Tsk, No, Eh-eh: Clearing the Path to Reinforcement with an Errorless Learning Mindset

Susan G. Friedman, Ph. D.

Professor Emeritus, Department of Psychology

Utah State University

Behavior Works, LLC

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Abstract: We all know the saying, "If at first you don't succeed, try, try again." Unfortunately, trial and error approaches typically result in low rates of reinforcement that generate unwanted fallout. Learners practice errors making correct responding less likely, and they become frustrated, setting the occasion for aggressive behavior and giving up. This fallout led researchers and practitioners to ask, are errors really necessary for learning to occur? Errorless learning is a term used to describe a teaching approach that limits incorrect responses through careful arrangement of the teaching conditions. In this presentation, the basic elements of designing an error reduced learning environment are discussed in order to design more effective, efficient and humane training plans.

Many of our most effective training strategies weren't as well known in the past as they are today. Take Thorndike for example, who in 1898 sorely needed a shaping procedure to teach a dog to go to the corner of a large pen. Thorndike wrote:

> I would pound with a stick and say, "Go over to the corner." After an interval (10 seconds for 35 trials, 5 seconds for 60 trials) I would go over to the corner (12 feet off) and drop a piece of meat there. He, of course, followed and secured it. On the 6th, 7th, 16th, 17th, 18th and 19th trials he did perform the act before the 10 seconds were up, then for several times went during the two-minute intervals without regarding the signal, and finally abandoned the habit altogether (p.77).

While Thorndike's apparent devotion to data is impressive, his trial and error approach to dog training got in the way of their success. I looked up trial and error in the Urban Dictionary – admittedly not exactly an academic resource but this "satirical crowdsourced online dictionary of slang words and phrases" ("Urban Dictionary, 2016), is right on target. The "crowd" contributed the following descriptions of trial and error learning:

- Trying something until you get it right.
- The next best thing to guessing.

- When you mess up repeatedly until you do something right.
- A person will try something, get it wrong, learn from the mistakes, try again, and hopefully eventually get it right.
- A systematic means of determining a solution to a problem, often involving a large amount of time; often involves eliminating possibilities.
- The story of my life.

Tradition

Trial and error (T&E) is the standard approach to teaching exemplified by the well-worn proverb, "If at first you don't succeed, try, try again." While both operant training and T&E procedures rely on selection of behavior by consequences, success with the T&E approach is accidental, a chance occurrence. Although the feedback provided by incorrect responses (i.e., punishment or extinction) may eventually guide the learner to the correct behavior, it can take a lot of "Tsk, No, Eh-eh" consequences to prune the many incorrect choices off the possibilities tree. This makes T&E a slow process, which often leads to negative fallout. Learners practice errors and effort is punished (Chance, 2009, p. 312). Further, research indicates extinction is an aversive procedure that generates undesirable emotional reactions described as frustration, aggression and giving up. Pierce and Cheney (2013) report the following fallout (information in brackets and italics added):

> Pigeons flap their wings in an aggressive manner and will even work for an opportunity to attack another bird during the presentation of the S^{Δ} [*S-delta, the extinction stimulus, i.e., the no-response signal*] on a multiple schedule. Birds will peck a different key if such pecking turns off the extinction stimulus, implying that the stimulus is aversive. There are other problems with successive discrimination procedures. Because emotional behavior is generated, discriminative responding [*correctly responding to the discriminative stimulus, S^{D}, and correctly not responding to the extinction stimulus, S^{Δ}*] takes a long time to develop. In addition, spontaneous recovery of S^{Δ} responding from session to session interferes with the acquisition of discrimination. Finally, even after extensive training, birds and other organisms continue to make errors by responding in the presence of the signal for extinction [S^{Δ}] (p. 238).

The pervasive use of T&E represents, at least in part, the cultural fog about how behavior works. High rates of errors are not necessary for learning to occur and can actually work against mastery. To reduce the fog, it's important to be clear: Prompts are information, not bribes; operating on the environment to gain reinforcers is our biology, not a trick; and learning success resides in the environment, not in the learner. With less clarity than this we may miss the power of changing conditions to change behavior.

In an excellent article in which operant training and T&E are discussed, Rosales-Ruiz (2007) shared B.F. Skinner's perspective from his book, *The Technology of Teaching*, published in 1968:

> Errors are not a function of learning or vice-versa nor are they blamed on the learner. Errors are a function of poor analysis of behavior, a poorly designed shaping program,

moving too fast from step to step in the program and the lack of the prerequisite behavior necessary for success in the program.

Errorless Learning

Errorless learning is a term used to describe a teaching approach that limits incorrect responses by means of carefully arranged teaching conditions. Terrace (1963) researched errorless learning with a successive discrimination task. In the traditional successive discrimination procedure (different than Terrace's procedure), a pigeon, for example, is reinforced with food for pecking a disk on the wall of an operant chamber (called a key light or key) when it's illuminated red. After many repetitions, when the pecking behavior in the presence of the red key is well established the color of the key changes to green and pecking is no longer reinforced. With the standard protocol then, the red light is the discriminative stimulus (S^D) that cues pecking for food reinforcement, and the green light is the stimulus delta (S^Δ) that signals the extinction condition, i.e., pecking will not produce food reinforcement. The red and green keys are then alternately presented with the corresponding reinforcement and extinction conditions in effect. After initially making many errors (due to response generalization), the correct differential response to key color gradually occurs (Pierce & Cheney, 2013).

Alternatively, Terrace used two procedures in his errorless discrimination training not typical of standard discrimination training. First, the S^Δ condition, the green key, was introduced very early in the program before pecking in the redlight condition was well established. Second, Terrace used a fading (i.e., fading in) procedure to present the green key at different values, gradually increasing brightness, wavelength and duration over the repetitions. These two procedures resulted in faster learning of the discrimination and very few errors. The pigeons trained with the errorless discrimination procedures made about 25 errors (i.e., pecking the green key light) compared to 2000 to 5000 errors made by the pigeons taught with standard procedures. Only those birds trained with T&E exhibited emotional responses in the presence of the S^Δ. The pigeons trained with the errorless approach remained calm until the red disk, the S^D, appeared.

These findings have been widely replicated across species. Powers, Cheney, & Agostino (1970) found that preschool children taught a color discrimination with errorless learning procedures learned faster and with fewer errors, and they enjoyed learning more than the children taught with standard procedures. Roth reported similar results with dolphins (as cited in Pierce & Cheney, 2013).

More Than a Protocol: A Mindset

Terrace's errorless discrimination protocol, which includes early presentation of the S^Δ and fading in the discriminative features of the S^Δ, is one important way in which we can improve learning outcomes. But, there is a bigger picture to be considered by having an errorless mindset. Simply put by Rosales-Ruiz (2007):

> We also know that what makes possible the exclusive use of positive reinforcement is the program. Every time that we find ourselves correcting or waiting too long for the response it is time to reconsider the shaping program (p. 6).

In other words, the rat is never wrong, it's *the program*. The errorless learning mindset is one of taking responsibility for reducing errors, which is in our power to do. Behavior is always conditional. Behavior never occurs in a vacuum. Knowledgeable, skilled and creative

arrangement of conditions, i.e., antecedents and consequences is key to reducing errors and increasing efficient, effective, and happy learners. Below are some examples of using antecedents, consequences, and four notable procedures with an errorless learning mindset.

Antecedent Influences

Antecedent influences are those stimuli, conditions and events that set the occasion for behavior to occur. The overlapping categories of antecedent influences are briefly discussed below.

Setting events. Not all antecedent arrangements are learning solutions. Changing physical features in the training environment can make the right behavior easier thereby setting the learner up for success. Sometimes it is as simple as removing the cue for the error and adding a cue for the correct response. For example, in 2015 Pella Shades launched a media campaign demonstrating the value of setting events. By lowering his Pella window shade, the caregiver reduced his dog's incessant barking as people passed by (see LoveThatRebecca, 2015). Other examples include arranging substrates for ease of movement, expanding entry and exit doors, keeping food reinforcers tucked into pouches instead of visible in hands.

Motivating Operations. The strength of reinforcers isn't fixed, it's also conditional, i.e., reinforcer strength waxes and wanes depending on circumstances. Motivating operations are anything that establishes conditions that change the strength of a reinforcer. When daily diet is freely available it may be less motiving to work for so we train with special treats; when a behavior is cued by an unfamiliar trainer, responding may be less motivating so we encourage relationship building first, by means of depositing reinforcers in the reinforcement bank account. At Cheyenne Mountain Zoo, the trainers increased the value of going home by putting sticks on Ms. Ginger Beaver's path.

Discriminative stimuli and prompts. Pairing S^Ds with strong reinforcers results in strong, evocative cues. A weak response pattern is often the result of the weak reinforcers the cue predicts. I may know exactly what a fire alarm means but if I suspect it's just a drill and it's pelting hail stones outside, I may not bother to leave the building. Of course, we can't reinforce a behavior that never happens so prompts can be used initially and then faded out in order to transfer stimulus control to the S^D alone. Prompts can be verbal, visual, gestural and includes food lures and modeling. Prompts can be used in a least-to-most approach or a most-to-least approach, depending on the situation. The least-to-most approach is useful for assessing current skills, i.e., what the learner can do independently or with minimal prompting. Fading too fast or (more commonly) too slow can be problematic (MacDuff, Krantz, & McClannahan, 2001). Target sticks are frequently used prompts that can be quickly faded after a few reinforced repetitions of the desired response. Reinforcer placement can prompt the correct response. Peta Clark, a talented trainer from Australia, prompts the bow position by delivering the food reinforcer slightly under the dog's chest and then fades the prompt by gradually delivering the food in a more neutral upright position.

Consequence Influences and Cool Procedures

There are many important characteristics to consider in order to maximize reinforcement. The fundamental characteristics of effective reinforcement include clear contingency, i.e., the

dependency between behavior and outcomes. Contingency is best communicated with consistent reinforcement, especially in the acquisition stage of learning a new skill. Another important characteristic of effective reinforcement is contiguity. Contiguity refers to the immediacy with which reinforcement is delivered. Contiguity is often greatly improved with auditory or visual markers (bridges) like clickers, whistles and short utterances, which allow us to "tag" the correct response precisely as it occurs, after which the marker is backed up with a well-established reinforcer. Additionally, reinforcer type, quantity, novelty and variety can influence motivation and outcomes.

The training procedures we use, and our expertise using them, are two critical resources for reducing errors, frustration and aggression. Some of the sharpest procedural tools for replacing problem behavior and teaching new skills are shaping, differential outcome effect, differential reinforcement of alternative behaviors, and behavioral momentum.

The focus is of course on reinforcing the behaviors we want to see more. Positive reinforcement outcomes produce greater discretionary effort than other approaches, i.e., learners exceed the criterion required for reinforcement (Daniels & Bailey, 2014).

Shaping. Shaping is the process of reinforcing successive approximations of a desired behavior. Shaping allows us to train behaviors that may never occur otherwise. Chance (2009) describes five tips for successful shaping: First, reinforce small steps. Trainers who get poor results often require too much at once. Second, provide immediate reinforcement the instant the desired approximation occurs. Third, deliver small reinforcers, just enough to be effective without slowing pace. Fourth, reinforce the best approximation available, rather than sticking to some rigid preset plan. Fifth, back up to a previously successful approximation when necessary to progress more rapidly to the final goal (p. 141). The trainers at Zoo Knoxville used shaping to teach their elephants the component parts of a voluntary blood sequence. Dog behavior consultant Lori Stevens uses shaping to teach walking then trotting through cavaletti rails to build body awareness and strength in dogs. Lori adds difficulty by shaping the number, height, and distance between the rails.

Differential outcome effect. With the differential outcome effect, the reinforcer varies systematically with the behavior. For example, when browse reinforces shifting into the yard, and carrots reinforce returning to the barn. The differential outcome effect has been shown to be a robust phenomenon that can speed learning with a wide variety of species, learning objectives, and reinforcers (see for example, with horses, Miyashita, Nakajima, & Imada, 2000). At the Oakland Zoo, Senior Keeper Amy Phelps and consultant Lisa Clifton-Bumpass explored the differential outcome effect to teach giraffes to place their feet in the center of a radiograph plate. Foot placement anywhere on the edges of plywood mock-up produced lettuce and foot placement directly in the center of the mock-up produced banana slices. As behavior change is always a study of one, we should account for individuality when it comes to discovering which consequences actually function as reinforcer for each learner.

Differential reinforcement of alternative behaviors (DRA). Differential reinforcement of alternative behaviors is a combination of two procedures – reinforcement for the target behavior and extinction for the undesirable behavior. Differential reinforcement of alternative behaviors answers the question, "What do you want the animal to do instead of incorrect or inappropriate

behavior?" Trainers at the Columbus Zoo reinforced an Asian small clawed otter for holding a block, an incompatible alternative to grabbing the target they were using to prompt an open mouth behavior. Trainers at San Diego Zoo reinforced a male lion for laying down, an incompatible alternative to aggressive behavior at the shift door.

Behavioral momentum. Based on Nevin's work, Mace et al. (1988) described behavioral momentum as "the tendency for behavior to persist following a change in environmental conditions" (p. 123). Mace developed a corresponding applied intervention for non-compliance that consisted of delivering a sequence of cues with which the subject was very likely to comply (high probability requests) prior to delivering the low-probability request. Momentum-like effects were shown. The antecedent high-probability cue sequence increased compliance and decreased compliance-latency and task duration. Ken Ramirez from the Shedd Aquarium and Karen Pryor Clicker Training, uses behavioral momentum as a key feature in his response to missed cues with sea lions, beluga whales, otters, and other animals. After a very short interval of withholding the reinforcer, Ken cues a few high-probability behaviors and then gives the missed cue again. To use this procedure well, the animal must have the prerequisite skill of calm, focused attention on the trainer during the short pause (withholding of the reinforcer), itself a product of great training.

Get Real

On this planet it is neither realistic nor necessary to experience no errors whatsoever when learning new skills (which is another way of saying we don't need *every* response to lead to positive reinforcement). We are resilient and can bounce back after mistakes, even learning from them and enriched by them, given an empowered learning history that is rich with successes. After all, even the pigeons taught with Terrace's carefully orchestrated errorless discrimination technique made errors. But the T&E group made between 80 to 200 times more errors and were the only pigeons to show frustration and aggression. Clearly, reducing errors is a worthy goal, which leads to the question, how many errors is too many? If only there was a simple answer. Perhaps the question is better framed as, how would we know what is too many errors for any given individual? What's the measure? The answer lies in reading and heeding an animal's communications. Large and small changes in tails, eyes, fur and feathers are messages in the conversation we should be having with animals. Latency responding to cues, too much or too little focus, and response intensity also provide information about how many errors are too many for an individual learner. Further, serious problem behaviors, such as repetitive and self-injurious behaviors, may have an escape function (negative reinforcement). That is, problem behaviors may be performed in order to remove aversive conditions like the demands of largely unsuccessful training sessions, i.e., too many errors.

Also, it is interesting to note that some research suggests Terrace's errorless discrimination procedures may be most useful in situations where the contingencies are fixed (as is the case with many trained behaviors) rather than changing. With problem solving situations with frequently changing contingencies that depend on eliminating incorrect responses (e.g., search and rescue dogs), traditional T&E procedures may result in more flexible responding and allow better remembering and recall (Pierce & Cheney, 2013, p. 239). More research is needed to discover the interaction between training procedures and different operant classes of behavior.

Conclusion

Trial and error training approaches typically result in high rates of errors and low rates of reinforcement – the perfect recipe for unwanted fallout. Learners practice errors making correct responses less likely in the long run and often show frustration, aggression or just give up. Trainers too can be similarly demoralized by their animal's slow learning curve and the frequent withholding of reinforcers that results from incorrect responses. The operant training toolbox is full of alternatives that differ from trial and error learning because they provide ways to guide learners to reinforcement. One alternative to traditional trial and error training is Terrace's successive discrimination procedure, which has come to be known as errorless learning. However, errorless learning is more than a set of procedures. It is a mindset that encourages trainers to take responsibility for their learner's outcomes resulting in more carefully and creatively arranged environments and training plans. With the errorless learning mindset, animals in human care will experience higher levels of discretionary effort and success, which will greatly improve their welfare.

References

Chance, P. (2009). Learning and Behavior Active Learning Edition. Belmont, CA: Wadsworth, Cengage Learning.

Daniels, A.C., & Bailey, J.S. (2014). Performance Management: Changing Behavior that Drives Organizational Effectiveness. Atlanta, GA: Aubrey Daniels International Inc.

MacDuff, G. S., Krantz, P. J., & McClannahan, L. E. (2001). Prompts and prompt-fading strategies for people with autism. In C. Maurice, G. Green, & R. M. Foxx (Eds.), Making a difference: Behavioral intervention for autism (37- 50). Austin, TX: PRO-ED.

Mace, F. C., Hock, M. L., Lalli, J. S., West, B. J., Belfiore, P., Pinter, E., & Brown, D. K. (1988). Behavioral momentum in the treatment of non-compliance. *Journal of Applied Behavior Analysis,* 21, 123–141.

Miyashita, Y., Nakajima, S, & Imada, H. (2000). Differential outcome effect in the horse. *Journal of Experimental analysis of Behavior*, 74, 245-253.

LoveThatRebecca. (2015, August 7). Pella Shades, national TV campaign 2015: DENIED DOG [Video File]. Retrieved from https://www.youtube.com/watch?v=YfFliWRqbO0

Pierce, W.D. & Cheney C.D. (2013). Behavior Analysis and Learning. New York, NY: Psychology Press.

Powers, R., Cheney, C.D., & Agostino, N.R. (1970). Errorless training of a visual discrimination in preschool children. The Psychological Record, 20, 45-50.

Rosales-Ruiz, J. (2007). Teaching dogs the clicker way. Retrieved from http://stalecheerios.com/blog/wp-content/uploads/2011/07/Teaching-Dogs-the-Clicker-Way-JRR.pdf

Urban Dictionary. (2016, April 8). Retrieved from https://en.wikipedia.org/wiki/Urban_Dictionary

Terrace, H.S. (1963). Discrimination errors with and without “errors.” Journal of the Experimental Analysis of Behavior, 6, 1-27.

Thorndike, E.L., (1898). Animal Intelligence. Psychological Review Monographs, 2(8). Retrieved from https://archive.org/stream/animalintelligen00thoruoft/animalintelligen00thoruoft_djvu.txt

Trial and Error. (2004). In urbandictionary.com. Retrieved from http://www.urbandictionary.com/define.php?term=trial+and+error