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A Comparison of Response-Contingent and Response-Independent Autoshaping Trials In Rats

Jenna E. Gaskins

COLUMBUS STATE UNIVERSITY

A COMPARISON OF RESPONSE-CONTINGENT AND RESPONSE-INDEPENDENT AUTOSHAPING TRIALS IN RATS

A THESIS SUBMITTED TO THE

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BY

JENNA E GASKINS

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Approved by

Dr. Stephanie da Silva, Committee Chair

Dr. Mark Schmidt, Committee Member

Dr. Cindy Ticknor, Committee Member & Dean

Columbus State University

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ABSTRACT

Autoshaping is a procedure, combining both operant conditioning and classical conditioning, used in animal training to jump-start a target behavior. Lepper and Petursdottir (2017) found that response-contingent pairings (RCP) were more effective than response-independent pairings (RIP) in producing vocalizations in children with Autism Spectrum Disorder (ASD). RIP procedures entail a time-based intertrial interval (ITI) followed by the beginning of a trial, whereas RCP procedures include a response initiation period between the ITI and the trial. The current study compared RCP and RIP procedures to determine which one was more effective for acquisition of nose poking in rats. Number of days to reach acquisition (poking on at least 90% of trials) of nose poking, percent of trials with the target nose poke, and the latency to nose poke were recorded as indexes of procedure efficacy. All rats reached acquisition in RCP by the end of the study; however, one rat never reached acquisition in RIP. All rats required fewer sessions to acquisition in RCP than RIP, indicating that RCP may be more effective in autoshaping the nose poke behavior in rats. Extensions of this finding could be in autoshaping procedures and even in producing vocalizations in children with ASD.

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A Comparison of Response-Contingent and Response-Independent Autoshaping Trials in Rats

Autoshaping, which includes both operant conditioning and classical conditioning, is a method in animal training for teaching new behaviors. Operant and classical conditioning differ in the types of relations they involve. Operant conditioning involves relations between responses and stimuli when voluntary behavior is strengthened or weakened by consequences such as punishers or reinforcers (Skinner, 1937). This indicates that the consequences are dependent on the behavior occurring. For instance, an experimenter does not want his lab rat to press the lever while the rat is in the operant chamber. The operant chamber is set to shock the rat whenever the rat presses the lever. Given the aversive nature of a shock, this consequence will decrease the likelihood that the rat will press the lever while in the operant chamber. Classical conditioning is different from operant conditioning because it focuses on an association between two or more stimuli, independent of behavior (Pavlov, 1927). For example, in Pavlov's laboratory, a metronome sounded just prior to food deliveries. After repeated pairings of metronome and food, the dogs began to predict food delivery from the metronome due to stimulus-stimulus pairing, eliciting salivation when the metronome was presented. Salivation, however, was never required and did not impact the metronome-food relation/presentations.

Autoshaping has a greater effect on response acquisition than just classical conditioning or operant conditioning methods alone. Autoshaping first elicits a response by stimulus pairings without a response requirement, then reinforces desired behavior at the moment it occurs. Atnip (1977) demonstrated that autoshaping produced faster acquisition of a lever pressing behavior in rats when compared to classical conditioning or operant conditioning. Autoshaping has been used to facilitate the acquisition of skills within many animals such as rats (Atnip), mice

(Papachristos & Gallistel, 2006), monkeys (rhesus, Sidman & Fletcher, 1968; squirrel, Gamzu & Schwam, 1974), birds (pigeons, Brown & Jenkins, 1968; bobwhite quail, Gardner, 1969; leghorn chicks, Lucas & Wasserman, 1982; chickens, Downing & Neuringer, 1976; ring doves, Drew, Yang, Ohyama, & Balsam, 2004), and fish (cuttlefish, Purdy, Roberts, & Garcia, 1999). In pigeons, autoshaping usually involves presentations of a key light followed by food. Brown and Jenkins (1968) are credited with first demonstrating autoshaping. The procedure entailed a key light illumination on during the trial for 8 s and off during the intertrial interval (ITI). After 8 s, the key light turned off and the food tray was raised for the pigeon to eat as much as it wanted; the presentation of these two stimuli comprised one classical conditioning trial. If the pigeon pecked the key during presentation of the key light, the trial immediately ended (i.e., the light turned off and food was presented); the presentation of food immediately following a peck is an operant relation where the food presentation occurs sooner if a peck occurs. If a peck occurred in the ITI, the trial was delayed for 60 s (Brown & Jenkins, 1968). These repeated pairings of the key light and food led to conditioned responding, or initial pecking, to the key light; presentation of food immediately following pecking of the lit key strengthen voluntary (operant) key pecking. Because of the classical conditioning aspect of autoshaping, it is important to pair the stimulus that is being trained (i.e. key light) with the feeder (i.e. bird seed). This pairing is necessary for maintenance of the target behavior (Hitzing & Safar, 1970).

Within animal research, response-independent pairing (RIP) is used more often than response-contingent pairing (RCP). RIP procedures entail a time-based ITI followed by the beginning of a trial, whether it is the illumination of a key or the experimenter asking the participant for a vocalization (Brown & Jenkins, 1968; Lepper & Petursdottir, 2017). By being on a specific schedule, such as fixed time 20 s for the ITI, the trial initiation will happen every time after that fixed time (see Figure 1). RCP procedures include a response initiation period between the ITI and the trial (Papachristos & Gallistel, 2006; Lepper & Petursdottir, 2017). Immediately following the ITI, the subject at that point must perform a specific behavior to start the trial such as lever pressing or pressing a button. If the subject does not perform the specific behavior to initiate the trial, the trial never starts. Although no basic research with nonhumans has compared the efficacy of RCP procedures to RIP procedures, applied research in children with autism indicates that RCP might be more effective than RIP. Lepper and Petursdottir used stimulus-stimulus pairing (a procedure with structural parallels to autoshaping as stated by da Silva & Williams, 2020) to induce new vocalizations in nonverbal children with Autism Spectrum Disorder (ASD). In their study, the researchers employed both RCP and RIP procedures to determine which procedure was most effective in producing vocalizations. In RCP sessions, the response initiation behavior was a button press, in which the boys were previously trained to do. The sessions would start off with the presentation of the button within reach of the participant, but the trial would not begin without the button press. The experimenter then vocally presented either a target syllable or a non-target syllable. If it was a target syllable, the participant would receive a reinforcer, and if it was a non-target syllable, the participant would not receive a reinforcer. Upon termination of the trial, an ITI began for a minimum of 10 s, after which the button was presented again for the response initiation period. In RIP sessions, instead of a button press, a vocal observing prompt (such as look) was used to get the participant's attention followed by trial initiation, the experimenter presenting the target or non-target syllables. Since there was no response initiation period, trials happened on a specific schedule, which was determined by yoking the RIP sessions to RCP sessions. Yoking entails equating the session durations, to ensure the response initiation aspect of RCP sessions did not drastically change the amount of time in sessions with RIP having much shorter sessions. Lepper and Petursdottir found that the three boys produced more target vocalizations per minute in RCP procedures than in response to RIP procedures, demonstrating that RCP was better at producing vocalizations.

The finding that RCP procedures produced more of the target vocalizations allows for the development of more effective stimulus-stimulus pairing in programs for nonverbal individuals with ASD and begs questions regarding the efficacy of RCP procedures in acquisition of a skill in autoshaping behaviors in animal training. da Silva and Williams (2020) compared stimulus-stimulus pairing in human studies and animal autoshaping and determined that stimulus-stimulus pairing seems analogous to autoshaping procedures. Because they are so similar, it is important to draw parallels between stimulus-stimulus pairing and autoshaping to figure out effective procedures for autoshaping. Autoshaping typically uses RIP procedures to train new behaviors rather than RCP, which has been found to be better in inducing vocalizations in children with ASD. The closest study in animal autoshaping to one that used RCP procedures in basic research was done by Papachristos and Gallistel (2006) who used response-initiated trials (RCP) to train head poking in mice; however, it did not test RCP efficacy against RIP. After being placed in an operant chamber, a white noise and light signaled the opportunity for the mouse to initiate a trial by poking his head into one of the feeding stations located at the back of the operant chamber. After trial initiation, the mouse had the opportunity to poke its head in the feeding station in the middle of the front wall of the operant chamber across autoshaping trials that operated as those described previously (e.g., Brown & Jenkins, 1968). If the mouse poked its head in the feeding station before the end of the trial, the mouse received food immediately (which strengthens poking through operant conditioning). If the mouse did not poke before the end of the trial, the mouse received food following the termination of the trial (defaulting to a classical conditioning, or pairing, trial).

Although Papachristos and Gallistel (2006) did not investigate RCP versus RIP to determine their relative effectiveness in mice, their work introduced and tested the impact of session spacing, a method similar to trial spacing. Trial spacing refers to the amount of time given for ITI. Longer ITIs allow more space between the trials within a session. Trial spacing directly relates to response level and rate of acquisition (Balsam & Payne, 1979). For instance, Gibbon, Baldock, Locurto, Gold, and Terrace (1977) found that a higher ratio of ITI to trial duration resulted in faster acquisition of key pecking in pigeons than if it was a lower ratio of ITI to trial duration. This means that faster acquisition of key pecking occurred when there was more time between trials. Additionally, Lucas and Wasserman (1982) found that shorter ITIs led to lower percent of trials with the target peck. Because trial spacing has been shown to improve the acquisition of a skill, Papachristos and Gallistel (2006) questioned whether *session* spacing impacted acquisition in a manner similar to trial spacing. Using session spacing as a manipulated variable, Papachristos and Gallistel split the mice into four conditions: two sessions per day, one session per day, one session per two days, and one session per four days. First, the response initiation head poke in the back of the operant chamber at station H4 was required before the session could start. Following the response initiation head poke at station H4, another head poke at Station H2 was required for the trial, which resulted in food delivery. When using one session per four days, more trials occurred during each session, indicating a shorter latency period between the signal (white noise and illumination of station H4, the response initiation opening to head poke) of the opportunity to initiate a trial and trial initiation. Even though one session per four days had the most trials per session, one session per two days had the earliest onset of nose poking (all by session four). One session per two days yielded the second most trials per session, also indicating a shorter latency period between the signal of the opportunity to initiate a trial and trial initiation. Even though the results did not reach significance, visual analyses support possible session spacing effect in that the mice were able to initiate more trials per session as well as have onset in the earliest sessions when the sessions were not every day.

The purpose of the current study was to determine whether RCP or RIP was more effective in autoshaping the nose poke behavior in rats, testing the finding by Lepper and Petursdottir (2017) that RCP was more effective than RIP in producing vocalizations in students with ASD. Number of sessions to acquisition (poking on at least 90% of trials for three consecutive days), percent of trials with the target nose poke (number of trials with the target nose poke divided by total number of trials), and latency (time between the given stimulus and the target response) to nose poke were measures of autoshaping efficacy. Additionally, the current study expanded on research already done in this laboratory which did not find RCP to be more effective than RIP overall. By replicating this study, it was intended to determine whether RCP was more effective than RIP in producing acquisition of a target skill. In addition, the current study expanded on the prior study by conducting sessions every other day instead of daily to determine whether session spacing will affect the acquisition of nose poking. The hypothesis was that RCP would be more effective in autoshaping the nose poke behavior in rats, leading to acquisition earlier in RCP than RIP. Five rats completed one session containing two parts (one part RIP, one part RCP) every two days.

Method

Subjects

Five *Rattus norvegicus* were used: MJ, LJ, RY, BY, and BO. All rats were four months old when their sessions commenced. They were naïve to nose poking but had prior experience with lever pressing and eating dispensed pellets from a food tray in an operant chamber. They were housed individually in home cages with free access to water on a 12-hour light and 12-hour dark schedule in their housing room. All experiments were conducted during the light hours. The rats were fed six days per week with the standard rat chow to maintain a stable body weight. The bedding in the cages was changed two times per week, and the cages were washed once a week. The experiment was approved by the Institutional Animal Care and Use Committee (IACUC).

Apparatus

Five identical operant conditioning chambers (Med Associates Model ENV-008_VP) were used in the experiment. The work panels (front and back walls) were made of aluminum. The front door, ceiling, floor, and back door were made of Plexiglas. The operant chamber was 30 cm long x 24 cm wide x 21 cm high. The floor of the chamber had 19 aluminum bars approximately one cm apart, and the bars were parallel to the work panel. The work panels were aluminum walls with a lever and two nose poke holes. The lever was approximately 4 cm wide and extends approximately 2 cm from the work panel. The bottom of the lever was 7 cm above the floor of the chamber. The lever was centered on the work panel. The nose poke holes were on both the right-hand side and the left-hand side of the work panel. The nose poke holes were about 3 cm wide, big enough for the rat to fit his nose in at the bottom of the work panel. The nose poke holes were approximately 2.5 cm above the bars. The poking was detected by infrared beams in the nose poke hole that pass through the opening. The food opening had a diameter of approximately 3 cm and was 2.5 cm above the chamber floor. It was centered on the work panel below the lever. The automatic feeder dispensed pellets into a circular food tray contingent on the programming of Med-pc IV, a software interfaced to the operant chamber. The reinforcer pellet was 45-mg TestDiet pellets (AIN-76A formula) delivered via a Med Associates Model # ENV-203 feeder. Each pellet delivery occurred with a 1.0-kHz tone lasting 0.5 s and the signal for the nonreinforcement period in the apparatus was a 10-kHz tone. All tones were delivered through a Model # ENV-223 tone generator.

Procedure

Pretraining. Pretraining was not needed because rats had a history of lever pressing and eating from food magazines in these chambers. The target response was nose poking, a novel behavior.

General Procedure. The sessions were conducted every two days. Number of total sessions varied for each rat depending on how quickly the nose poke behavior was autoshaped/acquired. There were two parts to the sessions: RIP and RCP (see Figure 1). Each part of the session was 24 min long, occurring together with a short break for the researcher to start the next part, every two days. The rat stayed in the operant chamber between Part 1 and Part 2 of the session with the researcher starting Part 2 following Part 1 by opening the operant chamber and restarting the program. Sessions were discontinued after 14 days if no acquisition of the target skill was reached. Both the side of the nose poke and order of the parts were counterbalanced. Order of parts and type of nose poke (left or right) remained constant for each rat but was randomly assigned across rats to create the schedule shown in Table 1. Following the assigned Part 1, either RIP or RCP, the rat then was exposed to the other procedure. For example, if the rat was assigned RIP during the Part 1 of the session, RCP comprised the Part 2 of the bi-daily session. Similar to assigned part, if the left nose poke was targeted in Part 1 then the right nose poke was targeted in Part 2 (see Table 1).

RCP vs. RIP Autoshaping Trials. Sessions, conducted every two days, contained both RIP and RCP parts. Both parts of the session differed according to trial initiation (see Figure 1). Both session parts had a 10-kHz tone indicating the non-reinforcement period (see Figure 1). Following termination of the tone, RIP trials had the nose poke light illuminate for 8 s to start the trial. Upon trial initiation, the rat was able to earn the reinforcers after a completed the nose poke or upon the end of the trial (8 s); however, in RCP, the trial only began following a lever press. This means that, in RCP, the termination of ITI was followed by a response initiation period in which the rat was required to press the lever – emit a downward motion of the bar within the operant chamber by the rat - to begin the trial. Once the trial was initiated, all aspects of the RCP and RIP procedures were the same; the rat then had the opportunity to earn a pellet by nose poking or receive a pellet at the end of the trial (8 s).

Following each session, the fixed time (FT) value of the ITI for the next RIP part was adjusted to make the ITI of each RIP session similar to, or yoked to, the previous session's ITI during the RCP part. This yoking process was a necessary control since it is known that ITI length impacts acquisition in autoshaping or classical conditioning trials. Lepper and Petursdottir used a similar yoking method when they were equating RIP and RCP session durations. As noted above, both parts of the session contained ITIs. The lengths of the ITIs included fixed and variable time (VT) schedules in tandem (with each schedule arranged one after the other). In the RCP, a tandem FT 20 s VT 15 s schedule comprised the ITI. In RIP, there was a tandem FT *x* s VT 15s ITI schedule.

Measures and Analysis. Number of sessions required for acquisition of the nose poke behavior was measured. Acquisition criterion for autoshaped nose poking was defined as three consecutive days of nose poking in 90% of trials within a session part, RIP or RCP. Percent of trials with the target nose poke was calculated by taking the number of trials in which the target nose poke occurred and dividing it by the total number of trials within a session part, RIP or RCP. Latency was measured by the time in seconds that elapsed between the onset of the nose poke light and the occurrence of the nose poke. Number of sessions to acquisition, percent of trials with the target nose poke, and the mean latency to nose poke (after onset of nose poke light) were compared across RCP and RIP parts for each rat and across all five rats. Following data collection, these measures were compared visually and analyzed statistically using a Wilcoxon signed-rank test.

Results

It was hypothesized that RCP would be more effective than RIP, requiring fewer sessions to acquisition and possibly having a higher percent of trials with a nose poke. The percent of trials with a nose poke, sessions to acquisition, and mean latency were analyzed. Percent of trials with the target nose poke was calculated by taking the number of trials in which the target nose poke occurred and dividing it by the total number of trials within the session part. This was done every session for both RIP and RCP parts as shown in Figure 2. BY's RCP data from session one was omitted due to data loss. There was a 14-day limit on autoshaping of the nose poke for all rats, and BY was the only rat that reached the session cap. Nose poking occurred on a higher percent of trials in RCP than RIP for 69.77% of the sessions across all rats. Four out of five rats had a higher percent of trials with the target nose poke during RCP than RIP, having over 70% of RCP session parts higher than RIP session parts (MJ, 71.43%; LJ, 77.78%; RY, 85.71%; and BY, 76.92%). The fifth rat, BO, responded in the same percent of trials in RCP and RIP for 57.14% of sessions. Further analysis of the difference between RIP and RCP for the percent of trials the target nose poke occurred was done by finding the overall average percent of trials with the target nose poke across all days for each rat (see Table 3). Using the mean percent of trials across all sessions for each rat, median values for RCP were at a higher percent (86.90) than median values for RIP (74.69), indicating that RCP may be more effective in autoshaping of the target nose poke in rats (almost a 12% difference). A Wilcoxon signed-rank test determined whether the mean percent of trials with the target nose poke across all sessions, including past acquisition, was different in the two session parts, RCP and RIP. A statistically significant difference (W=0.00, z=2.02, p=0.04, r=0.64) was found in the mean percent of trials with the target nose poke across session parts between RCP and RIP. With the 0.64 for Pearson's r, the effect size was large, indicating a strong difference between RIP and RCP for mean percent of trials with the target nose poke. This demonstrated that a higher percent of the target nose poking occurred in a greater percentage of RCP session parts during trials, indicating that it may be more effective in training the nose poking behavior.

Acquisition criterion for each part of the session for autoshaping of the nose poke in RIP and RCP was defined as three consecutive days of nose poking in 90% of trials within a session part. All five rats reached acquisition in RCP, and four of the five rats reached acquisition in RIP (see Figure 2). Rats had a varied number of sessions conducted because it was based on when the rat reached acquisition in both RCP and RIP parts (see Table 2). Session numbers ranged from 7-14, with three rats reaching acquisition in both RCP and RIP by session 7. Rat BY never reached acquisition in RIP. Between all five rats, median values of RIP and RCP were 7 and 5, respectively, demonstrating a difference between RCP and RIP. Additionally, mean days to acquisition for RCP (*M*=5.4, *SD*= 1.14) was less than RIP (*M*=8.80, *SD*=3.03). A shorter number of mean days to acquisition indicates that the nose poke behavior was acquired faster in RCP than RIP. Additionally, the larger standard deviation for RIP indicates that there was more variance in the number of days to acquisition per rat than in RCP session parts, indicating that RIP less reliably trains nose poking. A Wilcoxon signed-rank test demonstrated that number of sessions required to reach acquisition were different in RCP and RIP, W=0.00, z=2.023, p=0.043, r =0.64. With the 0.64 for Pearson's r, the effect size was large, indicating a strong difference between RIP and RCP for days to acquisition. RCP needed fewer days to reach acquisition than RIP.

Lastly, mean latency was analyzed. For each session part, mean latency was calculated after each session. Latency refers to the time in seconds between the illumination of the nose poke and the nose poke behavior (see Figure 3). Four out of five rats had a shorter latency period in RCP than RIP overall. Mean latency was lower for RCP than RIP for 81.82% of sessions across all rats. Four of the rats had most sessions where RCP was lower than RIP (MJ, 100%; LJ, 77.78%; RY, 85.71%; and BY, 92.86%). BO had similar latencies between both RIP and RCP, demonstrating neither part had a shorter latency. To analyze the difference between RIP and RCP parts, an average was calculated across all sessions for each session part, which was then used to determine whether there was a significant difference between the two mean latencies (see Table 3). Looking at RIP and RCP mean latency across all sessions for each rat, the median values were found to be 1.971 and 2.701, respectively demonstrating a lower mean latency in RCP than RIP. Additionally, the means for RCP (*M*=1.843, *SD*=0.455) and RIP (*M*=2.701, *SD*=0.746), indicating that it took the rats less time in RCP to respond than RIP. A Wilcoxon signed-rank test was conducted on the mean latencies across all sessions for each session part per rat determining there to be no statistical difference between RCP and RIP mean latency periods, (W=2 , z=1.483, p=0.138). Without statistical significance, the latency differences observed in the sample of 5 rats may not be reliable.

Discussion

Rats were shown to reach acquisition, on average, 3.4 days earlier in RCP than RIP. Similar to the findings of Lepper and Petursdottir (2017), RCP was shown to produce acquisition of the nose poke behavior earlier as well as at a higher percentage across trials of nose pokes per total trials. As seen in Lepper and Petursdottir, RCP produced more of the target vocalizations in the three children with ASD than RIP methods. In the current study, RCP had a smaller standard deviation than RIP, indicating a more consistent impact of RCP compared to RIP for the nose poking behavior. Because RCP was shown to be more effective than RIP for all five rats, it may be a good indicator that RCP procedures are more effective in training target behaviors in animals and humans. Drawing from the methodology proposed by Lepper and Petursdottir (2017), we were able to reproduce training procedures that were applicable with other species. Papachristos and Gallistel (2006) used RCP autoshaping trials employing session spacing, in which the current study based the frequency of sessions. Sessions occurred every two days instead of daily to potentially increase acquisition of the nose poking behavior, because of the finding that sessions that are more spaced result in shorter latency. Using pieces of Lepper and Petursdottir (2017) and Papachristos and Gallistel (2006), the current study was able to test new autoshaping methods than were used before in traditional autoshaping studies. For instance, Brown and Jenkins (1968) used a forward pairing technique to autoshape key pecking in pigeons. Forward pairing is a method in which the stimulus (key light) occurs first followed by a reinforcer (food). Additionally, the pairings are response independent, meaning that they occur without the target behavior occurring. Gardner (1969) also used response key illuminations paired with response independent food presentations in Bobwhite quail. This finding brings into question the reliance of animal autoshaping on RIP methods, however, researchers must keep in mind that the subjects in the study must have acquired one skill before RCP can be used as a procedure.

One rat within the study, BY, never mastered nose poking by meeting the 14-session requirement for termination of training sessions in RIP sessions. This lack of acquisition could be due to a differential reinforcement of other behavior (DRO) during the ITI, paper ripping. The paper ripping behavior can be defined as pulling the paper in the lower tray of the operant chamber above the metal bars and shredding it during the session. There also was only archival evidence to the paper ripping because no video records were taken during the study. Using a video record would have helped to determine functionality of the behavior. One explanation of this behavior was that BY used paper ripping to fill the ITI. It then interfered with effective operant conditioning creating an adjunctive behavior. Falk (1971) determined that certain schedules could induce extra behaviors, and if those behaviors were strong enough to be sustained during the trials, they were termed an adjunctive behavior. Another explanation of the behavior is that BY could have thought paper ripping was the behavior that had a relationship with the reinforcer, or otherwise known as superstition (Skinner 1948).This superstition could have interfered with the target or even produced a stimulus that interfered with the programed stimuli. Lastly, it could have been as simple as the paper covering the nose poke light, blocking the illumination from BY's view.

The current study has a few considerations that should be considered. To begin with, the rats had a prior history with the operant chamber which may have given them an advantage in

RCP over RIP. The rats had previous history with a lever press in an experiment in the laboratory before starting the current study. The previous study is where BY acquired the paper ripping. The paper ripping should have been extinguished before the experimental procedure was given, however, the behavior was not expected to persist. There also was only archival evidence to the paper ripping because no video records were taken during the study. Having a video record would have helped to better determine functionality of the paper ripping behavior. Another consideration is the 14-day cap. Having a 14-day cap on autoshaping sessions did not allow for BY to acquire the nose poking behavior in RIP. It would have been beneficial to continue running BY until he reached acquisition in RIP. It also would be beneficial to determine whether there are any long-term differences between RIP and RCP by retesting the rats at a later date, perhaps five to eight months later. It might have been beneficial to see what the long-term effects of both were and whether RCP is still more efficient than RIP. Lastly, in order to assess session spacing effectively, it would have been beneficial to have another group or condition that was conducted at the same time as the current study. The data from the current study will be compared to prior data collected in the laboratory with autoshaping sessions happening daily; however, it may not be an appropriate comparison because they were not conducted during the same time.

Before drawing any conclusions about the applicability of research in animal autoshaping to human autoshaping research, it is necessary to consider the differences that exist between the two from the lens of autoshaping. da Silva and Williams (2020) found that there are procedural parallels between stimulus-stimulus pairing and autoshaping procedures, therefore, the differences between human autoshaping and animal autoshaping should be examined. Wilcove and Miller (1974) addressed the differences in human autoshaping and animal autoshaping finding that human autoshaping involves humans testing relationships between environmental events. This difference may make it harder to equate adult human autoshaping and animal autoshaping. With the inability to equate the two, the question becomes whether adults and non-verbal younger children learn the same and interact with autoshaping the same. Myers (1981) found that autoshaping happens in infants and is impacted the most by the operant contingency. This means that there needs to be a good reward and praise from an adult for autoshaping to occur. The fact that age plays into the effects of autoshaping showcases that as we develop we grow more complex and question our environment. Eberhardt (2019) found evidence that young children can learn novel vocalizations through stimulus-stimulus pairing producing higher rates of vocalizations over the course of the experiment. These results indicate that procedures that vary the time between trials help in producing vocalizations, showing that those who had longer ITI conditions had a greater likelihood of developing vocal responses.

If it is known that younger individuals do respond to autoshaping, could it still be effective in teaching vocalizations to non-verbal children with ASD, who are still developing? Lepper and Petursdottir (2017) approached this by testing two different forms of autoshaping, RCP and RIP, determining that requiring a response prior to a pairing trial was most effective in producing vocalizations in children with ASD. This could be due to the fact that requiring an orienting behavior may help the child focus on the trial before beginning rather than trying to get them to focus while the trial is already going. Bulla (2014) and Esch, Carr, and Grow (2009) both studied stimulus-stimulus pairing procedures in children with autism determining that stimulus-stimulus pairing was effective in producing vocalizations; however, with the new findings from the current study and Lepper and Petursdottir, new tactics such as RCP can be implemented to increase vocalizations in non-verbal children. The current study begs questions regarding whether animal autoshaping and stimulus-stimulus pairing are the same due to the replication of the finding by Lepper and Petursdottir that RCP was more effective than RIP in rats, using similar procedures. In fact, da Silva and Williams (2020) state that because stimulus-stimulus pairing and autoshaping seem to have structural parallels. Because both SSP and autoshaping depend on respondent and operant conditioning, identifying procedural parallels to get a superior method of human conditioning for producing vocalizations.

Overall, the current study expands the research by introducing a new autoshaping procedure that involves response-contingent pairing. This pairing procedure was shown to be more effective in all five rats, replicating a finding by Lepper and Petursdottir (2017) that RCP was superior to RIP for generating novel vocalizations in children with ASD. With the repeated finding that RCP is superior to RIP, a shift of procedures will begin to occur towards creating more effective training and teaching measures.

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Table 1

Counterbalanced Arrangement of Nose Poke Side and Order of Two Parts, Comprising Each Session for Each Rat

Rat	Part 1		Part 2	
MJ	Right Poke	RIP	Left Poke	RCP
LJ	Right Poke	RCP	Left Poke	RIP
RY	Right Poke	RIP	Left Poke	RCP
BY	Left Poke	RCP	Right Poke	RIP
BO	Left Poke	RIP	Right Poke	RCP

Table 2

Number of Sessions per Part to Acquisition

Rat	RCP	RIP
MJ	4	7
LJ	5	9
RY	5	7
BY	7	14*
BO	6	7

Note. * Fourteen was used as a cap value for not acquiring the nose poke behavior.

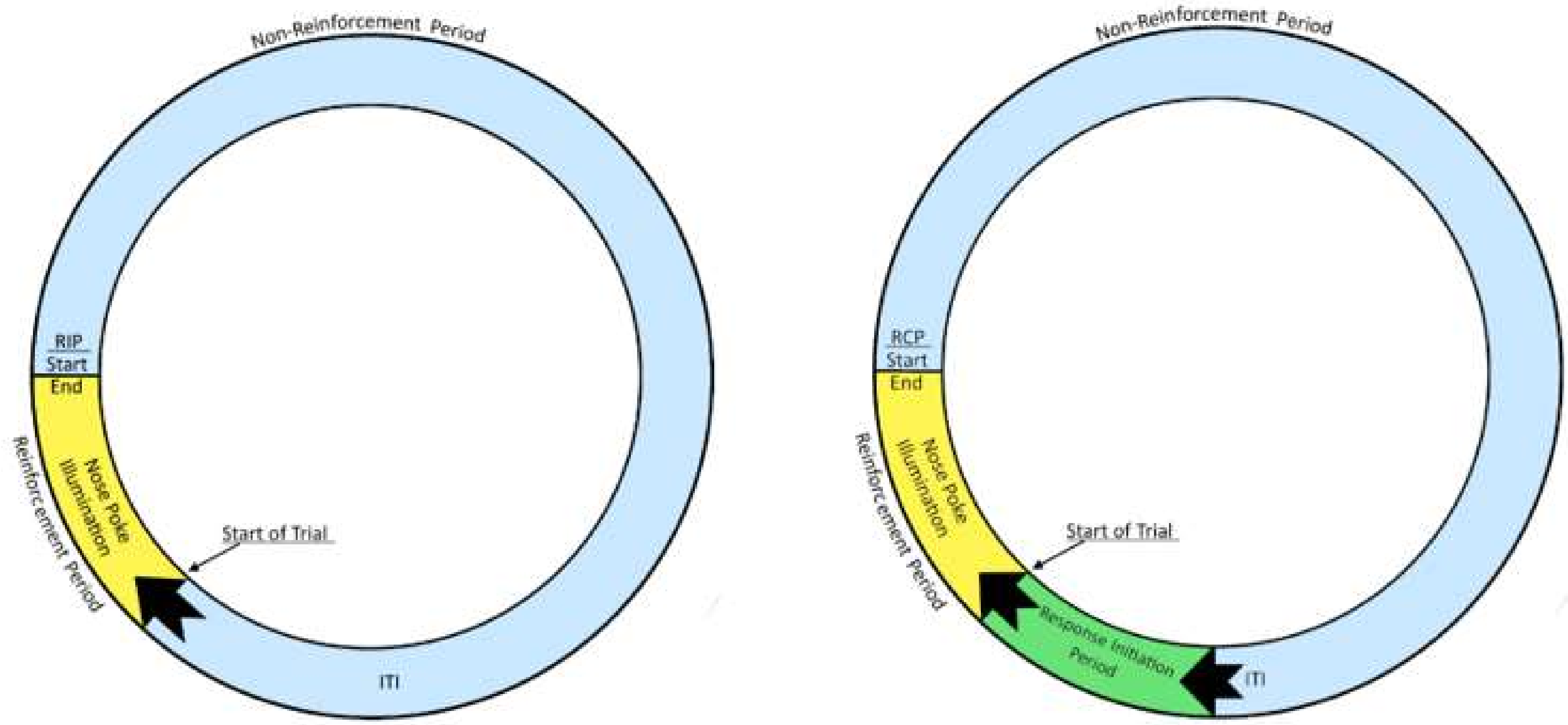
Table 3

Mean Percentage of the Target Nose Poke and Mean Latency Across All Sessions per Rat

Rat	Mean Percentage RIP	Mean Percentage RCP	Mean Latency RIP	Mean Latency RCP
MJ	95.34503	82.92446	2.2286	3.4286
LJ	86.46653	77.39244	2.0667	2.4000
RY	86.89697	74.68948	1.9714	3.0857
BY	93.15346	74.67006	1.0615	3.0462
BO	59.67248	53.07336	1.8857	1.5429

Figure 1

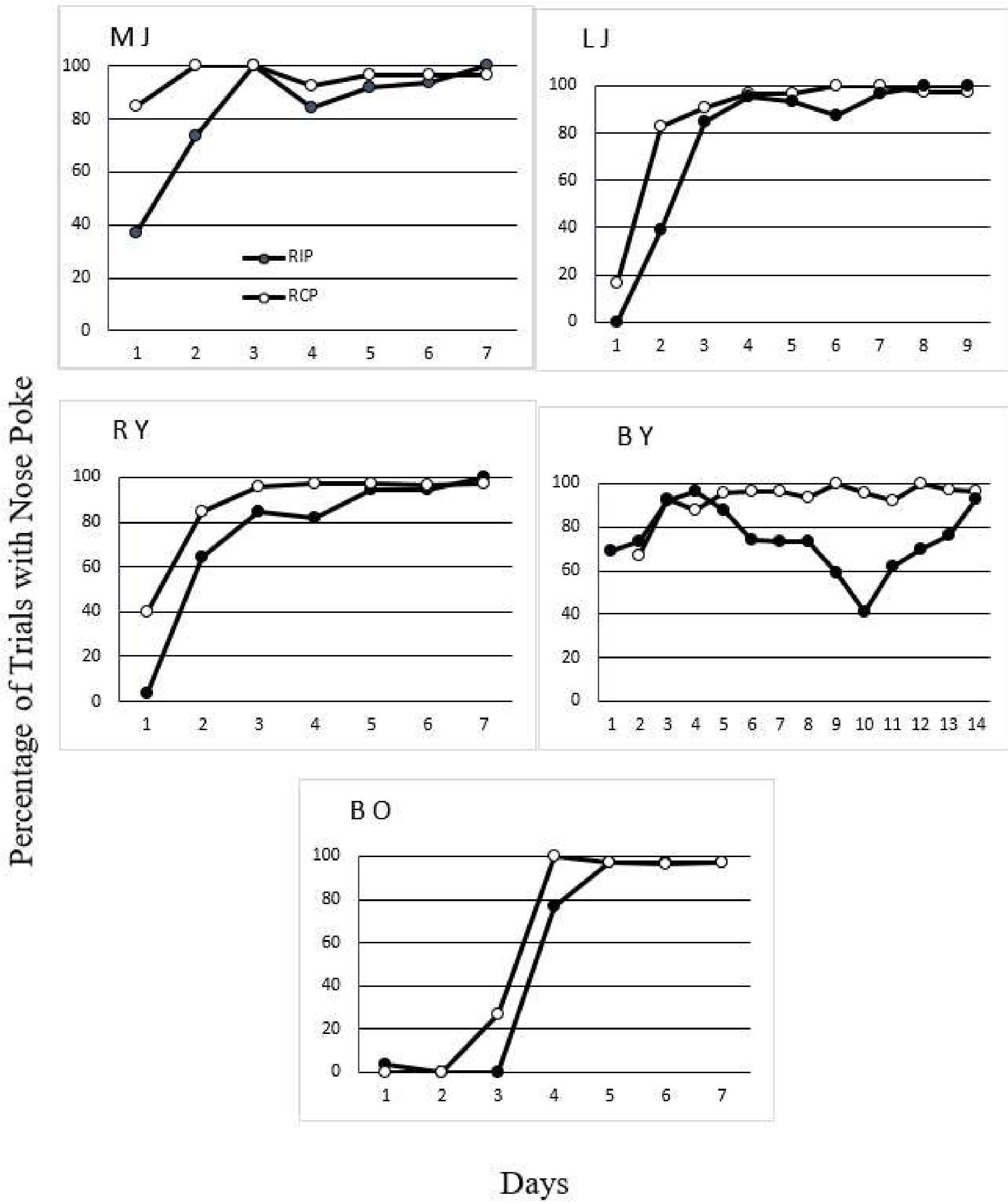
RCP and RIP Autoshaping Trials



Note. RIP: average of 45 s ITI, 8 s nose poke illumination. RCP: average of 35 s of ITI, response initiation period triggered by lever press, 8 s nose poke illumination. The rat must lever press to start the trial. Blue indicates ITI, green indicates trial initiation phase that requires a lever press, and yellow indicates nose poke illumination of either left or right nose poke.

Figure 2

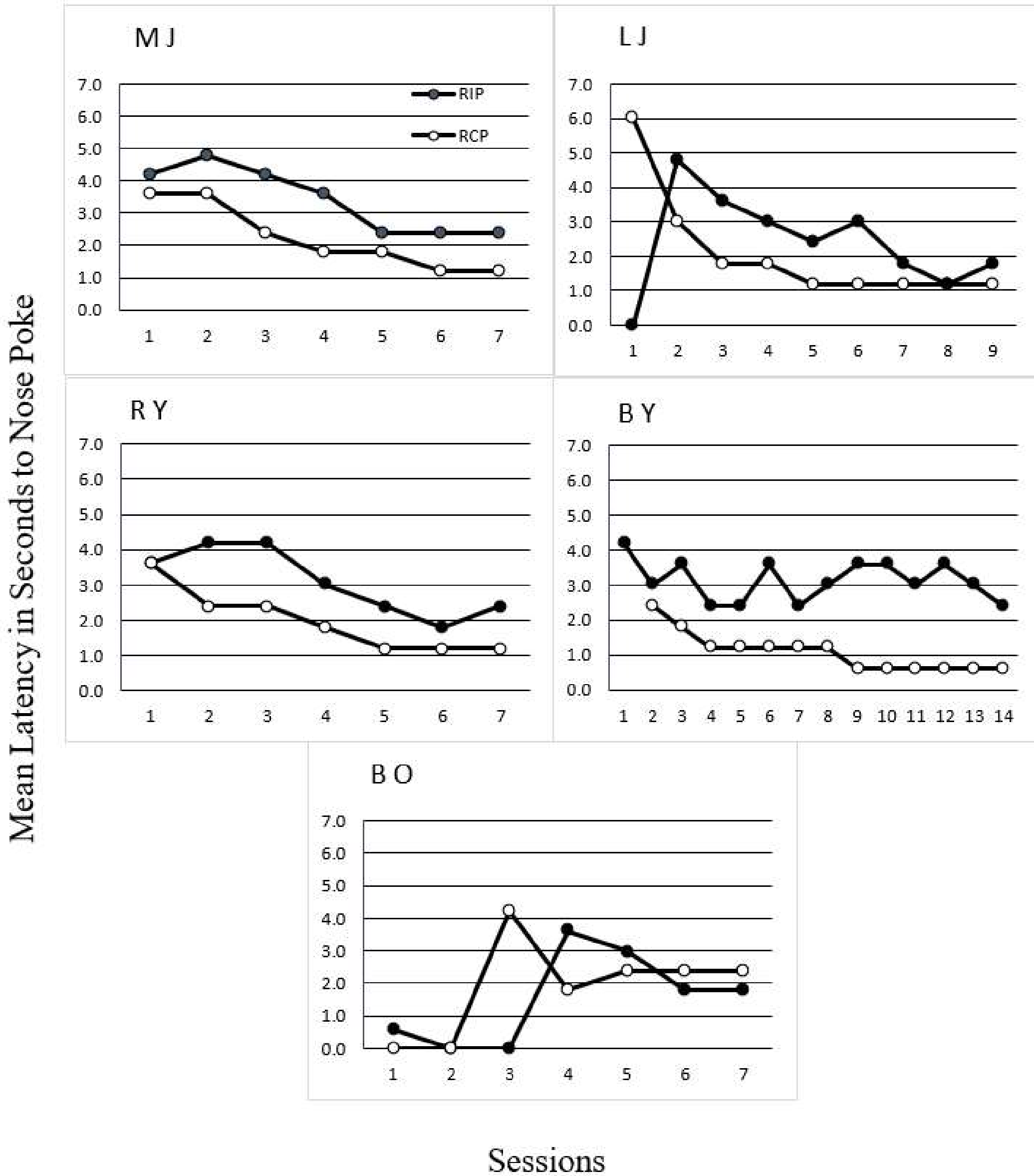
Percent of Trials with the Target Nose Poke in RCP and RIP Parts of Bidaily Sessions.



Note. Percent is based on the number of nose pokes compared to the number of trials. Open circles refer to RCP parts and closed circles refer to RIP parts. Sessions were terminated upon each rat's acquisition (nose poking in 90% of trials for three consecutive days) of nose poking in RCP and RIP (7-14 days).

Figure 3

Mean Latency (s) to Nose Poke per Day in RCP and RIP



Note. Latency was measured by time (s) from the onset of the nose-poke light until the nose poke occurred. Closed circles indicate RIP latencies and open circles indicate RCP latencies. Numbers of days varied between the rats based on when they reached acquisition for nose poking.