ORAL SYRINGE TRAINING ANIMALS: INDISCRIMINABLE AND DISCRIMINABLE PUNISHMENT CONTINGENCIES

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Animals are commonly trained to perform behaviors during routine husbandry procedures. However, some husbandry procedures have aversive consequences when the real procedure is performed. This commonly results in loss of the trained behavior. The present study assessed whether maintaining the antecedent environmental stimulus conditions between appetitive and aversive outcomes would prevent this effect and, conversely, whether adding a stimulus discrepancy would facilitate this effect. Three domestic rats served as participants in a multiple baseline across participants design with multi-element components. All three rats stopped performing a trained behavior when a discrepant stimulus reliably predicted an aversive outcome. In addition, all three rats continued to perform the same behavior when antecedent environmental stimulus conditions were consistent between aversive and appetitive outcomes. Results are discussed in terms of practical implications for behavior change agents and conceptual implications for learning theory.

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Introduction

Domestic, captive, and laboratory animals require numerous husbandry procedures during their lives for their daily management and wellbeing. The term "husbandry" encompasses all routine and non-routine animal care practices (Hosey, Melfi, & Pankhurst, 2009). Examples include physical inspections, weighing, venipuncture, medical treatment, shifting through gates, and transportation.

Increasingly, these animals are being trained to voluntarily cooperate with husbandry procedures (Young & Cipreste, 2004). Typically, such training involves an animal trainer teaching the animal to perform a specific action voluntarily when the animal is presented with a cue and then providing positive reinforcement for the animal's performance (Hosey, Melfi, & Pankhurst, 2009; Priest, 1991). For example, Bloomsmith et al. (2003) described a procedure used to train two pandas to voluntarily walk through gates. During training a keeper gave the verbal cue "shift" and then, if the panda passed through the gate, the keeper sounded a box clicker and gave the animal a treat food. The training program was conducted with different types of doors, multiple doors, and at different times of day. The program was successful, resulting in both pandas voluntarily passing through a variety of gates when given the verbal cue "shift".

However, some husbandry procedures must inevitably entail aversive consequences. For example, oral syringe acceptance will occasionally result in medication administration, needle acceptance can result in a blood draw, and presenting a body part for medical treatment could lead to pain or discomfort. This

means that the animal's trained compliance behavior for such procedures is likely to be punished when the real husbandry procedure is performed. In addition, animals often learn to perform alternative behaviors that prevent the delivery of the aversive consequence, such as moving away from the trainer. These behaviors are emitted in the presence of stimuli correlated with the delivery of the aversive consequence. These stimuli could include, for example, the smell of the medicine, the presence of a particular person, or the occurrence of a particular routine. Under these circumstances the compliance behavior often has to be retrained.

Voluntarily biting an oral syringe is one behavior that frequently has to be retrained after medicine has been administered from the syringe. However, extensive and complex training methods are not always feasible, particularly if an animal requires immediate or prolonged treatment. In these situations, trainers often resort to using either bribery or physical or chemical restraint in order to save the animal's life. Once the immediate threat to the animal's health has passed, then the syringe biting behavior will commonly be retrained. However, this inevitably leads back to the same cycle the next time the animal is treated.

This scenario also occurs with humans. Schiff, Tarbox, Lanagan, and Farag (2011) described a mother who had resorted to physically restraining her autistic child in order to get him to drink liquid medication. Schiff et al. successfully used a treatment package combining escape allowance, stimulus fading, and shaping with positive reinforcement to teach the child to voluntarily drink medication from an oral syringe.

Commonly, animal trainers try to solve similar dilemmas by attempting to make the aversive stimulus less aversive somehow. Desensitization procedures are often

employed for this purpose. Desensitization procedures involve cueing the target compliance behavior and then giving the aversive stimulation to the animal in gradually increasing intensities as training progresses. Animal trainers also typically provide food rewards for the animal's compliance with the procedure. For example, Weiss and Wilson (2003) described training four Aldabra tortoises to maintain a specific body posture during venipuncture. The trainers faded in the physical stimulation produced by a needle and gave the animals tactile and food reinforcement for maintaining their body posture during the procedure. Similar training techniques are common practice among animal trainers teaching animals to accept oral medication (Heidenreich, 2009; Klaiber-Schuh & Welker, 1997; Crouthamel & Sackett, 2004).

However, Weiss and Wilson (2003) described how the tortoises continued to react to the venipuncture with grunts and head retractions after desensitization training. This observation suggests that the physical stimulation from the venipuncture procedure remained aversive to the tortoises after desensitization training. Therefore, it seems likely that the animals' behavior was maintained by the tactile and food rewards from their trainers and desensitization training had minimal benefit for the animals.

Behaviors which result in both an aversive and appetitive outcome are problematic. If animal trainers use the common practice of combining desensitization and positive reinforcement procedures to train acceptance of aversive physical stimulation then the training environment is likely to become a "poisoned cue" (Pryor, 2002). This means that the animal is likely to later escape or avoid the training environment (Murrey, 2007). Such fallout hinders future training. Animal trainers require a methodology to train animals to accept aversive husbandry procedures voluntarily

without the animal subsequently avoiding the training environment. Such a methodology should not include both aversive and appetitive outcomes within the same contingency.

When an animal is treated for an illness or medical condition there are typically numerous novel stimuli present. Animals do not typically see veterinary staff on a daily basis, and veterinary staff members usually bring with them a host of novel and specialized equipment. In addition, there may be more subtle stimulus changes when an animal undergoes medical treatment, such as an increase in a keeper's body tension. Thus, there are many potential sources of stimulus control which may reliably predict aversive medical procedures.

However, perhaps if these stimuli were controllable and not novel then it would be possible to prevent an animal from learning under which situations complying with a medical procedure will result in an aversive outcome. If antecedent stimuli were unchanged then an animal might continue to perform the trained compliance behavior. For example, if the environment remained the same when an oral syringe contained a treat and when it contained medicine, then the animal might continue biting the syringe in both situations. Alternatively, the animal might no longer bite the syringe during either situation.

The present study assessed whether three animals would continue to bite an oral syringe if the antecedent environmental stimulus conditions were kept constant preceding appetitive liquid deliveries and aversive liquid deliveries. Three rats were provided with a history of positive reinforcement for biting an oral syringe. Then, each rat occasionally received an aversive liquid when they bit the syringe. It was hypothesized that if the antecedent stimulus conditions were the same when biting

resulted in appetitive and aversive outcomes then the animals would continue to bite the syringe containing an aversive liquid across repeated trials.

In addition, the present study also investigated the converse scenario. The experiment assessed whether the same animals would continue to bite an oral syringe when the antecedent environmental stimulus conditions were different for appetitive and aversive liquid deliveries. In these conditions there was a stimulus which was reliably correlated with aversive liquid delivery. This stimulus was not present during appetitive liquid delivery. It was hypothesized that under these conditions the animals would stop biting the syringe containing an aversive liquid but would continue to bite the oral syringe containing an appetitive liquid.

Method

Participants

Three female domestic brown rats (*Rattus norvegicus*) served as participants. Isabella came from a local animal shelter and was approximately 1 year and 4 months old at the beginning of the study and had no prior training experience. Georgie came from a pet store and was approximately 1 year and 10 months old at the beginning of the study and had approximately one year of training experience. Chloe came from a local animal shelter and was approximately 1 year old at the beginning of the study with no prior training experience.

None of the three rats had prior experience with oral syringes and none of the three rats had received oral medication in the past. However, all three rats had

consumed apple sauce on multiple occasions prior to the study. In addition, all three rats had licked alcohol from a spoon in their home enclosure.

All three rats were housed together at their owner's home. In addition, all three rats were fed their normal diet throughout the course of the study. The rats were not food deprived at any time during the course of the study. Their meal composition varied daily and included rodent pellets, fresh fruits, fresh vegetables, and treat foods. In addition, water was always freely available in their home enclosure.

Setting

All experimental sessions were conducted in the rats' owner's home on a 76 cm high dark wooden table with a 38 cm wide and 82.5 cm long flat rectangular surface. Two 10 cm by 10 cm white cardboard squares were attached to the table top with beige-colored masking tape, hereafter referred to as squares. Each square measured 12 cm by 12 cm, including the tape. The left square was affixed 12 cm from the left edge of the table and the right square was affixed 4 cm from the right edge of the table. The two squares were positioned 42.5 cm apart and 5 cm away from the front edge of the table (see Figure 1). The squares were not replaced during the course of the study. If there was liquid on the table surface or on the squares at the end of a session, then the table surface and squares were wiped with a damp sponge before the next session began.

Materials

All experimental sessions were recorded on a high-definition camcorder

positioned on a tripod to the front right of the table with a clear view of the entire table surface. Two 5 ml amber Baxa ExactaMed ® Oral Syringes were used during the study, hereafter referred to as syringes. In addition, one 5 ml clear plastic medicine dropper was used during the study, hereafter referred to as a dropper (see Figure 2). The dropper was used because it was hypothesized that it would be visually discrepant from the syringes for the rats. However, the first participant displayed similar responses toward the syringes and the dropper. In order to test the hypothesis that the syringes and dropper were not visually discrepant for the rat, a plate-and-dropper combination containing highly contrasting colors was constructed.

The plate-and-dropper combination was fabricated in the following manner: a black plastic plate with a 15 cm diameter was attached to the front of a white paper plate with a 20 cm diameter. Next, the bottom 3 cm of the joined plates was cut off in a straight line. Two pieces of masking tape were taped in diagonal lines across both plates. Last, the dropper was inserted through a hole in the center of the plates, where the diagonal tape lines crossed. The dropper was taped in place at a 45° angle. This dropper-and-plate combination is hereafter referred to as a plate (see Figure 2). The plate contained contrasting colors and was hypothesized to be visually discrepant from the syringe for the rats. Thus, the syringe and the plate were two different visual stimuli used during the study.

Prior to starting training sessions each rat was given a paired-choice preference assessment (Fisher et al., 1992) with seven pureed fruits and vegetables. Unsweetened apple sauce was the highest ranked food item for all three rats and was chosen as the rats' liked liquid. Monopolowa^{TM} vodka containing 40% alcohol by volume was chosen

as the rats' disliked liquid because prior researchers have had difficulty training rats to consume highly concentrated alcohol (Grant & Samson, 1985).

Measurement

Timestamps for two participant behaviors were recorded: turn and bite. In addition, timestamps for one experimenter behavior was recorded: removal. The turn, bite, and removal timestamps were used to calculate the two dependent variables: run time and pause time.

Behavioral Definitions

Turn was defined as the timestamp at which the rat's nose and both of the rat's front paws were oriented toward a square. This excluded instances where the rat's paws or nose were touching its body, such as during grooming.

Bite was defined as the timestamp at which the rat's mouth first opened to bite or lick the tip of the syringe or the end of the dropper. This excluded instances where the rat opened its mouth to bite the syringe barrel, plunger, or experimenter's hand.

Removal was defined as the timestamp at which the experimenter began to move the previously stationary syringe or dropper away from the table and towards their back.

Dependent Variables

Run time was calculated for each trial by subtracting the bite timestamp from the turn timestamp for that trial and rounding the resulting number to one decimal place.

Thus, run time was calculated using the following formula: $\text{run time} = \text{bite} - \text{turn}$. There was a 30 s time limit for all syringe and dropper presentations. Consequently, if the rat did not bite the syringe or dropper within 30 s of their turn timestamp then the run time for that trial was recorded as 30 s. As a result, the run time measure had a 30 s ceiling. Run time was calculated for Trials 2-6 in each session because a turn was not required to start the first trial in a session. Thus, run time could not be calculated for Trial 1.

Pause time was calculated by subtracting the turn timestamp for the following trial from the removal timestamp for the current trial and rounding the number to one decimal place. Thus, pause time was calculated using the following formula: $\text{pause time} = \text{the next trial's turn} - \text{removal}$. Unlike the run time measure, the pause time measure did not have a ceiling. Pause time was calculated for Trials 1-5 in each session. Pause time could not be calculated for Trial 6 because Trial 6 did not have a following trial.

Scoring Procedures

The experimenter scored all the data independently. Turn, bite, and removal occurrences were scored from the videos by advancing the digital video files frame-by-frame and recording the video timestamps for all turn, bite, and removal occurrences during every session. Each of these video frame timestamps were recorded in seconds to three decimal places. After all turn, bite, and removal timestamps were recorded for a session, then run time values were calculated for Trials 2-6 in the session and pause time values were calculated for Trials 1-5 in the session. Run time and pause time values were then recorded rounded to one decimal place.

One procedural error resulted in data being excluded from the data analysis and graphical display. This procedural error happened when removal occurred after less than 30 s had elapsed since the turn timestamp, but a bite had not yet occurred. In this case run time was not recorded for the trial but pause time was still recorded for the trial. This procedural error only occurred twice during the course of the study: on Trial 317 and Trial 339 for Isabella. Both of these trials were alcohol plate presentations.

Inter-Observer Agreement

Additional observers independently scored every trial in at least 25% of the sessions across each session type in each experimental condition for each participant. The observers scored each turn, bite, and removal timestamp by advancing the video recordings frame-by-frame in the same manner as the experimenter. In addition, the observers independently calculated each run time and pause time value for these sessions using the same formula as the experimenter.

Agreements were defined as the experimenter and observers scoring the same run time or pause time value ± 0.5 s for the same trial. Trial-by-trial inter-observer agreement was calculated using the following formula: $\frac{Agreements}{Agreements + Disagreements} \times 100$. Run time agreement for all trials for Isabella was 95% and pause time agreement for all trials for Isabella was 89%. Run time agreement for all trials for Georgie was 95% and pause time agreement for all trials for Georgie was 86%. Run time agreement for all trials for Chloe was 97% and pause time agreement for all trials for Chloe was 88%.

Procedure

Training

Prior to data collection each rat was trained to drink apple sauce from a syringe in a specific manner. The rat and experimenter's behavior chain at the end of training was as follows. When the experimenter held the syringe on one of the squares, then the rat moved towards the syringe and bit the syringe tip. At this point, the experimenter depressed the syringe plunger and the rat drank approximately 0.2 ml of apple sauce. The experimenter then removed the syringe from the table and held it behind their back, the rat turned towards the opposite square, and the experimenter presented the syringe on that square. Thus, when training was complete the experimenter was presenting a syringe on a square whenever the rat turned towards it, and the rat was moving toward a square whenever the experimenter presented a syringe there.

The rats' initial training to bite the syringe followed Crouthamel and Sackett's (2004) general shaping progression. The animals were first trained to lick apple sauce off the experimenter's finger and were then trained to lick apple sauce off the syringe with the experimenter's hand underneath it. Next, the rats were trained to lick apple sauce off the syringe by itself, then drink apple sauce squirted onto their tongue while licking, and finally bite the end of the syringe and drink apple sauce squirted into their mouth. At this stage the final behavior chain was trained using a combination of backward chaining and luring. Lastly, the luring was faded until the rat and experimenter were reliably performing the final behavior chain.

Each participant required a different number of training sessions to reach this point. Isabella had 16 training sessions over five days. Georgie had 10 training sessions

over three days. Chloe had 25 training sessions over seven days.

General Procedure

Each participant was transported to every experimental session in a small cardboard transport box which was then placed on the table. When the rat voluntarily left the box then the experimenter removed the box and stood in front of the table. The experimenter then picked up and held any syringes and/or droppers that would be presented during that session behind their back. When the rat oriented their head towards the experimenter, then the experimenter presented the first syringe on the right square. This first syringe was always an apple syringe. During each presentation the experimenter held the syringe or dropper either on the right edge of the right square facing toward the left (right square presentation) or the left edge of the left square facing toward the right (left square presentation).

When the rat bit the first apple syringe approximately 0.2 ml of liquid was delivered into the rat's mouth. Following this, the syringe was removed and held behind the experimenter's back. This concluded the first trial. The second trial began when the rat turned toward the opposite square and the experimenter presented a syringe or dropper at that square. The second trial ended when the syringe or dropper was removed. Four more trials were conducted in the same manner for a total of six trials.

If the rat did not bite a syringe or dropper within 30 s of turning towards it, then it was removed and the next trial began when the rat turned toward either the left or the right square. This meant that syringes or droppers were occasionally presented on the

same square for two trials in a row. During every trial in every condition approximately 0.2 ml of liquid was delivered into the rat's mouth if the rat bit the syringe or dropper.

Each experimental session consisted of six trials. At the end of the session, the experimenter placed the cardboard transport box on the table. When the rat entered the box, the experimenter picked it up and moved the rat to a play area where the rat remained between sessions. Four experimental sessions were conducted per day with each rat that had completed the training phase.

Baseline

Baseline (A) begun for each participant once the rat and experimenter reliably performed the final turn and bite behavior chain during training (see Procedure). During all baseline sessions an apple syringe was presented during every trial. The *apple syringe* used during all experimental conditions was a syringe filled with apple sauce and then wiped with a clean paper towel prior to the start of the session. The syringe was cleaned in this manner in an attempt to minimize any apple sauce odor on the syringe.

Alcohol-Containing Syringe Conditions

During all non-baseline sessions five of the six syringes or droppers presented during the session were apple syringes. Furthermore, the first and sixth trial presentations were always apple syringes. However, one alcohol-containing syringe or dropper was presented during either the second, third, fourth, or fifth trial in the session. Furthermore, since four sessions were conducted per day with each rat, the alcohol-

containing syringe or dropper was presented in the second, third, fourth, and fifth trials once per day in a predetermined order. There were additional trial order stipulations for multi-element conditions (see Experimental Design). The stimulus presentation order always changed between successive days and varied between rats on the same day.

Two different alcohol-containing syringe conditions were used: the alcohol syringe (B) condition and the masked alcohol syringe (E) condition. The *alcohol syringe* was a syringe filled with alcohol prior to the start of the session and then wiped with a clean paper towel. The syringe was wiped in order to minimize any alcohol odor on the syringe. The *masked alcohol syringe* was a modified alcohol syringe with the syringe barrel filled with alcohol, the syringe tip filled with apple sauce, and the outside wiped with an apple sauce-soaked paper towel prior to the start of the session. The syringe was wiped in an attempt to make the apple syringe and masked alcohol syringe carry similar odors.

Alcohol-Containing Dropper Conditions

Two different alcohol-containing dropper conditions were used: the alcohol dropper (C) condition and the alcohol plate (D) condition. The *alcohol dropper* was a dropper filled with alcohol prior to the start of the session. This condition was only used with Isabella. The *alcohol plate* was a modification of the alcohol dropper which consisted of the plate (see Materials and Figure 2) with the plate's dropper filled with alcohol prior to the start of the session. No attempts were made to minimize any alcohol odor on the droppers.

Experimental Design

The experimental design varied between participants because experimental manipulations were introduced on the basis of the participants' data. In addition, the experimental conditions were introduced after differing baseline lengths for each rat in order to control for any possible effects of longer or shorter baseline lengths. Isabella had 40 baseline sessions across 10 days, Georgie had 20 baseline sessions across five days, and Chloe had eight baseline sessions across two days. However, a multi-element design was incorporated in at least one experimental condition for each rat in order to compare two session types. Baseline (A), alcohol syringe (B), alcohol dropper (C), alcohol plate (D), and masked alcohol syringe (E) conditions were used through the course of the study, but only Isabella experienced all five conditions.

Isabella had an ABCD(BD)E(ED) design, which contained an alcohol syringe/alcohol plate (BD) multi-element condition and a masked alcohol syringe/alcohol plate (ED) multi-element condition. Isabella was the first participant to begin the study and her data informed subsequent experimental manipulation decisions for the other two participants. Georgie began the study six days after Isabella and had an ABD(BD) design, which contained an alcohol syringe/alcohol plate (BD) multi-element condition. The last participant, Chloe, began 10 days after Isabella and had an ABEB(BE)D(ED) reversal design, which contained an alcohol syringe/masked alcohol syringe (BE) multi-element condition and a masked alcohol syringe/alcohol plate (ED) multi-element condition.

The apple syringe was a constant variable throughout all experimental sessions because an alcohol-containing syringe or dropper was only presented during one trial in

a session. Thus, the rats' run times toward apple syringes could be compared with their run times toward alcohol-containing syringes and droppers across trials and experimental conditions. In addition, the rats' pause times after apple syringes could be compared with their pause times after alcohol-containing syringes and droppers across trials and experimental conditions.

Trial types were counterbalanced to control for trial order effects. As previously noted, an alcohol-containing syringe or dropper was presented once per day in the second, third, fourth, and fifth trials of the four daily sessions in a predetermined order. This requirement was also the case during multi-element conditions.

However, multi-element conditions had additional stipulations because multi-element conditions involved the presentation of two different types of alcohol-containing syringes or droppers. During multi-element conditions each type of alcohol-containing syringe or dropper was presented once in the second, third, fourth, and fifth trial of a session across every two days. In addition, two sessions of each of the two conditions comprising the multi-element condition were presented each day. The session condition order varied across days for each rat and varied between rats on the same day. In addition, during multi-element conditions, a maximum of three sessions of the same condition occurred in a row across consecutive days.

Results

Run time and pause time data for every trial in all experimental sessions are presented in Figure 3 for Isabella, in Figure 4 for Georgie, and in Figure 5 for Chloe. The run time graph is presented above the pause time graph for each rat. Thus, each

figure displays the rat's run time towards the syringe or dropper presented during that trial and the rat's pause time after the syringe or dropper's removal.

Baseline

During baseline all three participants demonstrated short and stable run times toward apple syringes with minimal variability. This is evident by visually inspecting the graphs and by calculating the rats' run time ranges. Including outliers, both Isabella and Chloe had a 2.4 s run time range and Georgie had a 1.6 s run time range. Isabella's run times ranged between 1.1 s and 2.3 s with a 3.5 s outlier (Figure 3). Chloe's run times ranged between 0.8 s and 1.2 s with a 3.2 s outlier (Figure 5). Georgie's run times ranged between 0.9 s and 2.5 s with no outliers (Figure 4).

Baseline pause time values were more variable than baseline run time values for all three participants. During baseline all three rats had larger pause time ranges than run time ranges. Chloe had the shortest pause time range at 5.9 s while, even excluding outliers, Isabella had a 24.7 s pause time range, and Georgie had the longest pause time range at 35.7 s. Isabella's pause times ranged between 1.6 s and 26.3 s with a 49.6 s outlier (Figure 3). Chloe's pause times ranged between 0.6 s and 6.5 s (Figure 5). Georgie's pause times ranged between 1.2 s and 36.9 s (Figure 4). During their pause times, the rats would often be consuming the apple sauce and grooming themselves. Notably, Georgie's baseline pause time values became less variable as baseline progressed (Figure 4). This did not occur for the other two rats.

Non-discriminated Alcohol Stimuli

All three rats had run times toward at least one alcohol-containing syringe or dropper which consistently fell within the range of their run times toward apple syringes in the same condition. During the initial alcohol syringe condition, Isabella and Georgie's run times were within the same range on alcohol syringe trials and apple syringe trials (Figure 3 and Figure 4). In addition, Isabella had run times toward alcohol droppers and masked alcohol syringes which were indistinguishable from her run times toward the apple syringes in those conditions (Figure 3). The third rat, Chloe, had run times toward masked alcohol syringes which always fell within the range of her run times toward apple syringes (Figure 5). These data indicate that the rats did not develop longer run times toward alcohol-containing droppers and syringes during these conditions, despite consuming alcohol during those trials.

During her first alcohol syringe condition and subsequent alcohol dropper condition, Isabella's run times toward alcohol syringes and alcohol droppers were within the range of her run times toward apple syringes (Figure 3). Isabella's run times toward apple syringes during these conditions ranged between 1.3 s and 3.9 s. Isabella's run times toward alcohol syringes and alcohol droppers during these conditions fell within this range, ranging between 1.5 s and 3.7 s.

The alcohol dropper condition was introduced with Isabella to see if she would develop longer run times towards the alcohol dropper than the apple syringe in this condition. Because this did not occur with Isabella, this condition was not introduced with the other rats. It is possible that Isabella did not develop longer run times toward the alcohol dropper than the apple syringe because rats have poor visual acuity

(Prusky, Harker, Douglas, & Whishaw, 2002). However, the present study did not test this hypothesis because it is conceivable that Isabella's run times may have become longer with repeated exposure to the alcohol dropper.

Like Isabella, during the alcohol syringe condition, Georgie's run times toward alcohol syringes were indistinguishable from her run times toward apple syringes (Figure 4). Georgie's run times toward apple syringes in this condition ranged between 0.8 s and 8.5 s. Her run times toward alcohol syringes all fell within this range, ranging between 1.1 s and 7.1 s. Georgie had a larger run time range than Isabella during the alcohol syringe condition but the data for both rats showed the same result in this condition.

During the subsequent alcohol syringe/alcohol plate multi-element condition, Georgie's longest run time toward an alcohol syringe took 12.6 s and occurred on Trial 278. During this time, Georgie hit the syringe with her paws three times and left and returned to the square twice. It is possible that Georgie was responding to some uncontrolled aspect of the alcohol syringe, such as the amount of alcohol in the syringe or the syringe's temperature. However, this possibility was not experimentally tested. Nevertheless, during every other session in this condition Georgie's run times toward alcohol syringes fell within the range of her run times toward apple syringes. Excluding Trial 278, Georgie's longest run time toward an alcohol syringe in the multi-element condition was 3.9 s while her run times toward apple syringes ranged between 0.8 s and 4.2 s. Thus, Trial 278 may be considered an outlier.

During her first alcohol syringe condition, the third rat, Chloe, developed longer run times toward alcohol syringes than toward apple syringes (Figure 5). This is a

different result from that seen with the other two rats in the same condition. Upon observing the videotapes it was hypothesized that Chloe was discriminating between alcohol syringes and apple syringes by smelling all of the syringes before biting them. At this point, a masked alcohol syringe condition was introduced. Chloe's run times toward masked alcohol syringes always fell within the range of her run times toward apple syringes during the masked syringe condition, the alcohol syringe/masked alcohol syringe multi-element condition, and the alcohol plate/masked alcohol syringe multi-element condition. Chloe's run times toward masked alcohol syringes ranged between 0.8 s and 1.2 s across all three of these conditions, while her run times toward apple syringes during the same conditions ranged between 0.8 s and 2.5 s, with a 5.6 s outlier.

The alcohol syringe was also masked for Isabella. During the masked alcohol syringe condition, Isabella had run times toward masked alcohol syringes which were indistinguishable from her run times toward apple syringes (Figure 3). During the masked alcohol syringe condition, and subsequent alcohol plate/masked alcohol syringe multi-element condition, Isabella's run times toward masked alcohol syringes ranged between 1.8 s and 2.6 s while her run times toward apple syringes ranged between 1.3 s and 3.0 s. During the masked alcohol syringe/alcohol plate multi-element condition, Isabella continued to display run times toward masked alcohol syringes which were within the range of her run times toward apple syringes in the same condition. These findings suggest that both Chloe and Isabella may have learned to identify the alcohol's smell during the alcohol syringe condition.

Interestingly, during the conditions in which the rats had similar run times toward apple syringes and alcohol-containing syringes and droppers all three rats had longer pause times after alcohol-containing syringes and droppers than after apple syringes. However, as the study progressed, this separation became less distinct for all three rats.

During the first alcohol syringe condition, Isabella had longer pause times after alcohol syringes than after apple syringes in the same condition (Figure 3). During her alcohol dropper condition, her pause times after alcohol droppers trended downward, until they were indistinguishable from her pause times after apple syringe during the same condition. In addition, during the masked alcohol syringe condition, and subsequent alcohol plate/masked alcohol syringe multi-element condition, seven out of Isabella's eight pause times after masked alcohol syringes fell within the range of her pause times after apple syringes during the same condition.

During her alcohol syringe condition, Georgie had longer pause times after alcohol syringes than after apple syringes (Figure 4). However, during Georgie's alcohol syringe/alcohol plate multi-element condition, this separation became less distinct. Eight out of Georgie's 14 pause times after alcohol syringes fell within the range of her pause times after apple syringes during this multi-element condition.

During Chloe's masked alcohol syringe condition, Chloe had longer pause times after masked alcohol syringes than after apple syringes (Figure 5). During the alcohol syringe/masked alcohol syringe multi-element condition, this distinction was still present but two out of Chloe's six pause times after masked alcohol syringes fell within the range of her pause times after apple syringes during the same condition. In addition,

during her subsequent alcohol plate/masked alcohol syringe multi-element condition Chloe did not have longer pause times after masked alcohol syringes than after apple syringes. Thus, these data indicate that Chloe's pause times after masked alcohol syringes became shorter as the study progressed. This trend is also evident in the other rats' data.

Discriminated Alcohol Stimuli

All three rats bit the alcohol plate at least once and subsequently displayed longer run times toward alcohol plates than apple syringes during alcohol plate conditions. As previously noted, there was a 30 s ceiling on run time values, after which the syringe or dropper was removed. All three rats had run times at this ceiling toward the alcohol plate. In addition, two of the three rats, Chloe and Isabella, developed ceiling-length run times toward the alcohol syringe after biting the alcohol syringe at least once.

During her first alcohol plate condition, Isabella developed ceiling-length run times toward the alcohol plate (Figure 3). She bit the alcohol plate during seven out of the 10 trials in which it was presented during this condition. In addition, Isabella maintained ceiling-length run times toward the alcohol plate during all 13 subsequent alcohol plate trials during the study. These data show that once Isabella developed ceiling-length run times toward alcohol plates then she maintained this pattern of responding. In addition, Isabella also developed ceiling-length run times toward alcohol syringes. During the alcohol syringe/alcohol plate multi-element condition, Isabella

developed increasingly longer run times toward alcohol syringes and had a ceiling-length run time toward the last alcohol syringe presented during that condition.

As previously noted, during her first alcohol syringe condition, Chloe developed ceiling-length run times toward alcohol syringes (Figure 5). In addition, when the experimental conditions were reversed back to a second alcohol syringe condition, Chloe again had longer run times toward alcohol syringes than apple syringes. However, interestingly, during the alcohol syringe/masked alcohol syringe multi-element condition she began biting the alcohol syringe again. During this condition, Chloe's run times toward alcohol syringes trended downward. However, Chloe's run times toward alcohol syringes remained higher than her run times toward apple syringes in this condition. Chloe's run time data path toward alcohol syringes remained higher than her data path toward apple syringes and did not overlap. Thus, the data suggest that Chloe was still discriminating between apple syringes and alcohol syringes despite biting alcohol syringes.

One possible interpretation of Chloe's decreasing trend in run time length toward alcohol syringes is that Chloe was biting the alcohol syringes in order to gain quicker access to the subsequent apple syringe. The alcohol syringe was replaced with the alcohol plate in order to test this possibility. During this alcohol plate condition, Chloe had ceiling-length run times toward alcohol plates for the first three sessions before biting the alcohol plate during the fourth session. During the subsequent alcohol plate/masked alcohol syringe multi-element condition Chloe had ceiling-length run times toward alcohol plates for the first three alcohol plate sessions before biting the alcohol plate during her final alcohol plate session. These findings suggest that Chloe was

probably not biting the alcohol syringe in order to gain access to the following apple syringe because she had ceiling-length run times toward alcohol plates after having alcohol dispensed into her mouth when she bit the alcohol plate. It remains unclear why Chloe developed shorter run times toward the alcohol syringe.

Like the other two rats, during her first alcohol plate condition Georgie developed ceiling-length run times toward the alcohol plate (Figure 4). However, unlike the other two rats, Georgie never developed ceiling-length run times toward the alcohol syringe. During the alcohol plate condition Georgie bit the alcohol plate five times before displaying three consecutive ceiling-length run times toward the alcohol plate during this condition. Georgie's ceiling-length run times toward alcohol plates maintained during the subsequent alcohol syringe/alcohol plate multi-element condition. Georgie displayed ceiling-length run times toward alcohol plates during 10 of the 14 alcohol plate sessions during this condition. It is unclear why Georgie bit the alcohol plate during the remaining four alcohol plate sessions. Similarly, it is unclear why Chloe bit the alcohol plate during her final alcohol plate session (Figure 5).

Apple Syringes

Georgie's run times toward apple syringes were markedly disrupted after her first alcohol syringe trial (Figure 4). During the eight sessions in the alcohol syringe condition, Georgie's run times toward apple syringes ranged between 0.8 s and 8.5 s. By comparison, during baseline, Georgie's run times toward apple syringes ranged between 0.9 s and 2.5 s. Thus, Georgie's run times toward apple syringes increased in both variability and length after her first alcohol syringe trial. However, twice - on Trial

166 and Trial 168 - Georgie turned toward the apple syringe, ran toward the apple syringe, stopped before reaching the square, and recoiled. These observations may indicate the development of a side bias for Georgie by the end of the alcohol syringe condition.

Isabella and Chloe displayed a less marked change in their run times toward apple syringes between baseline and non-baseline conditions than Georgie. Nevertheless, like Georgie, both Isabella and Chloe had an increase in length and variability of their run times after the alcohol syringe condition was introduced. Isabella's run times during baseline ranged between 1.1 s and 2.3 s with a 3.5 s outlier, and her run times toward apple syringes during all non-baseline conditions ranged between 1.2 s and 5.5 s with an 11.3 s outlier (Figure 3). Chloe's run times during baseline ranged between 0.8 s and 1.2 s with a 3.2 s outlier, and her run times toward apple syringes during all non-baseline conditions ranged between 0.2 s and 2.5 s with a 5.6 s outlier (Figure 5). Thus, excluding outliers, Isabella's run time range changed from 1.2 s during baseline to 4.3 s after baseline, and Chloe's run time range changed from 0.4 s during baseline to 2.3 s after baseline.

Additionally, Georgie had longer and more variable pause times after apple syringes after the introduction of the alcohol syringe condition (Figure 4). This increase in pause time variability and length is not seen in Isabella's data (Figure 3). It is also not apparent in Chloe's data which maintained a consistent amount of variability throughout the course of the study, and the least amount of variability of the three participants (Figure 5). Thus, after the first alcohol syringe condition was introduced, then run times

toward apple syringes were disrupted for all three rats but pause times after apple syringes were only disrupted for Georgie.

Interestingly, during the course of the study two of the three rats, Georgie and Isabella, bit the square, alcohol plate, alcohol syringe, and experimenter. Georgie bit holes in the square during her pause time after the first three alcohol syringes and again during her pause time on Trial 356. Once Isabella learned to avoid the alcohol syringe she began biting the experimenter's fingers during her run time on alcohol syringe presentations. Notably, Chloe never exhibited similar biting behavior.

Discussion

During the present study, all three rats demonstrated ceiling-length run times toward an alcohol-containing syringe or dropper during at least one experimental condition and maintained short run times toward an alcohol-containing syringe during a different experimental condition. Initially, when the rats had short a run time toward an alcohol-containing syringe then their subsequent pause time was longer than their pause times after apple syringes during the same condition. However, this dissimilarity lessened during the course of the study for all three rats.

Thorndike (1911) defined aversive stimuli as those stimuli that the animal seeks to terminate or avoid. Thorndike conversely defined appetitive stimuli as those the animal seeks to access or maintain. Contemporary behaviorists still use these definitions. For example, in their textbook, Pierce and Cheney (2008) defined aversive stimuli as, "a stimulus the organism evades, escapes, or avoids" (p.129). While the present study provides evidence that apple sauce was an appetitive stimulus for all

three rats, defining alcohol as an aversive stimulus for all three rats is more problematic. Historically, behavior theorists have defined avoidance behaviors as responses which prevent aversive stimulation from occurring (Mazur, 1990). Avoidance behaviors either postpone the aversive stimulation or stop it from happening (Catania, 2007). Following these definitions, the ceiling-length run times seen in the present study could be conceptualized as behavior chains the rats learned to avoid alcohol from being delivered into their mouths. However, an avoidance interpretation of the present data is problematic because it implies that during one set of conditions alcohol is an aversive stimulus and under a different set of conditions alcohol is not an aversive stimulus. Ceiling-length run times toward alcohol-containing syringes and droppers were only observed during some experimental conditions for all three rats (Figure 3, Figure 4, and Figure 5). During the other experimental conditions, the rats' run times were indistinguishable from those seen toward the apple syringe, which is an appetitive stimulus. Thus, using this terminology it would be possible to suggest that during one set of conditions the alcohol was an aversive stimulus while under a different set of conditions it was an appetitive stimulus.

An alternative description of the present findings explains the results within a positive punishment contingency. In this case, during one set of conditions biting an alcohol-containing syringe or dropper was punished, whereas under a different set of conditions this behavior was not punished. In other words, during alcohol plate conditions the alcohol plate became a discriminative stimulus for punishment for all three rats. In addition, the alcohol syringe also became a discriminative stimulus for

punishment for Isabella and Chloe. Note that during these conditions alcohol delivery is conceptualized as a positive punisher.

Conversely, the masked alcohol syringe did not become a discriminative stimulus for punishment for Chloe or Isabella and the alcohol syringe did not become a discriminative stimulus for punishment for Georgie. Thus, during the masked alcohol condition, alcohol delivery cannot be conceptualized as a positive punisher because the probability of the rat biting the masked alcohol syringe did not decrease after the rat bit the masked alcohol syringe. This is a similar conundrum to that faced by an avoidance account of the present data. Nevertheless, a positive punishment account of the present results is favorable to an avoidance account because it is functional and does not contain circular reasoning. Nevertheless, ceiling-length run times may be defined as avoidance responses.

The positive punishment description of the present findings suggests that alcohol cannot be conceptualized as a positive punisher for the individual animal outside of the context during which it was delivered. During all conditions, the consequence for biting an alcohol-containing syringe or dropper was the same. Biting an alcohol-containing syringe or dropper resulted in the delivery of alcohol into the rat's mouth. Thus, the alcohol delivery alone cannot be responsible for punishing biting behavior. Therefore, alcohol delivery can only be conceptualized as a positive punisher or aversive stimulus within its current environmental context.

The idea that stimuli must be seen as aversive or appetitive within the present context for the organism has similarities with Premack's (1965; 1971) theories about the nature of reinforcement drawn from his research. Premack (1962) demonstrated that

reinforcers and punishers are not static entities. Instead, a reinforcer can become a punisher and a punisher can become a reinforcer, depending on the organism's current preferences and the present contingencies. Schoenfeld (1969) stated that, "no stimulus is aversive in itself without regard to the parameter of its intensity and the circumstances of its delivery" (p. 673). The present research extends this suggestion to state that a consideration of the antecedents in a three-term contingency is necessary in order to define aversive consequences. In the present study, experimental conditions only differed in their environmental antecedents for the alcohol delivery consequence for biting. The consequences for biting remained the same throughout the experiment. What changed between experimental conditions were the visual discrepancies between the apple syringe, alcohol syringe, alcohol plate, and alcohol dropper, and the olfactory discrepancy between the alcohol syringe and masked alcohol syringe. Therefore, any description of the present findings must take into account the environmental antecedents in the contingency in addition to the consequence.

In the current experiment, the number of trials in a session during which an alcohol-containing syringe or dropper was presented remained the same throughout all experimental conditions. In addition, the trial number in which the alcohol-containing syringe or dropper was presented was counterbalanced such that that there were no temporal consistencies in the procedure. The only manipulation between experimental conditions was the presence or absence of external antecedent stimuli which reliably predicted that alcohol delivery was the current consequence for biting the syringe or dropper.

Previous research has shown that avoidance responding could develop on the basis of temporal consistencies in the experimental procedure (Sidman, 1953; Sidman, 1953). Further research demonstrated the development of avoidance responding on the basis of schedule differences without temporal consistencies or reliable external stimuli signaling imminent aversive stimulation (Herrnstein & Hineline, 1966). The present research extends these findings to suggest that if there are no schedule differences between conditions, temporal consistencies for aversive stimulation, or reliable external stimuli signaling impending aversive stimulation, then punishment will not occur because the contingency is indiscriminable.

The present study suggests that two-term contingency accounts of learning are fallacious and all learning occurs within the context of at least a three-term contingency. Skinner (1937) postulated the idea that respondent conditioning produces changes in stimulus-stimulus relations and operant conditioning produces changes in response-stimulus relations. However, Skinner's (1937) conception of the unit of selection in respondent and operant conditioning has not been unchallenged. Sidman (1978) suggested that Skinner developed this view because his early experiments were conducted in static environments and this lead Skinner to be misguided in devising two-term contingency accounts of learning. Sidman stated that all responses are made after discriminations. The present study provides support for this view. That is, whether or not alcohol functioned to punish biting behavior depended on the antecedent stimuli for biting.

Biting behavior was not punished by alcohol during the alcohol syringe condition for Georgie (Figure 4) or the masked alcohol syringe condition for Chloe (Figure 5) and

Isabella (Figure 3). Despite this, pause times were longer for all three rats during these conditions. Anecdotally, during these pause times the rats were commonly observed to be looking over the edge of the table, rearing, grooming, biting the square, and licking the square. It is possible that these behaviors served as attempts to contact a reliable environmental stimulus correlated with alcohol delivery. Future research could investigate this possibility.

As the present study progressed, all three rats' pause times after alcohol-containing syringe and dropper presentations became shorter. This indicates that the rats' reactions to alcohol delivery became less extreme during the course of the study. This presents a problem for a functional or topographical conception of an aversive stimulus because it would be fallacious to say that the animals had become desensitized or habituated to the alcohol on the basis of these observations alone. This point is illustrated by Chloe's data (Figure 5). During her alcohol syringe/masked alcohol syringe multi-element conditions Chloe began biting the alcohol syringe, despite having long run times toward the alcohol syringe during previous conditions. However, after biting the alcohol plate Chloe demonstrated ceiling-length run times toward the alcohol plate. This suggests a loss of stimulus control during the alcohol syringe condition. Because smell was not controlled during the present experiment it is difficult to speculate on why the alcohol syringe lost stimulus control over Chloe's behavior. Nevertheless, these observations suggest that the alcohol did not stop being an aversive stimulus for Chloe as the study progressed.

Run times toward apple syringes were longer for all three rats after the experimental conditions were introduced. These observations suggest that alcohol

delivery did more than punish biting behavior during certain conditions. Alcohol delivery may have also affected all biting behavior under all conditions. Conceivably, had the alcohol delivery occurred more frequently the rats might have demonstrated ceiling-length run times toward all syringes and droppers, including apple syringes. Alternatively, the rats might have left the experimental session by jumping off the table. Neither of these scenarios occurred during the present study. Future research is needed to determine where such a break point lies.

The present study suggests a training methodology for preparing animals for future aversive procedures, such as a course of oral medication, and ensuring that the animal does not avoid the procedure's environmental context after the aversive procedure has been performed. Simply, the results suggest that practitioners must maintain identical environmental stimulus conditions between training situations, dummy situations, and medicine dosing situations. This is a refinement of current techniques used to train animals to voluntarily accept aversive stimulation, which typically do not consider the environmental context (Young & Cipreste, 2004; Weiss & Wilson, 2003; Priest, 1991; McDonnell, 2000; Laule, Thurston, Alford, & Bloomsmith, 1996). These procedures use shaping and stimulus fading techniques in a similar manner to behavior analysts Levison, Fester, Nieman, and Findley (1964), who trained primates to voluntarily accept venipuncture.

Isabella's data (Figure 3) and Chloe's data (Figure 5) provide a caution for practitioners using this procedure. Both Isabella and Chloe learned not to bite the alcohol syringe during alcohol syringe presentations, as reflected in these rats' development of long run times toward alcohol syringes across repeated presentations.

Thus, practitioners must be observant and vigilant in order to identify any unforeseen sources of stimulus control which reliably predict medicine dosing. The animal may quickly learn not to bite the oral syringe under these conditions. If this occurs, then the practitioner will have to attempt to control that source of stimulus control. However, this task is difficult because stimuli are complex, which means that stimulus control is always inferential (Sidman, 1979). Thus, correctly identifying a source of stimulus control may be difficult to accomplish with some stimuli.

The training methodology suggested by the present experiment raises an ethical dilemma for practitioners because it trains animals to accept or tolerate unavoidable aversive consequences. In the present study, alcohol delivery was an aversive stimulation which occurred during the experimental conditions. During the alcohol syringe condition for Georgie (Figure 4) and during the masked alcohol syringe condition for Isabella (Figure 3) and Chloe (Figure 5), this aversive stimulation was arguably unavoidable. Conceivably, the rats could have not bitten any syringes during the entire session. However, this never occurred during the present study.

The learned helplessness literature suggests that unavoidable aversive events may be damaging to an organism's wellbeing (Maier & Seligman, 1976). However, this literature also suggests that unavoidable aversive events are less damaging to an organism's wellbeing if the organism first learns how to escape the aversive event (Maier & Seligman, 1976). Thus, perhaps it would be more ethical to first provide an animal with a stimulus reliably correlated with an aversive procedure, like a medicine dose from a syringe, before making the likelihood of an aversive outcome from the procedure indeterminable. In effect, Chloe had this order of conditions. Unlike the other

two rats, Chloe developed ceiling-length run times toward the alcohol syringe during her initial alcohol syringe condition (Figure 5). Interestingly, Chloe was the only participant not to bite the square, plate, syringe, dropper, or experimenter. Further research is needed to determine whether this correlation is a result of her condition order.

Another empirical finding suggests that providing an animal with such a history of successfully discriminating aversive outcomes might also be beneficial for maintenance. In the phenomenon of blocking, a previously trained source of stimulus control prevents subsequently presented antecedent stimuli from acquiring stimulus control over an organism's responding (Kamin, 1968). Thus, perhaps providing an animal with a reliable discriminative stimulus for punishment would inhibit the development of stimulus control by other stimuli within the environment. Further research is required in order to elucidate this possibility.

Interestingly, both Isabella and Georgie bit elements of their environment after consuming alcohol and during an alcohol-containing syringe or dropper presentation. These biting behaviors are not surprising. Rats will bite inanimate objects when given unavoidable electric shock (Azrin, Rubin, & Hutchinson, 1968). Similarly, in the present study the rats were given indiscriminable alcohol deliveries into their mouths. However, this observed biting highlights a danger for practitioners. An animal is likely to attack the practitioner when they give the animal unavoidable aversive stimulation. Practitioners must be mindful of this when using this procedure to deliver medication to an animal.

With the introduction of the alcohol syringe, run times toward apple syringes were disrupted for all three rats and baseline stability was never recovered (Figure 3, Figure 4, and Figure 5). In addition, pause times were longer after alcohol syringes and

droppers than after apple syringes for all three rats. These findings suggest that even though all three animals kept approaching the presented syringes and droppers throughout the course of the study the experimental environment was not unaffected. Practitioners should be mindful of this when implementing this procedure.

During the study the ratio of apple syringe presentations to alcohol-containing syringe or dropper presentations within a session remained constant. Five trials during each non-baseline session contained an apple syringe presentation and one trial contained an alcohol-containing syringe or dropper presentation. None of the three participants in the present study chose to leave the experimental environment or stop turning towards the squares under these conditions. This suggests that organisms are likely to remain in and return to environments in which pleasant events occur most of the time but sometimes an unforeseeable unpleasant event occurs.

These findings suggest that in some cases positive reinforcers can be detrimental to an organism's welfare because animals will accept or tolerate aversive stimulation in order to gain access to something they find appetitive. Similarly, Perone (2003) discussed the deleterious effects of positive reinforcement. Perone stated that, "positive contingencies can be dangerous specifically because they do *not* generate avoidance, escape, or their emotional counterparts, even when the contingencies are ultimately detrimental" (p. 6). However, aversive stimulation is not always detrimental to an organism's welfare. In the present case, drinking aversive medication may save an animal's life.

The present research offers a training methodology for practitioners who wish to train animals to bite an oral syringe using an appetitive consequence and do not want to

punish this behavior with aversive stimulation from medicine. In addition, this study highlights important theoretical issues for behavior theorists about how to identify and define aversive stimuli. Lastly, the present research suggests that punishment always occurs within at least a three-term contingency and any account of learning must consider the environmental antecedents preceding a response and its consequence.

Figure 1. Photograph of the experimental setting.

Figure 2. Photographs of the plate, dropper, and syringe materials.

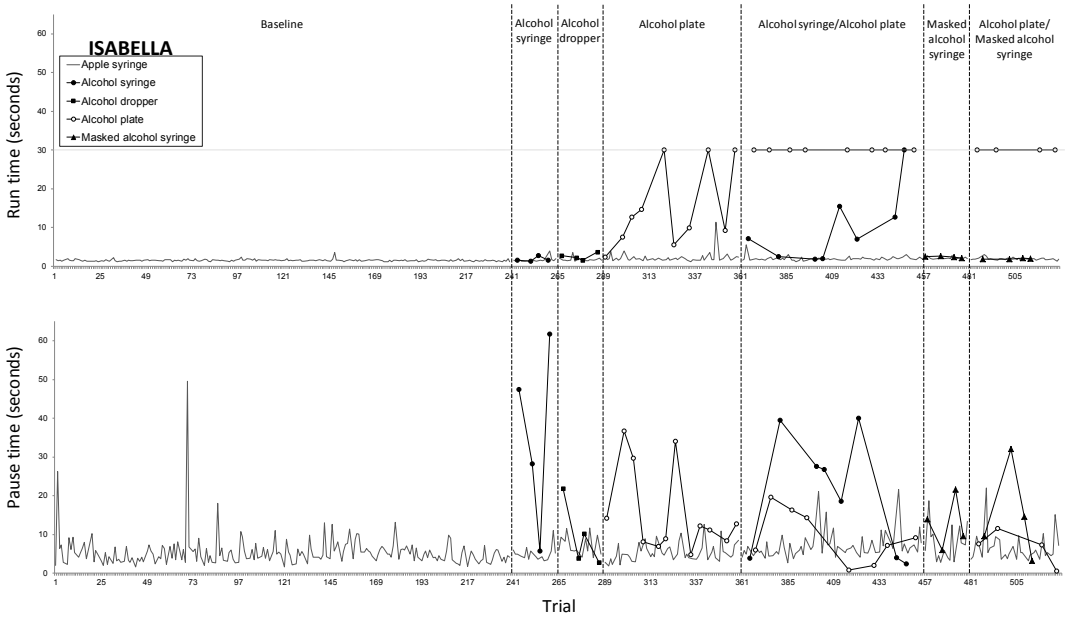

Figure 3. Run time and pause time in seconds rounded to one decimal place across all trials and conditions for Isabella. The single line series are apple syringe trials, closed circles are alcohol syringe trials, closed squares are alcohol dropper trials, open circles are alcohol plate trials, and closed triangles are masked alcohol syringe trials. Dotted grey line indicates 30 second run time ceiling.

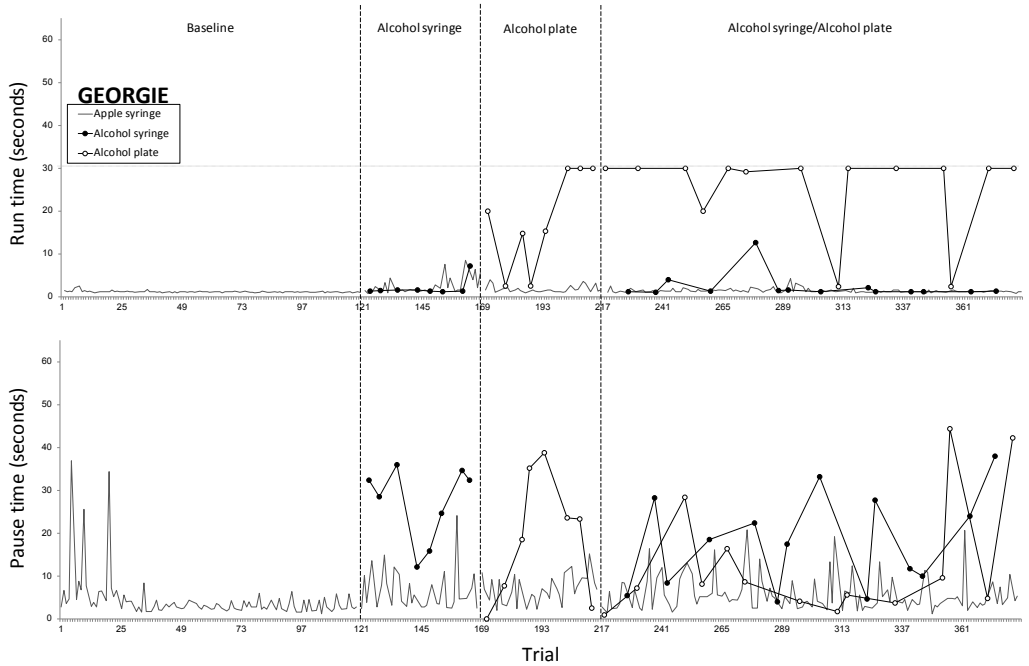

Figure 4. Run time and pause time in seconds rounded to one decimal place across all trials and conditions for Georgie. The single line series are apple syringe trials, closed circles are alcohol syringe trials, and open circles are alcohol plate trials. Dotted grey line indicates 30 second run time ceiling.

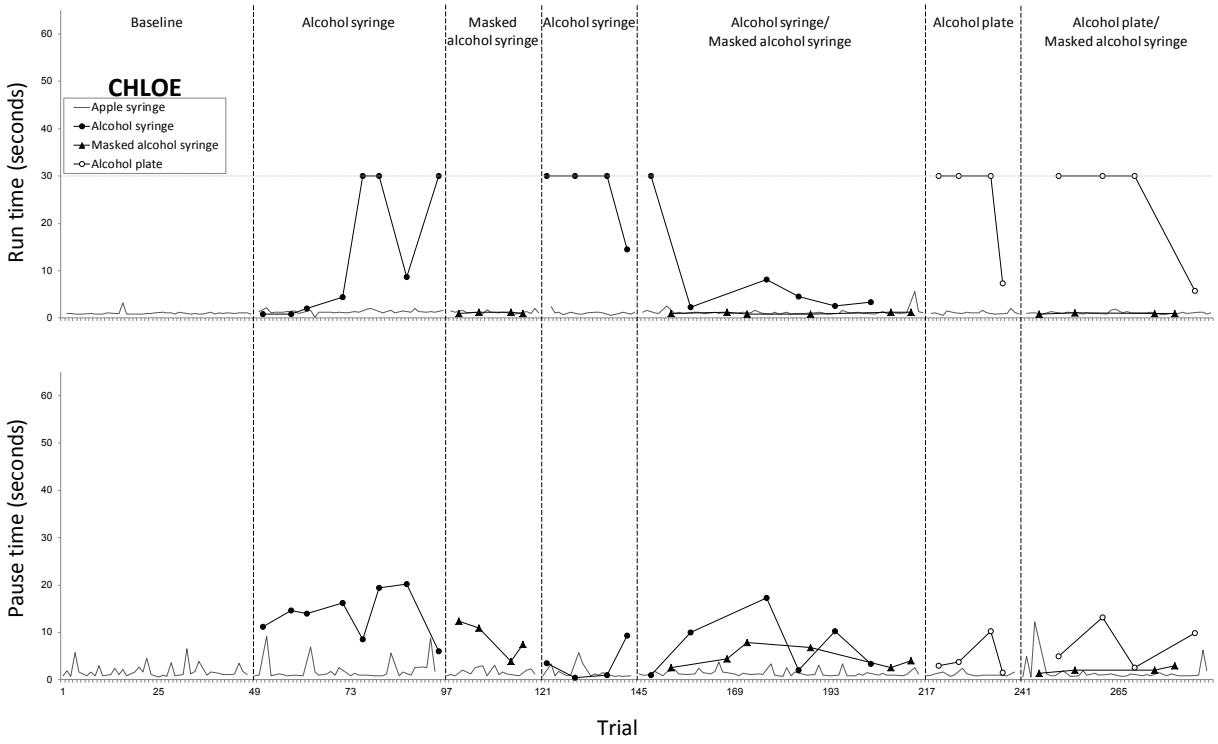

Figure 5. Run time and pause time in seconds rounded to one decimal place across all trials and conditions for Chloe. The single line series are apple syringe trials, closed circles are alcohol syringe trials, open circles are alcohol plate trials, and closed triangles are masked alcohol syringe trials. Dotted grey line indicates 30 second run time ceiling.

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