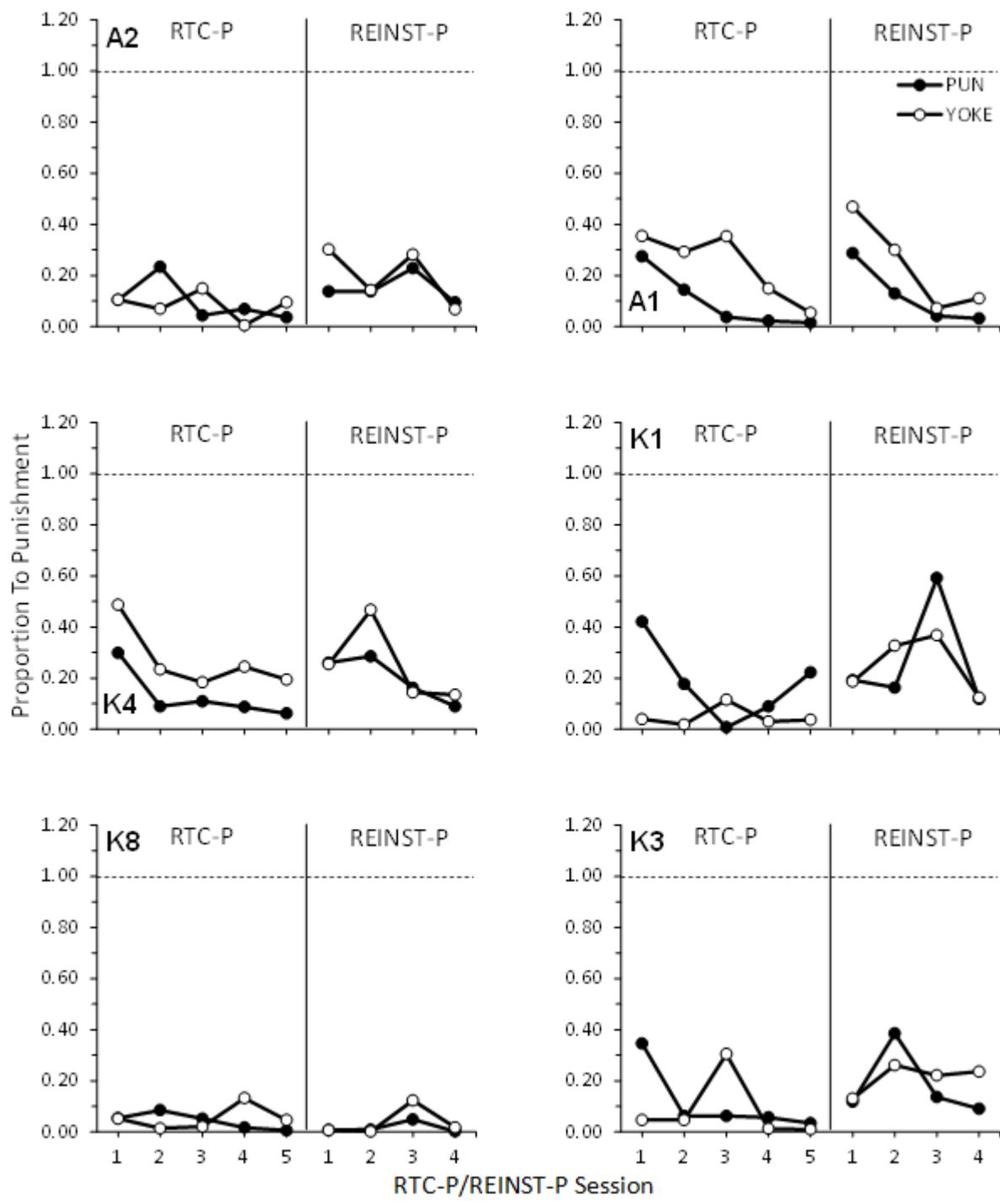
Figure 6. Response rates during the Resistance to change (RTC-P) and Reinstatement (REINST-P) probes. Rates in the first five sessions of the RTC-P probe and all four REINST-P sessions are plotted as a proportion of the mean response rate of the last five sessions of the preceding Punishment condition.

DISCUSSION

The present study was designed to investigate the effects of punishment on resistance to change and reinstatement. Analyzing the effects of punishment on resistance to change was complicated by the effects on responding of the punishment contingency during RTC extinction probes. During the RTC probes with no punishment, there was a greater proportion of baseline responding in the punishment than no-punishment component. Furthermore, in some rats responding increased above levels observed under punishment. Rather than indicating that punishment produced greater resistance to change, these data suggest that the greater persistence in the punishment component was a result of the punishment removal (i.e., recovery from punishment). Several previous studies have shown temporary increases in punished responding when punishment was terminated (Azrin, 1960), even in extinction (Boe & Church, 1967). This recovery from punishment therefore made it difficult to assess the effects of punishment on RTC.

During the RTC probes with punishment, response rates quickly decreased and response rates in four rats showed no differential effects. It is likely that behavior decreased rapidly, because the reinforcement contingency was no longer available (i.e., extinction) while the punishment remained in effect. Two rats, however, showed less resistance to change in components with punishment. Data from these two rats indicate that punishers decrease response persistence. It is unclear why only two rats showed this effect of punishment. Possibly, order effects contributed to the varied outcomes; those showing less resistance to change experienced RTC probes with punishment first, instead of after RTC without punishment. It is not obvious why that would make a difference, since the preceding phase (PUN) was consistent for all subjects. However, K3 also experienced the RTC punishment contingency first but did not show greater RTC under the punishment component, suggesting that other factors other than

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order effects may have been responsible for the varied outcomes seen during the RTC-Pun probe.

The results of the RTC probes are consistent with those reported by Hall et al. (2015). Hall et al. examined the effects of time-out punishment on resistance to change in pigeons with timeout present or absent during extinction probes. During extinction probes in which timeout was present, responding in the punishment component did not appear less resistant to extinction. During extinction without timeout, responding in the component previously associated with punishment appeared more resistant to extinction than responding in the unpunished component. Similar results were seen in the present study in that during the RTC-P probes, varied effects were seen and only two subjects showed less resistance to change in the punishment component and during the RTC probes, more resistance to change occurred in the component previously associated with punishment. To investigate the effects of aversive stimuli on RTC without the complications introduced by the punishment contingencies, Hall et al. introduced non-contingent punishment. During their Experiment 2, timeout was delivered response independently. Only when timeouts were delivered noncontingently and continued during probe conditions did responding in contexts with punishment show less resistance to extinction. The present study investigated the effects of response contingent punishment on RTC and reinstatement to determine whether punishment had equivalent but opposite effects of reinforcement on behavior. Future research should try to replicate their data with the use of noncontingent electric shock on resistance to change. Also, future research should investigate the effects of noncontingent electric shock and reinstatement, to examine whether noncontingent aversive stimulation will be effective at decreasing response persistence and the re-appearance of behavior.

During Reinstatement probes, response independent food deliveries occurred at the start of each component and response rates increased. During the REINST phase, there was greater rate of responding during the component previously associated with punishment. This is interesting because there was still greater recovery in the previously punished component although punishment had been removed for 10 sessions prior to reinstatement. This suggests that punishment has enduring effect on behavior.

During reinstatement with punishment, one out of the six subjects consistently showed less responding in the punishment component; some differential effects were seen across four other rats. Data for the reinstatement with punishment probe therefore provides only limited evidence that punishers can decrease the reappearance of behavior. Studies using noncontingent punishment would still be useful because the punishment during extinction plikely continued to have suppressive effects on responding.

Data from both reinstatement phases are consistent with reinstatement literature (Podelsnik & Shahan, 2009; Reid, 1958) that has shown that noncontingent reinforcement results in the reappearance of previously extinguished behavior. During both reinstatement phases, previously extinguished behavior re-appeared regardless of the presence or absence of the punishment contingency.

The present findings have some implications for theoretical interpretations of punishment. As described above the One Factor Theory suggest that punishers have a direct suppressive effect on behavior, whereas, the Two Factor Theory suggest that punishers decrease behavior indirectly. If results were consistent with One-Factor Theory of punishment, then during the RTC-P and REINST-P probes response rates in the component associated with punishment would have shown less response persistence and less reinstatement of behavior. If

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results were consistent with Two-Factor Theory of punishment, then during the RTC-P and REINST-P data may have shown more response persistence and more reinstatement because of the added negative reinforcers. Although data from the RTC- Pun probe were inconsistent, results from RTC with punishment probes from at least two rats and some data from the reinstatement with punishment probes indicate that punishers reduce resistance to change and may reduce the reappearance of behavior during reinstatement. The present data therefore provide some evidence for One-Factor Theory that views punishment as having equivalent but opposite effects of reinforcement.

Experimental studies that have investigated effects of punishment on unpunished behavior in multiple schedule of reinforcement have found both an increase and decrease in unpunished behavior when behavior in one component is punished (Brethower & Reynolds, 1962; Crosbie, 1977). The decrease of unpunished behaviors has been called induction, whereas the increase in unpunished behavior has been called contrast. The likelihood at which behavioral contrast and/or behavioral induction occurs depends on the intensity of the aversive stimulus and the subjects previous history with the aversive stimulus (Crosbie, 1977; Lerman & Vondran, 2002). Research investigation behavioral contrast and behavioral induction have not pinpointed the exact variables that cause this phenomenon (see Crosbie, 1997). In the present study, behavioral contrast occurred in three out of the six subjects in the first punishment phase and occurred in one out of the six subjects during the second punishment phase. Behavioral induction was also observed in three out of the six subjects in the first punishment phase and was also observed across four out of the six subjects during the second punishment phase.

Limitations

Shock intensities were individualized for each rat in order to find the lowest, most effective shock intensity. In some instances shock intensities were decreased, as higher intensities resulted in total suppression of behavior. However, at lower shock intensities, response rates gradually increased across sessions, possibly as a result of habituation. Similar results have been found in in prior punishment studies (Azrin, 1960). Adjusting subject's shock intensity was not necessarily an interpretive problem, but was a challenge for investigating punishment effects because it was difficult to find a specific shock intensity that caused enough response suppression with elimination behavior or causing behavior to habituate.

Also, further replication of conditions would provide a more thorough investigation into the effects of punishment on resistance to change and reinstatement. In the present study each RTC phase and reinstatement phase was conducted once. Another phase of RTC and reinstatement could determine if findings were similar with repeated exposures to these conditions.

Another important limitation of this study was that stimulus control was not measured. Behavior momentum theory suggests that the density of reinforcement associated with a specific stimulus determines response persistence (Nevin, 1974). However, in this study it was not clear that the difference in response rates across components during punishment conditions was due to stimulus control or due to the presence of absence of the aversive stimulus. A latency measure is one option to determine whether stimulus control was established. That is, the time until the first response in each component could be analyzed. If behavior were under the control of the discriminative stimuli, then the time of the first response would be shorter in the presence of the stimuli signaling no punishment.

The other serious limitations of this study were: (1) the probe type used to measure punishment effects on resistance to change, which was extinction, and (2) the use of contingent punishment. The problem with using punishment during extinction may be that behavior was suppressed so rapidly and almost completely by punishment that there was not much opportunity to see less RTC or less reinstatement. More specifically, when behavior is punished during extinction, response suppression occurs making it difficult to assess the effects of punishment on RTC and reinstatement. The other problem with using contingent punishment may have been a discrimination issue. In the RTC conditions without punishment, rats previously exposed to punishment were immediately transitioned to extinction phases during which punishers were no longer presented. The shift between these two phases was likely easily discriminable causing behavior to increase upon the removal of the aversive stimulus.

Future research

The present study examined the effects on contingent electric shock on response persistence and the reappearance of previously extinguished behavior. As noted above, future research in this area should replicate Experiment 2 of Hall et al. (20105) and examine the effects of noncontingent electric shock punishment on these processes. Investigating the effect of noncontingent punishment on RTC and reinstatement will avoid some of the complications of the punishment contingency. Typically, noncontingent reinforcement results in response decrease. If punishment has equal yet opposite effects as reinforcement, then one would expect for noncontingent punishment have minimal effects on response rates. Studies have shown that adding noncontingent reinforcement (Huppert & Iversen, 1975; Nevin at al., 1990), which decreases response rates, produce greater RTC. Thus, noncontingent electric shock, even if it does not affect response rate, should produce less RTC, and perhaps less reinstatement.

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Another direction for future research on RTC would be to use different probe types. Behavior momentum literature has examined response persistence using a variety of probes other than extinction, including prefeeding, food deliveries during the intercomponent interval, and noncontingent reinforcement. The use of extinction provides interpretation issues when examining the effects of punishment on RTC and reinstatement, because contingent punishment continues to suppress behavior during extinction, yet punishment removal causes recovery during extinction. Future studies should seek to investigate the effects of punishment on resistance to change using other RTC probes to better evaluate the effects of punishment on RTC and reinstatement.

Further research is also needed to investigate punishment effects on resistance to change and reinstatement in humans. Clinicians in applied setting are sometimes faced with clients who show severe problem behavior that is harmful to others or life threatening. Although positive-reinforcement techniques exist for reducing problem behavior, behavior sometimes persists and re-appears when reinforcers are accidentally delivered during extinction. Punishment may be one technique that can be used to reduce RTC and reinstatement of problem behavior in clinical settings.

Punishment contingencies have shown to be useful in decreasing a number of problematic behaviors (e.g., self-injurious behavior); however, clinical use of punishment raises ethical concerns (Matson & Kazdin, 1981; Matson & Taras, 1989; Vollmer, 2002). Research suggests the existence of several side effects associated with punishment, such as increases in aggressive behaviors, escape behaviors, and emotional reactions (for reviews see Azrin & Holz, 1966; Lerman & Vondran, 2002). When investigating the effects of punishment on response persistence, researchers should consider the occurrence the possibility of "side effects"

developing in response to its implementation. Also, the recovery from punishment when punishment is removed is another concern.

Possibly, noncontingent punishment may produce fewer side effects, because it may not generate response recovery. Basic research using noncontingent timeout has shown it to be effective in decreasing persistence of key-pecking behavior in pigeons. (Hall et al., 2015), The use of noncontingent punishment may also require fewer punisher presentations give that punishers are delivered independent of behavior and every occurrence of the maladaptive behavior does not have to be punished.

Although, research has shown punishment to be effective at decreasing a variety of problem behaviors, more research is needed examining the effects of punishment on resistance to change and reappearance of behavior before being implemented in applied settings. With additional experimental research, clinicians will be better informed as to whether punishment based techniques may be effective for reducing persistence of problem behavior. Any use of punishment should be effective at decreasing problematic behavior but should not affect the quality of life for the individual (Van Houten et al., 1988). Due to the potential for side effect, positive reinforcement techniques should be tried first.

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APPENDIX

WESTERN MICHIGAN UNIVERSITY

Centennial
1903-2003 Celebration

Date: February 13, 2013

To: Cynthia Peitras, Principal Investigator

From: Robert Eversole, Chair

Re: IACUC Protocol Number 12-11-01

Your protocol entitled "The Effects of Punishment on Behavioral Momentum" has received approval from the Institutional Animal Care and Use Committee. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: February 13, 2014