Journal of Applied Companion Animal Behavior

JACAB

Official Journal of the Association of Animal Behavior Professionals
www.associationofanimalbehaviorprofessionals.com

Volume 2, Number 1. 2008

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Vol. 2, No. 1. 2008

The Journal of Applied Companion Animal Behavior (JACAB) is a bi-annual peer-reviewed journal of essays of interest to professional companion animal trainers and behavior consultants. JACAB publishes essays of all kinds, including review of topics, original research papers, short communications, critical reviews, persuasive essays, theoretical works, technical articles and commentary.

The Association of Animal Behavior Professionals (AABP) was founded to promote professionalism and dedication to nonaversive methods among behaviorally oriented companion animal trainers and behavior consultants. The AABP seeks to establish a community of members aspiring to and sustaining a high standard of ethics and professionalism.

Target Audience: Professional companion animal trainers and behavior consultants.

Ethical Treatment of Animals in Research

This is the stance of The Journal of Applied Companion Animal Behavior on the use of animals in research.

Animals should not be harmed in the study of their behavior. The Journal of Applied Companion Animal Behavior recognizes a higher standard of ethical responsibility to the rights of animals under scientific investigation than is common at present. Full informed consent should also be secured from guardians of any animal used in any study. With regards to harm, broadly speaking, an animal is harmed if he is caused distress or physical harm. All reasonable precautions are to be taken to prevent the causing of harm to any animals. The Journal of Applied Companion Animal Behavior will not publish essays based on research carried out by the authors or those under their direction that caused harm to the subjects.

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Editor's Introduction

Welcome to the second issue of the Journal of Applied Companion Animal Behavior (JACAB). In this issue we have tried to include essays on species other than dogs in order to broaden the scope of the journal.

You may have noticed in the first issue that we included one article (my article on the notion of social dominance) that was particularly lengthy and an extensive treatment of its topic. We plan for this to be a regular occurrence, with an article in, hopefully, each issue that is longer and more in-depth than is common, even in most peer-reviewed academic journals. Our mission is to provide information that will be of interest, not to the average dog guardian, but rather for the serious professional seeking more reliable and in-depth information than can commonly be found. And so, in each issue we will try to include at least one essay that is even more extensive than our already rather extensive essays. In this issue, Christina Bond's article on the neurology of learning will be extensive.

In this issue I wrote what will likely be a controversial essay. Negative reinforcement based procedures are becoming popular, and there has developed what seems like a polarized group of proponents and critics and the dialogue has often been dogmatic on both sides. I approached the topic with truth as my sole criterion and not a determination to defend a predetermined conclusion (in fact, I made significant changes to my conclusion as I developed the essay). Although I was willing to come to actual conclusions, I tried very hard to keep it as objective as possible. Of course, many people will disagree with my findings but I hope they will reply with a dedication to objectivity. Furthermore, please note that I addressed only the topic and no proprietary procedures or individual proponents or critics. This is about the topic and not about the proponents or critics, and I hope critics of my article will respond in kind.

This will be a lively issue. I hope you find this and following issues useful.

On another note, this is an exciting time for the IIACAB. We recently polled members to determine what course they would prefer IIACAB to take. The results are below.

- Do nothing and leave it the way it is, 2 votes, 5.26%
- Move it toward more of an add-on coalition or co-op but not too much like a primary professional association, 13 votes, 34.21%
- Move it toward more of a primary professional association, 23 votes, 60.53%
- I don't care about this at all, 0 votes, 0.00%

Consequently, we are shifting toward a niche professional association model. We will be putting together an advisory board, a set of professional practice guidelines, stringent endorsement/certification criteria, and the focus will be on not only competence but also a *strong* dedication to animal-friendly methods. The IIACAB is now the AABP.

James O'Heare

Managing Editor, JACAB

The Challenge of Loose-Leash Walking: Strategies and Techniques

Caroline Spark, PhD, CDBC, CPDT

Spark, C. (2008). The challenge of loose-leash walking: Strategies and techniques. *Journal of Applied Companion Animal Behavior, 2(1)*, 7–11.

Walking on a loose leash is one of the harder things to teach people to teach their dogs. It seems to fly in the face of the basic human and canine instincts that are called into play as soon as a leash is clipped on and a door opened to the outside world. Dog pulls forward; human pulls back. Everything about loose-leash walking makes it a potential source of mutual frustration for human–canine walking partners. So it is not surprising that various methods of addressing its particular challenges have been developed.

In this article, I consider briefly why loose-leash walking can be so challenging, and then describe some methods that I have found effective in training my own dogs and helping other people to train theirs. I also look at ways of tackling common difficulties that dogs have in learning this behavior, and consider how pent-up energy and poor impulse control can factor into the mix. Finally, I note solutions for a few technical and attitudinal problems that handlers often experience, and emphasize the importance of a flexible, open-minded and supportive approach in working with determined pullers at either end of the leash.

From the Dog's Point of View

Maintaining a walking pace alongside a person appears to be quite beyond the comprehension of an untrained dog. Why walk slowly and in a straight line when the canine body yearns to move free and at its own pace, following a zigzagging abundance of sensory delight? To a dog, the experience of the leash is just one of many sensory experiences. Compared with the world that the dog accesses through his senses, the human at the other end of the leash is basically irrelevant—unless the dog learns otherwise.

When a dog pulls on leash, it is likely that one or more of the following holds true: he doesn't know what is required of him; he is physically or emotionally unable to perform the task (because he is too excited or frustrated, for example); he is confused about what is expected; he is not ready to perform at the level asked of him; or he finds something else more rewarding.

In addition, a tight leash does not communicate to an untrained dog that he is walking too fast. On the contrary, it may excite him (by association with something exciting that he smells or sees ahead), and make him pull harder. It can also be an effective way for the dog to ascertain, without actually looking, the whereabouts of his walking partner. When the leash is tight, the handler can't be far away.

Teaching the Basics

What the leash means to a dog, and how well he responds to it while walking, is all a matter of education. Dogs need to be taught, and taught well, how to walk on a loose leash. Otherwise they will teach themselves to pull, aided and abetted by the human at the other end of the leash.

Dog training professionals teach loose-leash walking every day of the week, and are always trying to come up with better ways of doing so. In my experience, methods that are underpinned by an understanding of learning principles and canine physiological responses (particularly the oppositional reflex) are particularly effective (Ailsby, 2000; Ganley, 2006; Parsons, 2005; Rugaas, 2005; Tillman, 2000). The following instructions (drawn largely from Ailsby, 2000) provide an example of one such approach.

1. Begin in a quiet, spacious part of the house. Choose a time when you are calm and focused, and the dog is hungry (motivated by food rewards) and well exercised (able to focus). Have plenty of small, delicious treats, and a clicker or verbal marker, at the ready.

A note on equipment: For this exercise, the dog should be wearing a flat buckle collar and 6-foot leash. Front clip harnesses (particularly for dogs with trachea damage) are useful alternatives. Retractable leashes are not suitable, since they reinforce pulling by remaining taut all the time. The dog learns to associate going where he wants to go with the feeling of a taut leash (Miller, 2004). Pinch and prong collars are not compatible with this method of teaching loose-leash walking, and may cause pain or discomfort that makes a pulling problem worse.

2. Wrap the leash around your hands and keep your hands at your belt buckle. Remember the basic rule of loose-leash walking: *Loose leash → go forward. Tight leash → go nowhere, EVER*! Loose leash means the snap is hanging straight down from the dog's collar.

3. Walk around slowly, marking (click or "Yes!") and treating your dog for being near you and keeping the leash loose, about 50 times or more.

4. The loose leash itself is the only cue needed for the behavior. If the leash is loose, move forward with your dog. If she pulls, stop and back up.

5. Give your dog a focal point, such as a large treat, or a favorite toy. Start so far away from it that your dog doesn't show any interest in it. Walk towards the focal point, marking and treating for a loose leash. If the dog does not pull at all on the way to the focal point, give her the treat or allow her to play with the toy. If she pulls, stop and back up until you are out of the focal zone, mark and treat 10 times once the leash is loose. Then start again, walking towards the focal point.

6. Many trainers find that the loose leash itself is the only cue they need. Some use a verbal cue such as "Close," "With me," or "Let's go." If you decide to use a verbal cue, wait until your dog is walking well on a loose leash before you introduce it.

7. Practice, practice, practice! Start where it is easiest for your dog, and build up slowly, in short sessions, repeating many, many times over. Practice in different places, with increasing distraction. For example, practice in other rooms of the house, then outside in the back yard, then in front of the house, then nearby in the neighborhood, and so on, taking care not to increase the degree of difficulty too sharply by practicing where there are many distractions. Plan on taking months, not days or weeks, to perfect this—try not to be in a hurry.

8. As your dog progresses, use naturally occurring distractions of appropriate strength to help to solidify the behavior. Practice with anything stationary that your dog wants to get to: something interesting to smell, a tree, fire hydrant, a friend or family member (standing still), the dog's dinner bowl. Anything your dog wants to get to can be used as a reinforcer. It is important to mark and reinforce the loose-leash position frequently, making it worthwhile for your dog to stay near you.

Troubleshooting

It takes skill, consistency, time and patience to really establish loose-leash walking, both for the handler and for the dog. Some common difficulties can be tackled as follows (Ailsby, 2000; Ganley, 2006).

If the dog is too interested in the focal point, the handler can back up and start even further away from it. Similarly, if the dog starts yo-yoing (coming with the handler when she backs up, then going to the end of the leash when she starts walking again), more distance is needed between the handler and the focal point. If the dog pulls so hard that the handler cannot back up, it can help to lower one's center of gravity and stand more firmly, or to work in a less exciting area. If the dog is very distracted and tries to pull the handler all over the place, it may help to find one thing that really attracts the dog's attention and work towards that. It is important to manipulate the level of distraction throughout, setting the dog up for success by working up gradually through increasing levels of distraction.

Two other techniques can also be tried to good effect. Firstly, if the handler is overly goal oriented and the dog is picking up on this, practicing with an unhurried attitude of "nowhere to go, nothing to do" can be helpful. This can be done by the handler shifting his own attention off the focal point, and changing direction by walking in squares or zigzags, or putting in a few U-turns. The second technique uses the sensation of the tightened leash as a cue for the dog to reorient to the handler (Parsons, 2005). The handler marks the moment any tension is felt on the leash, and reinforces the dog's turning back to the handler (or partial approximations of this). This *aikido*-like maneuver uses the energy of the problem against itself, rather than fighting it head-on. It can be a particularly effective strategy when the handler is overly focused on stopping the pulling behavior, and is getting frustrated by a lack of progress.

Energy and Impulsivity in the Mix

Pent-up energy can factor prominently into difficulties with loose-leash walking, and may need to be addressed before even trying to teach the skill. But this can be a catch-22 situation, if walking on leash is the only form of outside exercise the dog gets. In such cases, it can be helpful to take the focus off loose-leash walking temporarily, and explore ways of tiring the dog out within the constraints of his particular circumstances. For example, driving the dog to the dog park rather than being towed there can be a good option in the early stages of teaching a wildly energetic dog how to walk on a loose leash. For dogs who cannot be safely off leash in public areas, other strategies include playing active games such as "fetch" or "hide and seek" in the house or yard; borrowing or renting a neighbor's fenced yard; and using a long drag line in an unfenced area well away from traffic, other dogs and people. In addition, the power of the "daily sniff" cannot be overemphasized in designing ways to help dogs to shed excess energy. Ways of doing this include making dogs hunt for their meals by hiding kibble or small dishes of food around the house or yard; playing "find it" games with them; or giving them "free sniff" time in an area full of interesting smells.

En route to loose-leash walking, dogs with poor impulse control also need to learn self control. Building impulse control can be achieved gradually through simple daily routines (such as having to sit or lie calmly before meals are fed or doors are opened); regular "quiet time" away from stimulation; self-control games (see, for example, Ganley, 2006, p. 80); and detailed protocols such as those recommended by Overall (2007) and McDevitt (2007).

Novice handlers sometimes get the impression that progress in loose-leash walking will occur readily if basic training steps are followed, but this is not necessarily the reality for dogs with energy and impulse-control issues. The process can take months or even years, depending on the dog's age and history. In such cases, having realistic expectations about how long it can actually take to establish loose-leash walking as a reliable behavior can help the handlers pace the training process and stay the course.

At the Human End of the Leash

It is just as easy for handlers as for dogs to pull on the leash, both deliberately and inadvertently. Handlers may need to become more aware of their own tendency to pull on leash, in their attempts to keep control or as an expression of stress or anxiety. Once the leash position has been grasped, it can be helpful to provide a visual reminder for forgetful moments by tying a ribbon to the leash, so that it touches the floor when the leash is loose. If the ribbon loses contact with the floor, the handler stops and backs up. Using a video camera to review progress, or inviting a training partner with a clicker to mark correct leash positions, can also be helpful.

Another common problem for handlers is their reluctance to maintain a sufficiently high rate of reinforcement. An effective way of addressing this is to practice loose-leash walking beside a line of objects spaced closely together

(12–18 inches), marking and reinforcing at each object. As the handler gets good at this, she is in turn rewarded by clear improvement in the dog's interest in staying close and looking to her: a win–win situation all round.

Finally, the mindset of the handler can be a significant obstacle to teaching loose-leash walking effectively. It takes time, hard work and patience to establish the behavior. For novice handlers in particular, it can be easy to become frustrated or disheartened and give up prematurely. Unrealistic expectations are a major source of frustration, so realistic goal setting is important here. People have different degrees of skill and experience in teaching the desired behavior. Individual dogs learn at different rates. Puppies learn quickly, but take time to mature and are distracted easily. Adult dogs may learn more slowly, depending on previous training experience and whether they have additional problems, such as a lack of relationship with the handler, poor impulse control, or on-leash reactivity. For these dogs, loose-leash walking may take two or three years of consistent effort to establish reliably—and, for some, may not be a realistic proposition at all.

Practical support and encouragement may be needed while training loose-leash walking. Tracking progress, noting achievements and not allowing them to be eclipsed by what has yet to be accomplished are all important. Keeping a progress log can be useful here. Training with a friend can serve the same purpose, as it is often easier for someone on the outside to see the progress being made. While training, working in short sessions and avoiding training when tired or stressed are important. Self-calming techniques, such as diaphragmatic breathing, positive visualization and singing or humming while walking, can be useful too, and taking a complete break from training for a few days is always an option if tension or boredom is starting to mount. Keeping the mind as loose as the leash goes a long way towards solving problems that might crop up.

Conclusion

Although it is one of the more demanding training tasks, teaching loose-leash walking is well worth the time and effort involved. Making the goal of each individual session humble and realistic, experimenting with the strategies and learning aids described here and celebrating achievements all contribute to making steady progress at both ends of the leash. Handler and dog can walk out together as partners, not adversaries, and, as a consequence, their world is a bigger and more enjoyable place.

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The Facts About Punishment

S.G. Friedman, PhD, Utah, and Bobbi Brinker, Ohio

Published in Original Flying Machine, Issue 4: Jan/Feb 2001

Friedman, S. G., & Brinker, B. (2008). The facts about punishment. *Journal of Applied Companion Animal Behavior, 2(1)*, 12–15.

Nowadays, the issue of punishment has become an emotional minefield of misconceptions, good intentions, and general confusion. And this is the good news. We would be loath to return to a time when the use of punishment was unquestioned and was the most common, if not sole, strategy for changing undesirable behavior. A large part of the present confusion results from the perennial gap between research and practice. However, the negative effects of some forms of punishment have been studied scientifically and are well documented. These studies reveal compelling information about the detriments of punishment that no parrot guardian should be without.

Another problem is that punishment is what most of us do best ... or at least first. It is our teaching legacy passed down from generation to generation. We are virtually surrounded by punishing strategies used to influence our behavior: From overdue library books to dogs without licenses; fines, penalties and reprimands whirl around us like leaves in a storm. For many of us, to give up punishment as our primary tool with which to influence negative behavior is to leave us empty handed. With this article, we hope to narrow the gap between the research and practice of punishment as it applies to companion parrots and provide the relevant information you need to base your choice of teaching strategies on facts rather than cultural inheritance.

A Functional Definition

It is often repeated that parrots don't respond to punishment. This misconception results from using the term too loosely in ways that describe the upset emotional state of the person delivering the punishment rather than its result on the bird's behavior. It is true that parrots do not respond to rage, retribution or retaliation. Although these negative consequences may be punishing to some of us, our pets will not understand such complex interpersonal humanisms. A clear, functional definition of punishment is needed to correct common misconceptions and enable us to measure the efficacy of our teaching strategies. From this perspective, science provides a more useful definition than Webster does: Simply and precisely, punishment is a consequence delivered after a behavior that serves to reduce the frequency or intensity with which the behavior is exhibited.

There are two very important points to make about this definition: First, the effectiveness of any particular punishment is a highly individual matter. The proof of effectiveness is in the resulting behavior. A consequence that is punishing to one individual (i.e., that reduces a behavior) may actually be reinforcing (i.e., maintains or increases a behavior) to a different individual. Therefore, we can make an informed guess about what may be an effective punishment, but we can't know for sure until we see what happens to the frequency of the behavior it follows. Shouting at a screaming bird is a good example of a consequence that is *intended* to be a punishment, but, as evidenced by the increased screaming of many birds, it is often a very effective reward.

This brings us to the second point needing clarification: Punishment is not one single strategy but a collection of strategies that exist on a continuum from very mild to highly aversive approaches. Given our definition of punishment as a behavior-reducing technique, it is important to understand the nature of this continuum because there are some strategies on the very mild end that can be conditionally recommended with certain birds or for certain behaviors.

Strategies for Reducing Behavior

One mild form of punishment is to *withdraw or remove something desirable*, such as our hand or shoulder for perching. Many people have successfully reduced their birds' "beaky" behavior with this strategy, including watchband nibbling, earring snatching and shirt button cracking. Each and every time the bird engages in such behaviors, immediately but calmly and gently set him down for just a few seconds, then cheerfully offer him another opportunity to perch on your hand. With just a few repeated trials, most birds make the connection between the offensive behavior and being set down and they choose to stay put on your terms. No anger, frustration or rough handling is needed; only immediacy, removal, and a subsequent opportunity to do it right.

Removing a bird from your hand for beaky behavior is also a good example of how the effectiveness of a particular strategy varies from individual to individual. Some birds do not want to be handled. For them, the consequence of being set down would be reinforcing as evidenced by their continued or increased beaky behaviors.

Another example of mild punishment is to *ignore* a particular behavior, meaning to *withhold attention for a behavior that has been previously given attention*. Ignoring is not as easy as it sounds, but it is very effective when matched to the appropriate behavior and executed well. Here's the critical scientific fact about ignoring that you need to know: The first reaction most birds have to being ignored is to *increase* the frequency or intensity of the negative behavior. If your nerves wear thin and you stop ignoring during this predictable but temporary burst of behavior, you will reinforce it at this new higher frequency or intensity! Alternatively, if you maintain stalwart ignoring and do not waiver, the behavior will eventually decrease.

Ignoring problem behavior is only effective for those behaviors that are being maintained because of our attention and for those behaviors that can be *completely and totally* ignored. Some behaviors cannot or should not be ignored. Biting is a case in point. Although it is often recommended that to reduce biting, one should simply buck up and ignore it, this is not a practical strategy. Minimizing one's reaction is certainly a good idea but it is darn near impossible to maintain the composure of a stone while being pinched with the vice-like beak of the average parrot. Also, it is likely that many birds find the tactile sensations associated with biting inherently reinforcing, quite aside from our reactions. Indeed the only reliable way to teach a parrot not to bite is to not give him the opportunity to do so in the first place. Of course, self-injurious or otherwise dangerous behaviors need to be dealt with using strategies other than ignoring, as well.

When using mild punishment, ensure that the ratio of positive interactions to negative interaction is high. In an environment rich with praise and attention, mild methods to reduce behavior such as ignoring can be effective without apparent negative side effects. Nonetheless, not all of us are good ignorers or can ignore all types of behavior. And, some people find it too difficult to use the removal/withdrawal strategy with absolute consistency. Know your personal limitations and choose your teaching strategies to ensure success.

At the other end of the punishment continuum is the *presentation or delivery of aversive consequences*. Unfortunately, the list of examples of this form of punishment is long and too familiar. Aversive punishment includes consequences such as shaking your hand to unseat a bird's balance, squirting water at a bird from a spray bottle, throwing things at a bird or his cage, dropping a bird on the floor, shutting a bird in a closet, covering a bird for extended periods during non-sleep time, knocking a bird off his perch, forcing a bird to rapidly and repeatedly step from one hand to another, blowing in a bird's face, shouting, hitting, and plucking out feathers.

Some people argue for the use of aversive punishment on the basis of its effectiveness; however, serious problems are likely to arise from the use of aversive strategies even in cases of short-term or narrowly defined success. For reasons explained below, *no* form of punishment that includes the presentation of aversive consequences should be used with companion parrots at anytime ... ever. It is not only unnecessary but also harmful. If you apply only one fact about punishment to teaching your parrot, let this be the one.

Problems with Mild Punishment

The use of even mild forms of punishment warrants careful deliberation and thoughtful planning. First, you should consider the *nature* of the behavior you hope to teach your bird to exhibit less often. It is not reasonable to try to eliminate natural behaviors such as the infamous cockatoo dawn greeting ceremony, those frustrating food-tossing marathon events or the hungry shark transformation that otherwise sweet birds exhibit when you dare to put your hand in their cages. With a little creativity, the responsibility for accommodating frustrating or annoying natural behaviors rests quite comfortably on human shoulders. Perhaps you can take your shower while your bird welcomes the day; special cups and cage aprons go a long way to reduce the mess caused by natural food-tossing behavior; and feathered sharks can be peaceably removed from their cages on perching sticks and returned to their feathered angel states once they are outside of their cages.

Second, carefully consider the probable *cause* of the problem behavior: Very often, the behavior driving you crazy is a legitimate expression of unmet needs. When this happens, the appropriate strategy is to meet the bird's needs rather than treating the communication as a problem behavior. For example, birds do not typically scream incessantly when they are well nourished, appropriately housed, provided ample time out of their cages, engaged in independent play, and offered daily, focused time with family members.

Finally, consider *how to change* the behavior. If there is a positive alternative strategy to even mild punishment (and in our experience there most often is), use it. Positive teaching strategies have all sorts of positive spin-offs and none of the detriments of punishment. Positives spin-offs for your bird include the opportunity to learn to do something more not less, to learn new behaviors rather than unlearn old ones, to live in an environment saturated with praise, and to increase confidence that only good things happen in the presence of humans—a requisite for trust. There are many highly effective alternatives to punishment. Teaching acceptable replacement behaviors or teaching behaviors that are incompatible with the negative behavior are two examples well worth learning about.

In short, we suggest that you answer the following three questions before using mild punishment with your parrot: 1. Is it unreasonable or inappropriate to expect a bird to stop behaving in this way? 2. Is the negative behavior a result of an unmet need? 3. Is there a positive teaching strategy that can be used instead of punishment? If the answer to any of these questions is yes, look for ways to change your expectations, meet your bird's needs, and/or use a positive teaching strategy to help you and your bird become the best possible companions for the long-run.

Unacceptable Side Effects of Aversive Punishment

Research on the effects of aversive punishment is not new nor has it been narrowly investigated. On the contrary, this research spans many decades and has been replicated with many different species of animals, including humans. Although there is some variability in the way researchers describe their results, the fact is there is a pattern of negative reactions or "side effects" that are consistently observed in many subjects who have been punished with aversive consequences.

The first predictable side effect is *a sustained effort to escape the punishing situation*. If escape is blocked, as with our caged and clipped companion parrots, the animal may 1. withdraw from further interaction, 2. suppress responding, 3. escalate or counter aggression, and/or 4. over-generalize fear, often to the point of phobia.

For most of us, these side effects are painful to read about, no less observe, in our beloved parrots. Sadly, many of us have known or heard about birds that have withdrawn by refusing opportunities to come out of their cages. These poor souls cower dismally in the corners of their cages for hours on end. Other birds may suppress responding to the most basic activities. They can refuse to step up or even stop eating. It is not unheard of for birds to attack their owners or become fearful of people and things that never caused them any direct harm.

Based on these scientific facts, there is no justification for using aversive punishment with our birds. There are no long-term benefits, and the costs are grave. Ironically, it is the *short*-term effect of punishment that keeps so many of us using it. Every time an animal responds to punishment by doing something less often, the person who delivered the punishment is rewarded. For example, if your parrot stops chewing the windowsill when you throw a shoe at him, chances are you will throw shoes more often. This presents a significant obstacle to reducing our use of punishment to influence behavior and is worthy of introspection.

The Commitment to Change

Whatever we call ourselves in reference to our parrots, be it pet owner, caretaker, parent or guardian, we are all teachers in the most fundamental sense. Each and every moment spent with our birds is a moment that teaches them something about living with humans. In the perpetual role of teacher, we should borrow the physicians' guiding principle: First do no harm. We have learned from years of empirical study over hundreds of scientific experiments that in fact *aversive punishment does do harm*. We have also learned that even mild forms of punishment should be used cautiously and knowledgeably.

The individual nature, age, species and history of any particular bird add another level of complexity to choosing the best practices for our parrots. Some birds, those that are confident, bold and trusting, can be resilient to some punishment techniques. In other words, we may well get away with lesser teaching strategies with some birds under some conditions that would be detrimental to others. However, experience has shown that very young birds, re-homed birds, and birds with existing medical and/or behavioral problems are especially vulnerable to the adverse responses associated with punishment.

There will always be many unknowns about behavior; there will always be important variables that are out of our control. Behavior is just too complex for simplistic cookbook approaches to mentoring our birds where we look up problem behaviors in a table of contents and follow behavioral recipes. Each situation is unique and requires careful analysis and informed consideration. Facilitating well-adjusted, independent, confident companion parrots through the use of positive teaching techniques is more than just a commitment to learning new strategies; it is also a commitment to changing our legacy. The time for such change is now.

Anthropomorphism: How it Affects the Human–Canine Bond

Sarah Elizabeth Boni

Companion Animal Sciences Institute

va_siegers@hotmail.com

Boni, S. E. (2008). Anthropomorphism: How it affects the human–canine bond. *Journal of Applied Companion Animal Behavior, 2(1)*, 16–21.

The human–animal bond is defined as "a mutually beneficial and dynamic relationship between people and other animals that is influenced by behaviors that are essential to the health and well-being of both" (American Veterinary Medical Association, 2001). This definition perhaps illustrates an ideal that some may say has yet to be achieved. While the symbiotic relationship between man and dog is often described as one of mutualism, a relationship in which both species benefit from the interaction, one could argue that the relationship is closer to amensalism, where one species hurts the other unknowingly. Coppinger and Coppinger (2001) have used the example of pure-bred dogs in describing the amensalistic relationship, stating that they live in genetically inbred populations that will eventually destroy them. Some would even go so far as to call the relationship parasitic, where one species (canines) benefits at the expense of the other. It appears that there is no single term capable of encompassing the entire human–canine relationship. As every relationship is unique, so it should be uniquely defined. However we choose to define it, our relationship with the canine species is largely due to our anthropomorphic views of them.

Anthropomorphism is defined as the "attribution of human mental states (thoughts, feelings, motivations and beliefs) to nonhuman animals" (Serpell, 2002). According to Mithen (1996), the roots of anthropomorphic thinking are found in early *Homo sapiens*. The ability to understand and anticipate the behavior of others by using self knowledge, known as "reflective consciousness" (Humphrey, 1983), evolved due to its enormous survival value in allowing people to become better hunters. Mithen also states that without anthropomorphism the domestication of animals would never have been possible. In order to capture and domesticate an animal, humans would have needed to anticipate the actions of that animal, which would have required an understanding of how they think. Anthropomorphic thinking allowed humans to incorporate dogs into their social milieu. Without the beliefs that our dogs "enjoy" our company, "miss" us when we are gone or feel affectionate towards us, our relationship with dogs would lose much of its value, becoming superficial and essentially meaningless.

Over time, the role of the domestic dog has changed considerably. Whereas dogs once functioned as working animals (guarding, shepherding, hunting etc.), the primary function of many dogs today is in a more general capacity: that of companion. A 1996 survey conducted by the American Animal Hospital Association (AAHA) found that 75% of pet owners considered their animals akin to children (AAHA, 1996). Dogs have been moulded by humans physiologically, morphologically and behaviorally to fill the unique role of providing a nonhuman source of social support (Serpell, 2002). Anthropomorphic thinking allows our companions' behavior to be viewed in human terms. And from this way of thinking humans have benefited greatly.

Much research has been devoted to the various ways in which companion animals can improve human quality of life. Studies have shown the owners of companion animals to have lower blood pressure (Baun, Bergstrom, Langston, & Thoma, 1984; Friedmann, 1979; Vormbrock & Grossberg, 1988), increased rate of survival after a heart attack (Friedmann, 1995; Friedmann, Katcher, Lynch, & Thomas, 1980; Friedmann, Thomas, & Eddy, 2000), and lower susceptibility to stress (Allen, Blascovich, Tomaka, & Kelsey, 1991; Serpell, 1991). Having animals present in therapy has been shown to increase attendance rates (Beck, Seraydarian, & Hunter, 1986) and increase the sociability of hospitalized patients (Corson, Corson, Gwynne, & Arnold, 1977). Animal-assisted therapy has been used with survivors of sexual abuse (Lefkowitz, Paharial, Prout, Debiak, & Bleiberg, 2005) and to help patients to relax and feel safe in treatment (Kruger, Trachtenberg, & Serpell, 2004). Animals have also been shown to increase general psychological wellbeing, by making people with animals appear more approachable (Sachs-Ericsson, Hansen, & Fitzgerald, 2002) and encouraging social relationships (Serpell, 2000).

Although the benefits to humans are undeniable, little research appears to have been conducted on how these anthropomorphic relationships impact on our animals; in fact, anthropomorphic selection (selection in favour of physical and behavioral traits that facilitate the attribution of human mental states to nonhumans) may be responsible for many of the welfare problems afflicting our companions (Serpell, 2002). Breeding for traits that appeal to our emotional perceptions has led to companion dogs suffering some debilitating consequences. The English bulldog is one of the most extreme examples. Thompson (1996) described the English bulldog as resembling a "veterinary rehabilitation project." Due to a congenital defect known as chondrodystrophy, or abnormal cartilage development, the English bulldog suffers from numerous health conditions, including heart failure due to chronic oxygen deprivation (Panckeri, Schotland, Pack, & Hendricks, 1996). As a result of producing the cosmetic appearance of a "pushed in" face, we have compromised the breathing of brachycephalic breeds such as pugs, Boston terriers, Pekingese and boxers, which suffer from various respiratory disorders. These breeds are more susceptible to heat stress as a result of respiratory obstructions, and can suffer from multiple eye problems due to their shallow eye sockets. They also have an increased risk of periodontal disease due to overcrowding of the teeth. Merle is a dilution gene that lightens patches of coat over a dog's body and is found commonly in Great Danes, Australian shepherds, collies and various other breeds. Dogs with merle coats or coats containing excessive amounts of white run an increased risk of being born blind and/or deaf. Yet these dogs continue to be bred for the very characteristics that disable them.

Tail docking, ear cropping and dew-claw removal originated as means to prevent injury to dogs. While hunting or working, these appendages were at risk of being snagged and torn. Nowadays these procedures are considered elective surgeries and, as of 2003, the AAHA opposes them when performed for cosmetic reasons. Not only are they of no benefit to the animal but they can result in impairment. Dogs rely heavily on postural communication, and those without tails or with unnaturally positioned ears have a reduced ability to communicate effectively. Despite these factors, docked tails and cropped ears are still required in the conformation ring. Tail docking is performed when the pup is between 3 and 5 days of age (British Veterinary Association, 2006). At this young age, it is impossible for the breeder to know which pups are of show quality and which are not (S. Eviston, personal communication, January 3, 2008). Therefore, this painful cosmetic act is performed on all pups regardless of their future purpose. Advances are, however, being made; docking and cropping have been banned in a number of European countries.

With regard to behavior, the role of anthropomorphic attitudes becomes less clearly defined. Although there is currently no proven link between behavioral problems in dogs and anthropomorphic treatment by the owner (Voith, Wright, & Danneman, 1992), there is little doubt that anthropomorphic views of canine behavior and learning can complicate and delay resolution of existing behavioral issues. According to Serpell (2002), the second most common behavior problem seen by animal behaviorists is separation distress. Dogs have been bred for centuries to increasingly depend on humans, resulting in dogs that become extremely distressed when left alone. The results of a study by Topal, Miklosi, and Csanyi (1997) showed that dogs who were viewed anthropomorphically by their owners showed more dependent behavior and decreased performance in problem solving. The authors concluded that this decrease in performance was due not to lack of cognitive ability but to the dogs' strong attachment to humans. Dominance theory has perhaps the greatest potential to directly harm the human–canine bond. Konrad Most was influential in introducing the concept of social dominance to popular dog training. Most believed that the only means for a dog trainer to establish himself as "pack leader" was through physical confrontation between trainer and dog "in which the man is instantly victorious" (Most, 1910/1955). Besides imbuing the dog with adversarial motivations, Most's misleading interpretations not only justify but condone abusive training practices. Despite these and other problems, Most's dominance theory is still widely accepted by many authorities (Lindsay, 2001).

Although interest in companion animal behavior has increased over the past decade, it also appears that our anthropomorphic views of animals have also increased. Dogs are carted around in strollers and designer handbags; they wear rhinestone-studded collars and have more clothes than some people. Their birthdays are celebrated, and some pet stores even have gift registries. While dressing a dog in designer clothes may be in itself harmless (it could even be seen as beneficial, indicating a high level of attachment on the part of the owner), other events show a marked decrease in our awareness or consideration of canine behavior. The media is increasingly fascinated with stories of dog attacks. Whereas at one time they showed an interest in reporting events that might have explained an attack, most attacks reportedly now occur "without warning." While all canine attacks are tragic, they are also a learning opportunity; to ignore the potential insight that could be gained from studying the circumstances surrounding these attacks is a double injury to both dog and victim. A recent study found that 53.2% of owners relinquishing their dogs for euthanasia and 51.3% of owners relinquishing their dogs for adoption agreed that dogs misbehave to spite their owners (Kass, New, Scarlett, & Salman, 2001). Such anthropomorphic views with regard to problem behavior contribute to unrealistic expectations and inappropriate actions taken to correct those problems. A similar study found that the top reason for relinquishing a dog to a shelter was behavioral problems. Of those problems, 72% were aggression directed towards humans and/or other animals (Salman et al., 2000). The study also found the population surveyed to possess very poor knowledge about the animals they owned.

The demands placed on companion dogs are enormous. Modern dog owners demand that canine companionship be achieved within the often inflexible framework of their lifestyle. In a survey of dog owners who relinquished dogs to a shelter, the top reasons for relinquishment other than behavioral were owner lifestyle, owner unprepared or had inappropriate expectations, and animal characteristics (shedding of hair, wrong sex, wrong size etc.) (New et al., 2000). Companion animal groups are lobbying for their dogs to have more access to public places where dogs are not usually permitted. A group in Ottawa, Canada, recently began a campaign to allow dogs on public transport (National Capital Coalition for People and Dogs, 2007). Harmless as this may seem, questions arise about whether the stress to dogs of riding on a bus and the possible consequences to canines and humans have even been taken into consideration; the principal argument is that, since other major cities allow dogs on public transport, why should Ottawa be any different?

In her book *The Culture Clash* (1996), Jean Donaldson states that the "anthropomorphic view has outlived its usefulness" and that the greatest gains for animal welfare are to be found in understanding behavior and learning theory. This is perhaps a simplistic point, given that there is little incentive for people keeping animals as companions to educate themselves in this manner. Donaldson believes that we can continue to love our dogs and still see them for what they are; even if we abandon our anthropomorphic views, there remains plenty about our companions to continue to fascinate and intrigue us. As humans, our compassion and empathy for others are strongly linked to our ability to perceive them as similar to us. When we take away from dogs insight and consciousness, we strip them of their human status. Still, our society is learning to be increasingly tolerant. We are opening our eyes and viewing cultures and people that are foreign to us with more acceptance and even respect, different though they are. It is possible then to believe that we can love and cherish our four-legged companions for the amoral, fur-bearing creatures that they are.

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A Comparison of Common Treatments for Coprophagy in *Canis familiaris*

Broox Boze

Department of Biology
Colorado State University

Bboze@colostate.edu

Boze, B. (2008). A comparison of common treatments for coprophagy in *Canis familiaris*. *Journal of Applied Companion Animal Behavior, 2(1)*, 22–28.

Abstract

Coprophagy is a common and undesirable behavior among domestic canines. Data from this study show that 49% of domestic dogs have attempted to eat feces at some point in time and that 28% of dogs are currently coprophagic. Many dog owners are disgusted by this behavior and will go to great lengths to find a treatment for it. Some alter each fecal deposit with hot sauce or other aversive substances, while others try simpler methods such as medication or punishment. Research on coprophagy in canines is sparse, and little is known about treatment efficacy, making coprophagy hard to prevent. In rare cases, medical disorders and intestinal parasites are believed to cause malnourishment, forcing dogs to look for nutrients in abnormal sources. These medical etiologies should be ruled out before owners actively prevent coprophagic behavior.

This study used a survey-based design to compare 11 methods for preventing coprophagy. Data showed that the most effective treatments for coprophagy require an active owner–dog relationship. Preventing access to the feces by keeping the dog on a lead, rewarding positive post-elimination behavior and distracting the dog from the feces were the most effective treatments studied. The medications Deter® and Forbid® were moderately effective, with success rates being much higher in younger dogs. The least effective treatment studied was actively ignoring the behavior in the hope that it would go away. The owner of a coprophagic dog must take an active role in preventing coprophagy and be aware of the dog and its surroundings.

Introduction

The word "coprophagy" comes from the Greek roots *copros* (feces) and *phagein* (eating). While necessary for some species' survival in the wild, domestic canines exhibit coprophagy primarily in captivity, indicating that something could be internally or externally amiss. Canines known to engage in coprophagy include wolves (*Canis lupis*), coyotes *(C. latrans*) and pet dogs (*C. familiaris*).

Feces eating can be divided into two main categories: caecotrophy, where animals ingest specific feces types (soft or hard pellets from lagomorphs and rodents who possess a separating mechanism in their digestive tract), and coprophagy, a more general consumption of feces from animals with only one type of feces. Although coprophagy describes consumption of all fecal types, it may be further divided into autocoprophagy, in which the animal eats its own feces, and allocoprophagy, which is consumption of excrement from a conspecific (Galef, 1979). For the purposes of simplicity, this research refers to consumption of all feces types, including those of other species, as coprophagy.

Despite its being an undesirable behavior, there are situations in which coprophagy is natural and even necessary for canines (Beaver, 1994; Wells & Hepper, 2000). Bitches consume pups' feces to keep the nest clean and undetectable by predators (Houpt, 1982). Coyotes (*C. latrans*) ingest other coyotes' feces and then replace them with their own to mark their territory (Livingston, Gipson, Ballard, Sanchez, & Krausman, 2005). Since ungulate digestive systems are only 50–60% efficient, organic matter in their excrement is considered a valuable source of food and nutrition (McDonald, Edwards, & Greenhalgh, 1973), with antioxidant and immunostimulant properties (Houpt, 1982; Negro et al., 2005). Although consumption of ungulate feces is considered natural for canines, the dense matter comprising such feces can trigger medical complications and prevent normal stomach function (Widdowson, 1994).

Coprophagy outside of these conditions, in otherwise normal adult canines, is not instinctive but may be sustained by influences like anxiety, boredom or stress, or nutritional or psychological deficiencies. Animals may seek to balance a nutritional or pancreatic enzyme deficiency (Hart & Hart, 1985). The attention canines receive as punishment for eating feces may inadvertently reinforce the behavior through operant conditioning (Wells, 2003). Minimal research supports these hypotheses, and veterinarians lack the resources to advise concerned clients. Some owners, so disgusted by the behavior that the bond between human and canine is irreversibly damaged, consider euthanasia when conventional treatments are ineffective (McKeown, Luescher, & Machum, 1988).

An animal eating the feces of other species or individuals increases the probability of disease transmission. Parasites transmitted through fecal matter include giardiasis, whipworms, hookworms, roundworms and salmonellosis. Although veterinarians express little concern about coprophagy as a health issue or vector of disease transmission (McKeown et al., 1988), most owners want to stop the behavior.

This study evaluates 11 common treatments for inhibition of coprophagy in domestic dogs. These include three medicines, taste aversion through diet change, addition of meat tenderizer as a dietary supplement, alteration of the feces with unpleasant substances such as hot sauce, prevention of access to the feces, punishment, distraction, and rewards for appropriate post-elimination behavior. Most case studies on coprophagy treatments do not look at coprophagy as a general disorder but focus on an individual. Comparing treatments in a variety of individuals allows insight into the motivational and causal mechanisms of coprophagy and provides veterinarians and pet owners with better information on the success of numerous treatments.

Materials and Methods

Participants and Distribution

In June and July 2006, 632 dog owners completed a self-administered survey about their dogs' coprophagy and their attempts to stop this behavior. Canines studied were assumed healthy based on vaccination records and assessment of several common disorders (dry heaving, chronic diarrhea or vomiting, pica, and food allergies). Ninety-seven per cent of dogs had current rabies vaccination and 95% were up to date on distemper vaccination. Eighty-five per cent of dogs in this study were spayed or neutered. A variety of full- and mixed-breed canines from 2 weeks to 21 years of age were included in the sample, with slightly more females (56%) than males (44%).

Data were collected from three sources: dog parks, a veterinary hospital and an online survey. Four hundred and sixty-six responses were received online using SurveyMonkey® software, and 166 were collected at Countryside Animal Hospital, and Pine Ridge and Fossil Creek dog parks in Fort Collins, Colorado.

The web-based electronic link to the survey was distributed through online message boards and chat programs devoted to specific breeds and general dog care. Message boards included Yahoo, Google and America Online citations, along with www.dog.com, www.forum.dog.com, and www.ILoveDogs.com.

Physical sites were visited at a variety of times on both weekdays and weekends, during daylight hours. Every individual who entered the park at a given time was asked to complete a survey, and every individual asked to participate did so to completion. Respondents were asked to complete a survey about animal behavior, with no indication that the study was about coprophagy. Respondents having more than one dog were asked to complete a separate survey for each dog. There was 100% participation, and all respondents participated without compensation. A chi-square test for categorical data showed no difference in presence of coprophagy among data collection locations ($X^2 = 3.270$, $df = 3$, $p = 0.351$), and data were pooled for analysis.

Data on frequency and intensity of coprophagy were collected. Owners also reported the types of feces consumed and demographic information on the canine's age, weight, breed, sex, environment, care and feeding schedule, and medical history. The effectiveness of treatments to stop this behavior was measured on a 5-point semantic differential scale, where applicable treatments were anchored with "very effective" and "ineffective" treatments.

Data Analysis

Since surveys were administered without prior knowledge of the canine's behavior, it was possible to estimate the frequency of coprophagy in *Canis familiaris*, which has not been done previously. The focal animal of this research is any coprophagic canine, with noncoprophagic canines serving as a control group. Since feces type and environmental stimuli may alter coprophagy, the efficacy of treatments within subgroups is also analyzed. All statistical analysis was done with SPSS for Windows (Version 11.5).

Results

Data indicate that 49.2% (311 of 632) of canines have attempted to eat feces at some point in time and that 28.5% of canines currently engage in this behavior more than once a month.

Because the type of feces consumed may affect the motivation, canines were divided into three groups: those that consume feces regardless of type, those consuming only canine feces, and those eating only herbivorous animal feces. The efficacies of common treatments for canine coprophagy in each category did not vary significantly (Figure 1).

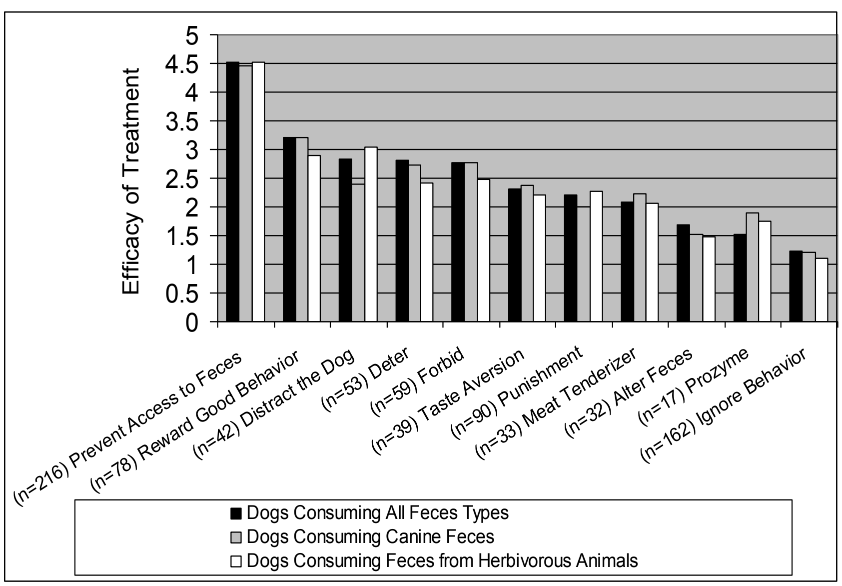

Figure 1: Comparison of treatments for coprophagy in *Canis familiaris* based on the type of feces consumed. Treatments are ranked on a scale where 1 = not effective and 5 = very effective.

Preventing access to feces was the most commonly used and most effective way of stopping the behavior (4.5 on 1–5 scale). Rewarding good behavior (mean 3.1) and distracting the canine from the feces (mean 2.7) were the next best treatments. Because the three most effective treatments involve owner interaction, it suggests that coprophagy is not motivated by a medical disorder but by the environment or situation created by the environment in which the dog lives.

This is supported by the fact that none of the medications tested were reported to be very effective. Prozyme® rated 1.7, suggesting it did not work well in most instances. Deter® and Forbid® received success ratings of 2.61 and 2.67, respectively. Success for these treatments was bimodal, with owners believing them to be either highly effective or not effective at all. There was no significant difference in weight ($p = 0.733$), exercise ($p = 0.124$), sex ($p = 0.102$), or diet-based type of food ($p = 0.894$) between these two groups of canines.

Younger canines responded better to medication than older animals (Figure 2). There was a significant difference in efficacy of both medication types when dogs were divided into two age groups: dogs 1–4 years old and those older than 4 years. In addition, there was also a difference between the ages of those responding well to Deter® (3.5 years) and those that did not (5.6 years).

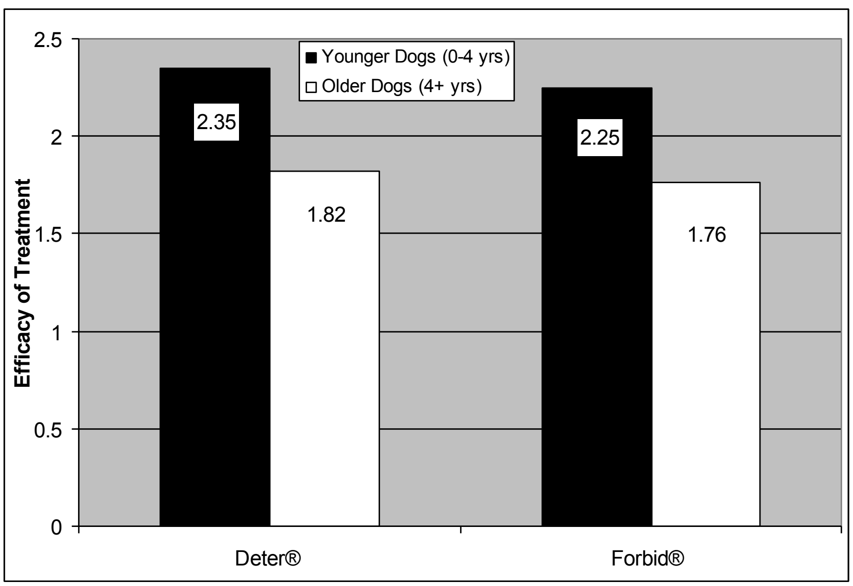

Figure 2: Comparison of age difference in canines' response to medical treatments for coprophagy. A significant difference (α = 0.10) was seen between age groups for both Deter® (p = 0.0381) and Forbid® (p = 0.0836).

Modern dog trainers use positive reinforcement over punishment in most cases (Marschark & Baenniger, 2002). Data show that rewarding good behavior (mean 3.1) is more effective than punishment (mean 2.5). Owners reporting that punishment was effective had dogs that weighed an average of 26 pounds more than those where it was not effective ($p = 0.0167$). It is not clear why weight might affect the efficacy of punishment, and no differences in the efficacy of punishment were apparent in the amount of owner interaction with the pet ($p = 0.8539$) or whether the dog was spayed or neutered ($p = 0.1791$).

While the second most common treatment for coprophagy was actively ignoring the behavior, it was found to be the least effective method (mean = 1.17) for decreasing the frequency of the behavior. Altering the feces, used by less than 5% of dog owners, was slightly less effective (mean = 1.15). Ignoring the behavior did not decrease its frequency, which indicates that coprophagy in domestic canines is not motivated by age and will not likely self extinguish. This also indicates that the behavior is not motivated purely by a canine's need for attention.

Several sources suggest that boredom could be a motivating factor for coprophagy because canines have nothing else to do. This idea is supported because toys such as rawhide and rope, which can be manipulated, entertain and enrich an animal's environment (Houpt, 1985; Loveridge, 1998). Case (2005) relates this to coprophagy and suggests that free feeding may relieve boredom and consequently reduce unwanted coprophagy. Canines were separated into five groups based on frequency of feeding. Binary regression indicates that feeding schedule is not a good predictor ($p = 0.894$) of coprophagic frequency between groups (odds ratio = 0.99; 95% confidence interval, 0.92–10.57). The presence or absence of toys such as rawhide or rope was not found to be a good predictor of coprophagy ($p = 0.35$; odds ratio = 1.17; 95% confidence interval, 0.1–1.34).

Discussion

Attempts to understand motivational factors for coprophagy found that effective treatments for one canine may not work in others and the reasons for this are multidimensional. Because canine consumption of herbivores' feces is normal, it was assumed that motivation and prevention would be different for dogs consuming certain types of feces. However, no differences in efficacy of treatments were found among the types of feces consumed.

Since the three most effective treatments (preventing access to feces, rewarding positive post-elimination behavior, and distraction) for preventing coprophagy involve owner–dog interaction, data indicate the behavior is controllable. Owners must first consult a veterinarian to determine if coprophagy is motivated by intestinal parasites or a medical disorder in their dog and then take an active role in preventing the dog's access to feces. The owner can be effective in preventing coprophagy in the majority of cases by keeping the dog on a lead when opportunity is high. Some owners opt to muzzle their unaccompanied dog when they cannot be with it.

Animal trainers support positive reinforcement versus punishment (Hiby, Rooney, & Bradshaw, 2004; Marschark & Baenniger, 2002), and our data indicate that coprophagic behavior was more likely to subside when wanted behaviors were rewarded than when unwanted behaviors were punished. Note that the interpretations of both punishment and reward were left up to the subject filling out the survey. This study did not differentiate between positive and negative punishment, so the definition of punishment could include a variety of actions including verbal commands, the removal of treats, or painful stimuli such as kicking, electric shock or even hitting the dog. Rewards could also vary and include things such as verbal praise, play or food treats.

Data indicate that youth could be important in the efficacy of medications for coprophagy. The reasons for this are not well understood. It seems unlikely that a physiological difference would exist between older and younger dogs. From personal observation, it appears that younger dogs are more likely to engage in exploratory behavior and that their behaviors may be more malleable because they have not become habit. From a behavioral perspective, younger dogs are less likely to have multiple associations with coprophagy, and the associations with it could be easier to interrupt. Another potential explanation is that older dogs engage in coprophagy for psychologically compulsive reasons rather than exploratory ones. If this is the case, we would not see the behavior being stopped by the types of medication currently in use for preventing coprophagy and designed to work through a physiological change or taste aversion. Prozyme® is composed of four highly concentrated enzymes (lipase, amylase, protease and cellulase), which aid in digestion, and help break down food so that nutrients are absorbed more effectively. Deter® and Forbid® are prescription drugs that rely on wheat gluten and monosodium glutamate for taste aversion. On the other hand, if the behavior is compulsive, then medications such as antidepressants or selective serotonin reuptake inhibitors would be more effective.

Logistic regression showed that the time the dog spends alone, interaction time with humans, and exercise were not good predictors of coprophagy in canines when these factors were tested alone. Results also indicate that boredom is not a good predictor of coprophagy. Loveridge (1998) and Houpt (1985) found that rawhide and rope toys enrich an animal's environment; if boredom were a motivating factor, coprophagy should decrease with the presence of toys. In addition, an inverse relationship between coprophagy and frequency of feeding was expected because of the human interaction. However, this was not evident.

Effective treatment may reduce or extinguish coprophagy, but a better understanding of the motivational factors involved is necessary. Further research on the behavior and environment of canines who engage in feces eating will provide understanding, and eventually prevention, of coprophagy.

Conclusions

1. Efficacy of treatments did not vary by type of feces consumed.
2. The best way to prevent coprophagy in canines is to prevent access to the feces.
3. Medical treatments for coprophagy are more effective in younger dogs.
4. Punishment is not an effective way to prevent coprophagy.
5. Coprophagy does not appear to be motivated by boredom.

Acknowledgements

I would like to thank Janice Moore, Sarah Bevins and Charles Stone for thoughtful discussion on the topic and Stacy Hines-Lambiase for her help with data collection. I couldn't have completed this project without the statistical guidance of Michael Lacy and intellect of Jennie Jamtgaard.

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Early Introduction Age and Other Factors: Precursors to Feline/Canine Friendship?

Jacqueline Munera

New College of Florida

Munera, J. (2008). Early introduction age and other factors: Precursors to feline/canine friendship? *Journal of Applied Companion Animal Behavior, 2(1)*, 29–32.

The two most popular domestic animals are ever more frequently expected to interact amicably, or at least cohabit, with unrelated conspecifics as well as other species during their daily existence. Domestic cats (*Felis catus*) have been living with humans for an estimated 4,000 to 9,500 years, most likely beginning in Cyprus as descendants from the African wild cat (*Felis libyca*) (Bradshaw, Horsfield, Allen, & Robinson, 1999; Cameron-Beaumont, Lower, & Bradshaw, 2002; Vigne, Guilaine, Debue, Haye, & Gerard, 2004). In comparison, domestic dogs emerged between 35,000 and 100,000 years ago (Savolainen, Zhang, Luo, & Leitner, 2002; Vila & Savolainen, 1997) and have been cohabitating with humans for approximately 14,000 years (Nobis, 1979, in Clutton-Brock, 1999).

Both species were most likely primarily self domesticated, at least initially, through lowered flight distances generated in response to human-generated food sources, refuse areas for dogs (Coppinger & Coppinger, 2001) and rodent populations subsisting on cultivated grains for cats (Turner & Bateson, 1988). Dogs subsequently faced selection pressure towards category and job niches opened by human social evolution, such as livestock guarding and herding, hunt assistance, and human protection. Cats, on the other hand, have faced very little active pressure in development to coexist with humans (Izawa & Doi, 1994) and, in fact, it is only recently that cats have been selectively bred in accordance with recognized breed standards.

Although cats and dogs both belong to the order Carnivora, their natural social structures are quite different, particularly in hunting and group living styles (Bradshaw & Brown, 2006; Fox, 1971). Dogs are generally known for their highly social natures and adept scavenging skills, whereas cats are, often falsely, considered asocial and prefer solitary hunting. The question then arises as to how two such very different species can so easily cohabitate in human households. The answer to this question may lie in the fact that there are actually many similarities between the species—for example, both are astute observational learners, and both use visual, olfactory, vocal and tactile methods of communication that are similar to those used by many other mammals.

Additionally, both species are able to decipher not only each other's communications, but also those of the humans they live with. In a study comparing cat and dog responses to visual pointing gestures (Miklosi, 2005), both species performed equally well on a task using the gesture to find hidden food, but there were differences in attention-getting behaviors performed by each in an attempt to get assistance from their naive humans on a second portion of the test. The dogs were much quicker than the cats to engage in attention-getting behaviors such as increased gazing and vocalizations in an attempt to receive help from their human. The cats performed fewer signaling behaviors and worked at getting the food on their own for a longer period of time, indicating a tendency towards independence consistent with a solo hunting preference. However, many cats eventually did signal to their humans for assistance, indicating the ability to adjust species tendencies in order to thrive in domestication.

Individual innate personality differences have also been well defined and recognized in both cats and dogs. For example, primary categorizations of basic personality types as supported by Feaver, Mendl, and Bateson (1986) include aggressiveness, fearfulness, sociability and curiosity, and are generally considered stable across the individual's lifetime. Some personality types, such as sociable and curious, may be more conducive to interspecies affiliation, whereas others, such as fearful and aggressive, may be less conducive. Similarly, a second study found consistent behavioral styles, defined as Staying Indoors, Boldness, Investigative and Rubbing, in feline individuals at different ages (Lowe, 2001). It is important to note the Lowe (2001) study showed a positive correlation between the handling kittens received during the first 8 weeks of life and boldness characteristics at 4 months of age, indicative of how human actions may impact on a cat's personality and therefore future affiliation with other species in the household. For example, a kitten that has received handling and socialization by humans may adapt well to an interspecies household, while a kitten receiving little or no handling and socializing may have a more difficult time adjusting.

Highly relevant in any behavioral research, specifically research that relies on behavioral interpretation by laypeople such as that gathered in owner opinion surveys, is the ability of human observers to correctly interpret the physical actions and vocalizations of a different species. Research literature is not quite clearcut on this aspect of behavioral interpretation, but in general, humans are able to comprehend overall communications from cats and dogs. For instance, it appears that humans are able to classify at least five different feline meow vocalizations according to predetermined context, but only at a moderately significant level (Nicastro & Owren, 2003). Though the results were only moderately significant, people who had more extensive prior experience with cats were markedly more accurate than those who had little or no experience, as was also reported in previous research that included human analyses of photos and videos of both dogs and cats (Bahlig-Pieren & Turner, 1999).

This indicates that humans can become more accurate at understanding and interpreting cat and dog behavioral communications with exposure, an idea that most likely also applies to cats and dogs cohabiting and interacting with their own species or another on a daily basis, particularly if they were introduced while one or both were juvenile. An early study involving Chihuahua pups reared with kittens from 25 days to 16 weeks of age showed these pups to be more social with kittens than pups not reared with kittens, and kittens reared with pups were more social to other dogs than those not reared with pups (Fox, 1969). A more recent study based on observation of cat/dog interactions and survey responses by their owners showed more amicable relations when introductions between the two animals occurred when at least one was juvenile: less than 6 months of age for cats and less than 1 year of age for dogs (Feuerstein & Terkel, in press). One reason may relate to the existence of critical socialization periods lasting from 3 to 12 weeks of age in dogs and approximately 2 to 9 weeks of age in cats (Beaver, 1999, p. 138; Beaver, 2003, p. 128). Primary social bonds within or between species are formed and species identification occurs during this time, facilitating interspecies affiliation if exposure occurs. These affiliations may then be further strengthened during the juvenile period, approximately 9–12 months of age for cats and 6–18 months of age for dogs (Beaver, 1999, p. 165; Beaver, 2003, p. 200).

The Feuerstein and Terkel (in press) study was the only published research literature located by this author on the subject of cat and dog interrelations. In addition to the findings on impact of introduction age on future affiliation, there were results indicating that cats and dogs were able to establish amicable relations and understand body language of the other species particularly well when the cat was in the home first. In particular, dogs were significantly more likely to display amicability towards the cat when the cat was in the home first, but there was no correlation between order of adoption and behavior of the cat towards the dog. It is suggested by the study's authors that this difference may be due in part to a dog's higher sensitivity to a decrease in human attention when a new cat is brought into a household because of their genetic social tendencies.

The Feuerstein and Terkel (in press) study also utilized owner survey and in-home researcher observation to evaluate impact of gender and neutering on cat/dog interrelations. The questionnaire results revealed that female cats exhibited higher levels of aggression and indifference and lower levels of amicability to the dogs than male cats. The questionnaire suggested no impact of neutering on the dog–cat interactions, but behavioral observations suggested that neutered female cats exhibited a greater number of frightened and submissive behaviors towards dogs than intact females. However, the study results did not include information on timing or age at time of neuter, which possibly plays a role in the overall effects the process may have on the individual's behavior, including that of interspecies interaction.

It is generally recognized that utilization of an introduction protocol is more conducive to creating the potential for more affiliative relations between household residents than simply placing a new animal in the territory of current resident animals. Some introduction techniques commonly recommended include initial separation, area and scent swapping, use of pheromone diffusers, and slow introduction with desensitizing and counterconditioning techniques. However, this author was unable to find any published research literature on the effects of introduction protocols on interspecies relations. So although it is conceivable that a more noticeably positive affiliation would occur between animals introduced slowly, and with techniques friendly to their innate social development, than between those that are simply placed together to "work it out" among themselves, there is no known research available to evaluate the different techniques.

Throughout the world, humans frequently choose to share their homes with domestic cats and dogs, effectively creating social structures spanning across species. These three species have not truly coevolved, yet they are often able to peacefully cohabit, form close bonds and effectively initiate and understand communication. With some thought and preplanning involving introduction protocols, acquisition order, gender and individual personalities, cats and dogs can thrive in interspecies households.

Further study on how these successful interrelations support the needs of the individuals involved may lead to overall more cohesive understanding and peaceable interactions between all species expected to live together, while giving behavior professionals more tools to facilitate affiliative interrelations.

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Journal of Applied Companion Animal Behavior
Vol. 2, No. 1. 2008

An Analytical Evaluation of "Differential Negative Reinforcement of Successive Approximations to Alternative Behavior" Procedures in Changing Aggressive Behaviors: a Contribution to the Dialogue

James O'Heare

Companion Animal Sciences Institute

CASInstitute.com
jamesoheare@rogers.com

O'Heare, J. (2008). An analytical evaluation of "differential negative reinforcement of successive approximations to alternative behavior" procedures in changing aggressive behaviors: a contribution to the dialogue. *Journal of Applied Companion Animal Behavior*, *2(1)*, 33–49.

Introduction

Negative-reinforcement-based procedures, sometimes known as escape and/or avoidance conditioning, for changing negative-reinforcement-maintained (fear-based) aggressive behavior in dogs have become popular in recent months. The procedure is winning many advocates; however, there are critics of the approach, and negative reinforcement has generally been seen as best avoided because of its aversive nature. Proponents argue that it is no more aversive than systematic desensitization if carried out properly, that it is more effective and quicker than alternatives and that it generalizes better because it utilizes natural reinforcers. Critics counter that it is more aversive than an approach that uses positive reinforcement with counterconditioning and that it is not as reliable, efficient or effective as positive reinforcement with counterconditioning procedures because the latter address both emotional motivating operations and the operants involved.

I will evaluate graded differential negative reinforcement of successive approximations to alternative, other or incompatible behaviors (hereafter citing graded D-RSAA[1] for short) with regards to aggressive dog behavior maintained by negative reinforcement. It is my conclusion that neither extreme entrenched position in this debate is credible, and that while graded D-RSAA has a place in minimally aversive behavior change programming, it is not necessarily superior to alternatives, and may have a more limited role than proposed.

Review of Aggressive Behavior and Explication of D-RSAA

We should start with a brief review of how aggressive behaviors are maintained and with an explication of the graded D-RSAA procedure I am evaluating.

Aggressive behaviors, as with all operants, are maintained by reinforcement. Although some contingencies involve positively reinforced aggressive behaviors, the vast majority of aggression consults involve the negative reinforcement of the aggressive behaviors. In other words, the aggressive behaviors are maintained or increase in frequency or intensity as a result of the ceasing or avoiding of some stimulation. In practical and colloquial terms, this means that the aggressive behaviors are motivated by "fear" responses and escape or avoidance from the stimulus in question is the reinforcing stimulation maintaining them (e.g., snarling, lunging and snapping convince the feared individual to back off). The learner uses aggressive behaviors because these have come to be effective means

[1] The only topic being critiqued here is graded D-RSAA and claims made by some proponents of such a procedure. I will not be evaluating any particular proprietary protocol or identifying the sources of specific claims.

of escaping from or avoiding "unpleasant" stimulation.

Graded D-RSAA is not commonly understood, partly because proponents do not describe it precisely and partly because critics seem more prepared to attribute to the procedure what they expect rather than what it really is (common cognitive bias). Although the name I have given this procedure is a little on the long side, it has the benefit of properly identifying the mechanisms involved, which allows us to better understand what we are and are not evaluating, which contributes to clarity in the topic. In a graded D-RSAA, the learner usually remains stationary. The aversive stimulus (or "trigger") is initially brought to a point where the learner attends to it (or sometimes shows initial early signs of stress) but does not yet sensitize to it.[2] The rule is set that successive approximations to prosocial behaviors will be negatively reinforced with increased distance from the problem stimulus. The complementary rule is set that accidental sensitized responses (i.e., increased fear, general emotionality and aggressive and/or escape/avoidance attempts) are extinguished. Each successive trial involves continuing to differentially negatively reinforce approximations to calm, relaxed tolerance of the aversive stimulus and, ideally, eventually prosocial interaction with the stimulus. In other words, prosocial behaviors are shaped with negative reinforcement. Through repeated trials, the learner is conditioned to emit prosocial behaviors and not antisocial behaviors when confronted by the stimulus in question.

[2] In early contemporary versions of the procedure, the aversive stimulus was brought to a point where the dog sensitized and that was used to determine the initial threshold point. The procedure has been modified now to bring the aversive to a point where the learner attends to it or perhaps shows initial signs of distress but does not yet sensitize. This is definitely an improvement and readers familiar with the early approach should take note of this adjustment.

Claims and Issues to be Evaluated

Choice Between Systematic Desensitization and Graded D-RSAA

Proponents of graded D-RSAA procedures often frame the choice as being between graded D-RSAA and systematic desensitization. Systematic desensitization is a respondent-conditioning-based procedure, used to change the conditioned emotional responses that motivate aggressive operants. Systematic desensitization involves three components:

1. relaxation training;
2. graded exposure; and
3. counterconditioning.

A typical systematic desensitization procedure starts by either encouraging relaxation with massage or other practices or else simply carrying out the procedure when the dog is calm and relaxed. The important thing is that the learner enters the procedure in a relaxed and calm state and remains so throughout. The aversive stimulus is identified and a hierarchy of intensity of exposure to it is constructed. This usually involves dimensions such as distance, orientation and distraction. The dog is exposed to an intensity of exposure to the aversive stimulus at which they attend to the stimulus but do not sensitize to it (i.e., it is not yet aversive, as discussed below and shown in Figure 2). Treats, praise, play or other pleasure-eliciting stimuli are often paired contingently and contiguously with the aversive stimulus until the aversive stimulus, at that intensity of exposure, comes to elicit a pleasure-related response. At that point you move to the next level in the hierarchy and the process is repeated. Successive trials build on this until the stimulus that previously elicited fear elicits either joy or relaxation at a level of intensity that can be expected in real life, and generalization is then programmed. If you use joy-eliciting stimuli such as play or treats, then the conditioned response will be pleasure. You do not have to do so, though. You may simply maintain the relaxation and calmness. In that case, the conditioned response will become calmness and relaxation. Either approach is acceptable although, in individual cases, one might be more appropriate than the other.

Proponents of a graded D-RSAA procedure often point to their procedure as superior because it involves a functionally relevant contingency—that is, that it involves a reinforcer that is particularly meaningful to the learner (i.e., escape/avoidance). But, in systematic desensitization, the motivation is addressed directly rather than indirectly. Proponents of graded D-RSAA also often argue that you cannot change conditioned emotional responses directly (i.e., without first changing the operant), but research has clearly demonstrated that you can. In 1920, Watson and Rayner published a landmark study on conditioned emotional responses and, in 1924, Jones published a study on changing fear responses in a boy named Peter. Lynch and McCarthy (1967) published an article on respondent conditioning of emotional responses with petting. Respondent conditioning occurs reflexively. If you arrange a procedure in which a learner is exposed to an aversive stimulus at an intensity where they are not sensitized and make that stimulus predict pleasure-eliciting stimuli instead, the emotional response will change. By changing the emotional response directly, you improve the efficiency of doing so and quickly remove the motivating operation for the aggressive behaviors. If the learner associates the stimulus with relaxation or joy rather than fear, there will simply be no need for the aggressive behavior. In that context, systematic desensitization would seem to address the problem of the emotional responses much more efficiently and effectively than using a functionally relevant reinforcer such as escape or avoidance (as opposed to treats or play, which proponents might consider functionally irrelevant).

Proponents often suggest using graded D-RSAA rather than systematic desensitization or another procedure because they observe that many people carry out these procedures poorly. They may argue, for example, that poorly performed systematic desensitization is likely to generate aggressive behavior chains and encourage rather than discourage aggressive behavior in the future (which they then use as an abductive argument to use negative reinforcement instead). There seems to be a misunderstanding involved, though. For a behavior chain to be trained, accidentally or purposely, the aggressive behaviors need to be evoked. This might occur in some applications of counterconditioning on its own if the aggressive behavior is indeed evoked regularly. The previously negatively reinforced aggressive behaviors may, in this arrangement, become positively reinforced aggressive behaviors. While this is certainly a risk of pure counterconditioning with regular trials in which the aggressive behaviors are evoked, systematic desensitization avoids sensitization (more easily than negative reinforcement can; see Figure 2) and aggressive behaviors, and therefore does not pose a behavior chain risk. To the extent that it would, this risk would also be likely (perhaps more likely) with graded D-RSAA procedures; however, if properly executed, both procedures avoid sensitized responses. Therefore, this criticism is unfounded if applied to properly conducted systematic desensitization procedures. Furthermore, graded D-RSAA can at least as easily be misused. A common mistake while using graded D-RSAA is exposing the learner to too intense an exposure so that the stimulation becomes more aversive, or moving far too quickly. One reason for this common error is that the negative reinforcement relies on the aversiveness of the stimulus. See Figure 2 for a visual representation of why negative reinforcement must expose the learner to a higher intensity of aversive stimulation than positive reinforcement with counterconditioning or systematic desensitization. We can compare how likely misapplication of the procedures can be in that regard, but I see no reason why positive-reinforcement-based procedures or systematic desensitization would be misunderstood or misapplied any more than graded D-RSAA. Otherwise, we should be comparing the procedures with an assumption that each is being applied properly. Criticizing one for the problems associated with its misapplication while comparing this to proper application of one’s favored procedure is unacceptable.

Where the contingency maintaining the aggressive behavior is negative reinforcement (that is, escape or avoidance based and "fear" motivated), systematic desensitization becomes a viable procedure. By removing the motivation to escape or avoid the stimulus in question, we ensure that the reinforcement for the aggressive behavior loses its reinforcing capacity, and the behavior declines or ceases. It is argued that systematic desensitization is often a slow process with frequent setbacks. Because of this, it is argued that an operant approach is preferable. It is argued that by changing the contingency with a pure operant approach, the operants will become more or less likely. Desirable behaviors are then reinforced and undesirable behaviors prevented from being reinforced (i.e., extinguished). The option posited is negative reinforcement, largely because it uses the highly salient and valued reinforcer of escape and avoidance to achieve the operants in question. But it is far from established that this is the only choice.

As mentioned above, proponents often argue that systematic desensitization is very slow, whereas graded D-RSAA procedures are quick. Proponents often justify the aversive quality of the procedure by arguing that a fast resolution is vitally important and that graded D-RSAA is faster than the alternative. Systematic desensitization can sometimes be slow, but a graded D-RSAA procedure could also be slow in some cases. There are no empirical grounds on which to claim that a well-executed graded D-RSAA procedure is any quicker (or more reliable) than a well-executed graded differential positive reinforcement with counterconditioning procedure (discussed further below). Anecdotally, from what I have seen, and from consulting colleagues, they seem to take approximately the same time. In any case, it has not been established that negative reinforcement achieves quicker results than positive reinforcement and counterconditioning or systematic desensitization procedures.

Natural Versus Contrived Reinforcers

As briefly mentioned above, proponents argue that the graded D-RSAA procedure makes use of natural reinforcers, whereas other approaches tend to make use of unnatural reinforcers. The term "natural reinforcer" or "naturally existing reinforcement contingency" refers to the particular reinforcement contingency for the particular learner in question in the usual or common environment in which the contingency takes place or, put another way, the contingency that exists independently of the behavior consultant's intervention. These reinforcers are not highly contrived but rather resemble the actual reinforcer qualitatively. A natural reinforcer is functionally relevant to the learner. A more natural reinforcer is used to promote better generalization. It can help ensure that the contingency arranged for in the behavior change program smoothly transitions to the real world and the new training remains effective with less work from the trainer. Proponents argue that by using escape or avoidance as the reinforcer, the most natural reinforcer is being utilized and therefore it will generalize well into the real world. They argue that positive-reinforcement-based approaches using food, play or praise make use of particularly unnatural or contrived reinforcers and therefore are not likely to generalize well to the real world. They point out that the trainer will have to maintain the contrived reinforcement indefinitely if they want that contingency to remain effective. This is probably the strongest argument for a negative-reinforcement-based procedure rather than a positive-reinforcement-based procedure. A couple of perspective points can be raised, though.

First, where counterconditioning or even mere habituation is encouraged, the motivating operation for the aggression-related contingency is changed drastically, making the natural reinforcer of escape or avoidance irrelevant or obsolete. A procedure that uses graded differential positive reinforcement of successive approximations to an alternative behavior in which counterconditioning is achieved (discussed further below), or straight systematic desensitization, will efficiently change the primary motivating operation for the aggressive behaviors. Once the fear is removed, so too is the motivation (or reason) to escape. In this case, the functional relevance for the contingency involving aggressive behaviors is moot.

Certainly for the replacement behaviors, functional relevance is important, though. Furthermore, as the negative-reinforcement-based behavior change program progresses, fear becomes less prominent and, in that regard, escape reinforcers become less functionally relevant (see Figure 2). As fear becomes less prominent, the calm, relaxed or joy-related emotional response will motivate prosocial behaviors, and escape behaviors then lose their functional relevance. In fact, we might expect the contrived reinforcers to become natural reinforcers.

Second, there are several strategies for promoting generalization, making use of natural reinforcement contingencies being just one of these. Miltenberger (2004, pp. 413–425) and Cooper, Heron, and Heward (2007, pp. 625–648) outline several strategies for promoting generalization. While making use of natural reinforcers is one important strategy, it is not the only one. Using natural reinforcers is not always possible, and many successful behavior change programs are built on contrived reinforcers. Among the other strategies, Miltenberger recommends reinforcing instances of generalization as they occur, incorporating a variety of relevant stimulus situations from the real world into the training situation, and training a range of functionally equivalent responses, meaning a variety of prosocial behaviors, any of which achieves the same reinforcement.

Furthermore, anyone who has trained a behavior to a high level of reliability with “contrived” reinforcers such as food can tell you that the performance criteria required to earn positive reinforcement can be increased and placed on an intermittent schedule, and the reinforcer generalized to include praise or play and still maintain the behavior solidly, even under high levels of distraction. Moreover, stressed dogs will not accept food, making the use of food an excellent ongoing gauge of the dog’s emotional responses, requiring less expertise of the trainer. While programming for generalization, you may not be able to arrange for some stimulus conditions. One benefit during generalization programming for a positive-reinforcement-based approach is that the learner can be cued to perform specific behaviors for which reinforcement is then easily delivered. These installed alternative or incompatible behaviors can be very handy in the real world.

Nonetheless, making use of natural reinforcers that are functionally relevant to the learner will ensure that later, in the real world, the behavior generalizes effectively, and it is an important way to ensure that the contingency does not fall apart but rather continues to access reinforcers. If a particularly unnatural reinforcer is utilized, the trainer must pay particular attention to encouraging generalization, and those using food in particular will have to be careful to promote generalization into the real world, and likely continue to maintain the contrived reinforcement purposely and reliably. With natural reinforcers, you can allow the real world natural reinforcers to continue to maintain the behavior. While the problem of generalizing the behavior in the real world and the importance in that regard of ensuring the behavior accesses natural reinforcers must be considered, this does not necessarily demonstrate on its own the superior nature of negative reinforcement. In fact, as positive-reinforcement-based training progresses and the stimulus loses its aversiveness, alternative behaviors do access natural reinforcers (e.g., praise, treats, play).

Differential Positive Reinforcement of Successive Approximations: A Comprehensive Alternative

> Positive reinforcement leaves us free to indulge our curiosity, to try new options. Negative reinforcement instills a narrow behavioral repertoire, leaving us fearful of novelty, afraid to explore. … continued negative reinforcement transforms more and more of the people, objects, and places around us into negative reinforcers (Sidman, 2000, p. 96)

Differential positive reinforcement (DR+) is a well-established behavior change procedure that has been used successfully for many years and is supported by a large body of research. In DR+, a problem behavior is targeted for extinction while another, alternative or incompatible behavior is targeted for positive reinforcement. In this way, the undesirable behavior can be replaced with a desirable behavior. The procedure is flexible also. You may train an alternative behavior outside of the stimulus situation and then carefully install it into the problem situation, transferring stimulus control to the problem stimulus (that is, so that the problem stimulus comes to evoke the new behavior). The new behavior can include walking or turning away from the stimulus, getting the dog's attention off it (a cued cutoff behavior), or looking to the problem stimulus without aggressive behaviors so that the learner can monitor and acknowledge it (more comforting for some dogs). Many consultants train the learner to initially acknowledge the stimulus and then look to the handler. The specific behaviors can be chosen as appropriate on a case-by-case basis. Alternatively, prosocial behaviors can be shaped (D+RSAA). Usually the DR+ procedure is carried out in a graded, stepwise manner (graded D+RSAA) so that the learner is only exposed to the problem stimulus at a level of intensity that is not yet aversive. In a comprehensive procedure, antecedents (i.e., setting events, motivating operations and discriminative stimuli) are manipulated in order to make performance of the undesirable behavior highly unlikely or impossible and the desirable behavior highly likely. In this way, the learner discovers that the desirable behavior will be positively reinforced. Because the learner is maintained subthreshold (ideally, sub-aversion threshold rather than merely sub-sensitization threshold) and pleasant consequences are utilized, counterconditioning (CC) is also achieved simultaneously. The problem stimulus comes to predict the pleasant stimuli utilized and comes to elicit pleasure-related emotional responses. So, while undesirable behaviors are replaced with desirable behaviors using operant conditioning, the emotional response that motivates the problem operant is changed using respondent conditioning. The goal is, to repeat, to change the emotional motivation for the aggressive behavior in order to make the aggressive behavior obsolete, and to train alternative prosocial behaviors in the stimulus situation that previously evoked aggressive behaviors. The beauty of this approach is that it does *not* rely on the experience being aversive and it addresses not only the behavior–consequence but also the motivation for choosing a behavior (antecedent–behavior).

An obvious criticism is that positive reinforcers simply could not be as powerful as negative reinforcers. It is true that, when faced with a feared thing, nothing is more powerful than escape—that is, negative reinforcement of whatever behavior will achieve escape quickest. The power of negative reinforcement cannot be denied. That is why it is important to countercondition the emotional response at the same time as installing replacement behaviors and ensure that there are as few aggressive responses as possible.

Some proponents of graded D-RSAA argue that a positive-reinforcement-based procedure introduces a new contingency rather than changing the existing contingency. The reasoning goes like this: After positive-reinforcement-based training, the learner will likely perform the alternative behavior in the same situation in which training took place but if the stimulus situation is pushed, the aggressive contingency remains intact; the learner knows that aggressive behaviors "work" well and so they will revert to this behavior when pushed above their threshold. They argue that this is not the case with negative reinforcement, that it does change the contingency in question rather than install a new one. Colloquially, it is argued that, with positive reinforcement, we have not "proved" to the learner that aggressive behaviors will not "work," whereas, with negative reinforcement, we have "proved" to the learner that aggressive behaviors will not "work." This is an interesting line of reasoning. Critics counter with the following points.

Counterconditioning of the emotional motivating operations for aggressive behavior does, in fact, change the actual contingency in question. By changing the emotional responses that motivate the aggressive operants, the value of escape/avoidance consequences is changed diametrically and hence the behaviors can easily be changed with positive reinforcement of some alternative behavior that pays off.

Furthermore, in both procedures, it is the extinction trials that "prove" to the learner that the aggressive behaviors will not "work" as opposed to the reinforcement trials, which demonstrate to the learner that some other behavior will pay off in some way (e.g., relief or treats or play). Extinction is minimized in both procedures, so it is only to the extent that each includes extinction trials that they do in fact "prove" to the learner that aggressive behavior will not work. Extinction is quite aversive, which is why both procedures are arranged to minimize these trials and instead focus on increasing the learner's repertoire of prosocial behaviors available to them in these situations. In a positive reinforcement procedure, the discriminative stimulus comes to indicate that certain prosocial behaviors will result in high-value "pleasant" consequences. The question of whether this reinforcer is "natural" or not or whether it involves installing a different contingency has merit, but quite simply, if you arrange the environment so that the stimulus in question comes to indicate that the problem behavior will not pay off and a different, desirable one will pay off heavily, you do in fact efficiently and effectively modify the contingency. The goal, in positive reinforcement, is to make prosocial behaviors "pay off" so well that the learner does, in fact, choose this option over aggressive alternatives. Establishing operations can be implemented that will create a highly valued positive reinforcer. But the key to making this choice work is the counterconditioning process described above—because negative reinforcement is so powerful, we need a way to make it obsolete. As escape/avoidance outcomes become less valuable (because the learner comes to like, rather than fear, the stimulus), positive reinforcement becomes more and more useful in these situations. And "natural" also.

Moreover, in both procedures, purposeful programming for generalization is important, so whether the learner is pushed past their threshold largely depends on addressing the various components of the stimulus package that have had a history of evoking the aggressive behaviors. With positive-reinforcement-based procedures, guardians do not have to rely specifically on the stimulus situation to achieve alternative behaviors. Guardians may cue specific behaviors as needed for troubleshooting. This is a flexible option available to those making use of positive-reinforcement-based approaches.

Before I move on, I would like to briefly discuss a benefit of graded D+RSAA with CC over graded D-RSAA. Graded D-RSAA requires exceptional skill in reading learners and shaping prosocial behaviors. Shaping itself is a rather advanced skill, and shaping while trying to maintain the learner at just the right distance for the stimulus to be mildly aversive but not generating excess emotionality and determining at what point to move the process forward or not requires a high degree of professional competency, which is fine for a competent professional, but not something the average companion animal guardian could be expected to do well. A graded D+RSAA with CC program, on the other hand, is flexible in terms of whether shaping is used and what behaviors are installed, and it maintains the learner at a distance that is easier to manage and less provocative. Because of this, it is something that behavior consultants can coach guardians on and allow them to continue working on with minimal supervision relative to graded D-RSAA. This, in my view, is a major benefit of using graded D+RSAA with CC.

Aversiveness and Emotionality in Negative Reinforcement Versus Systematic Desensitization or Positive Reinforcement with Counterconditioning

Proponents of graded D-RSAA protocols argue that the procedure is minimally aversive. Often the comparative argument is made that a graded D-RSAA procedure is no more aversive than systematic desensitization, which seems to be a useful standard. Proponents often claim that all behavior change procedures used to change aggressive behaviors must expose the learner to the aversive stimulus in question. This point is debatable. Certainly both procedures expose the learner to the problematic stimulus, and that is one possible interpretation of the claim. The difference though, is that in negative reinforcement, exposure *must* be intense enough that escape will be reinforcing, whereas in graded D+RSAA with CC, the ideal exposure intensity is mere attention at an intensity at which escape would not yet be reinforcing. You can see this visually depicted in Figure 2 and this is a very important point. Because negative reinforcement relies necessarily on this exposure intensity and graded D+RSAA with CC relies on merely attending to the stimulus, the graded D+RSAA with CC option can be argued to be at least potentially the less aversive procedure. Even if this is the case, though, the negative reinforcement option can be made fairly minimally aversive. While negative reinforcement can potentially be a highly aversive procedure resulting in extensive problematic secondary effects, proponents of graded D-RSAA point out that the graded and sub-sensitization threshold (though still aversive) nature of the procedure, as well as meeting other requirements for effective reinforcement (i.e., mainly contingency and contiguity[3]), ameliorates the risks of countercontrol, aggression, problematic associations with the trainer etc. They argue that, because the learner comes to learn that they can easily turn off the aversive, there is very little stress involved. If contingency can be maintained and the learner is indeed maintained sub-sensitization threshold, then it does seem likely that fallout can be minimized significantly, if not avoided completely.

As far as maintenance of this contingency goes, the research does tend to suggest that, if the learner knows exactly how to avoid an aversive and the response effort is minimal, then doing so is indeed minimally aversive. In other words, once you come to learn that some specific behavior can turn off something unpleasant, you are not as stressed or fearful of it because you know you have control over it. The less contingent the aversive is, or the more out of the learner's control it is, the more disempowered they are and the more likely learned helplessness, aggression and other side effects of aversive stimulation become. One problem is that, when making use of unpleasant stimulation alone, there are no pleasant stimuli to promote counterconditioning. One might achieve habituation merely through repeated exposure in a graded D-RSAA, but counterconditioning would be preferable to mere habituation. Furthermore, as noted repeatedly in this essay, negative reinforcement relies necessarily on aversive stimulation and so it behooves us to explore what aversive stimulation means and how it might relate to graded D-RSAA below.

Aversive stimulation is defined as any stimulation that a learner acts to evade, escape or avoid (Pierce & Cheney, 2004, p. 420). It should be noted that this implies that the stimulus is "unpleasant" for the learner. A learner only acts to evade, escape or avoid something to the extent that it is perceived as unpleasant. Note that the only operant quadrant that does not involve aversive stimulation is positive reinforcement. Negative reinforcement, positive punishment and negative punishment each necessarily involve aversive stimulation.

It is posited by some that aversiveness per se is not as relevant as whether the stimulation elicits emotionality. While this may be an acceptable claim (remember, emotionality indicates that stimulation is particularly aversive), the fact that a learner acts to evade, escape or avoid a stimulus necessarily implies that the experience was unpleasant. It bears repeating, the procedure only works to the extent that the stimulation is unpleasant (not the case with graded D+RSAA with CC). The perspective of emotionality as opposed to merely meeting the criterion of aversiveness seems acceptable and consistent with the moral principle of choosing behavior change procedures that are minimally aversive and

[3] That is, that the reinforcer follows the behavior immediately, each time it is performed and not generally otherwise.

intrusive. Avoiding excessive problematic emotionality is indeed an important practice in the ethical application of any behavior change procedures. Distinguishing between aversive and emotional in this context is simply a difference in scale (see Figure 1). The aversiveness scale ranges broadly from any "unpleasantness" (determined through either emotional behavior or escape/avoidance behavior), whereas the emotionality scale ranges more narrowly on the same continuum from particularly aversive to profoundly aversive. A minimally aversive experience does not rise to the level of eliciting intense emotionality. For clarity, referring to the quantity of aversiveness or emotionality is really measuring on the same scale; it is just that emotionality picks up further along than aversiveness (i.e., by the time emotionality is outwardly expressed, the experience is already quite aversive).

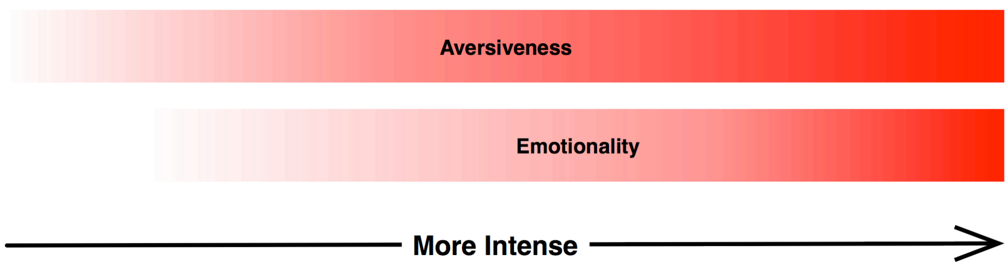

Figure 1. The relationship between aversiveness and emotionality.

Is it plausible then that a graded D-RSAA procedure is no more aversive than a systematic desensitization procedure (i.e., elicits no more emotionality)? Even though proponents often ignore graded D+RSAA with CC in this comparison, we should also include it along with systematic desensitization. Both systematic desensitization (or graded D+RSAA with CC) and graded D-RSAA necessarily involve the presentation of the problem stimulus (the discriminative stimulus that evokes the aggressive behaviors). No one can plausibly deny this. As we have seen, all that is required for a graded D+RSAA with CC (or systematic desensitization) procedure is attention to the stimulus, a point at which it is not yet experienced as aversive. Furthermore, the procedure is most effective when the stimulus is maintained as nonaversive. Graded D-RSAA, on the other hand, must involve presentation of the stimulus at an intensity that is at least a little bit aversive, and generally the more aversive it is the more effective negative reinforcement will be. Of course, graded D-RSAA is performed ideally at a point where it is the least aversive it can be while remaining effective to reinforce escape behaviors. Therefore, in consideration of this, one could rightly say that, generally, graded D+RSAA with CC and systematic desensitization can be less aversive than graded D-RSAA. In practice, trainers can and often do push the intensity too far. In these situations, graded D+RSAA with CC is likely to suffer most, quickly becoming ineffective. I will briefly explore the relationship between negative reinforcement and aversive stimulation and put this in context with discussion of emotionality.

Again, for negative reinforcement to operate, it *must*, by its very nature and definition, involve aversive stimulation. It is otherwise logically impossible. If the event is nonaversive, then the procedure *cannot* be effective. The choice is between aversiveness on the one hand or ineffectiveness on the other, and neither option seems ideal. Does this necessarily rise to the level of producing overt indications of emotionality, though? Not necessarily, although this depends on our definition of emotionality, which is a somewhat ambiguous notion at present. Emotional behavior often involves changes in respiration, heart rate, galvanic skin response and blood pressure; changes in physiology, such as cortisol levels; and operants that the emotions motivate. Clusters of these respondents and operants are usually given names such as "frustration/anger" or "fear." We often do not observe many of the respondents involved but we easily observe the operants that they set the occasion for, including escape or avoidance behaviors (not to mention vocalizations or defecation and other species-specific emotional operants). So, if we define stimuli as aversive by observing escape or avoidance behavior, it seems reasonable that we should also consider this as emotional behavior since the "unpleasantness" is implied. It might be argued that minimally aversive stimulation can produce escape or avoidance behavior but that only a meaningfully intense aversive stimulation will also produce other obvious species-specific indications of emotionality. This may or may not be the case, and I would stipulate that with increased intensity of aversive stimulation we observe more intense and obvious indications of emotionality. The question is whether an aversive stimulation that evokes mere escape or avoidance behavior not yet rising to the intensity to produce intense indications of "fear" is acceptable or not. Intelligent people might disagree on this point I would think, and acceptability will be context dependent in any given case.

Further Potential Issues

It is conceivable and indeed plausible that through graded D-RSAA, the learner has not changed their emotional response to the stimulus in question but rather merely learned operantly to emit prosocial-looking behaviors as the best means to escape what they continue to perceive as "unpleasant." The conditioned emotional response has not been addressed, at least directly, and, while the learner has learned an effective escape/avoidance behavior and thereby staved off the likelihood of problematic secondary effects of aversive stimulation such as learned helplessness and countercontrol ("neuroses"), the emotional response has not been changed. The reliability of the change in behavior is called into question. In a laboratory arrangement, the target behavior will indeed decline and prosocial behaviors increase, but in the real world, the particular prosocial escape/avoidance behaviors may not always be effective on a continuous schedule. No research, as far as I could find, has been done to determine the reliability of graded D-RSAA-based procedures in these situations.

To the extent that the conditioned emotional response is changed or, separately, to the extent that there is indeed a decline in the aggressive behaviors, it has not been ruled out that mere habituation accounts for some or even all of the reduced frequency of the behaviors or any concomitant changes in the emotional response. The procedure involves repeated presentation of the feared stimulus without any resulting trauma to the learner, and habituation remains a rival hypothesis to explain a decline in the aggressive behaviors. Anecdotally, behavior consultants who begin cases with a meeting with the guardian and learner for filling out history forms, going over agreements and so on often see significant habituation effects to the problem stimulus in that time, resembling the timeframe used in a graded D-RSAA session. If it is the case that habituation contributes to the decline in aggressive responding, then the negative reinforcement component is not per se the sole cause of the change. This suggests that negative reinforcement is not per se an efficient procedure to achieve these results but rather some other procedure, such as a positive-reinforcement-based procedure that involves pleasant consequences other than increased distance from the thing in question, can be used to achieve these same ends. It further flies in the face of the argument that operant conditioning is the primary or sole variable at work.

Related to a point above, the learner is exposed to the problem stimulus while they are in the acquisition stage of learning. In this stage, the learner does not know what behavior will "work," and trainers using negative reinforcement typically do not prompt specific behaviors but rather capture approximations to prosocial behavior when they emerge. One must be very aware of the learner's behaviors and reinforce even an eye blink, opening of the mouth, relaxation of muscles, or brief glances away from the aversive stimulus, and in this way prosocial behaviors are shaped. Many positive-reinforcement-based procedures, on the other hand, involve behaviors that are trained prior to exposure and applied to the situation. For behaviors that are free-shaped with positive reinforcement, again, the less aversive exposure to the problem stimulus and the use of "pleasant" consequences promote less stress. The acquisition stage can be a stressful stage of learning on its own, let alone being faced with a feared stimulus. The problem arises that the behavior that will access the negative reinforcement is contrary to the emotional state the learner is in. The learner is under at least very mild stress and is at least mildly fearful (they have to be in order for escape to be reinforcing). If the learner sensitizes, the trainer waits for the learner to calm down and display approximations of prosocial behaviors. Setting aside the hypothesis that this sounds a lot like habituation in the guise of a negative reinforcement procedure, the prosocial behavior expected represents a significantly different emotional state (indicated by emotional respondents and operants) than the learner is in. This sets the acquisition stage up to be even more stressful. Eventually the learner does "calm down" (i.e., habituate), and approximations of prosocial behaviors are then reinforced. After several trials, the learner does indeed transition from acquisition to a maintenance stage, discovering which behaviors will result in increased distance. Observers of this procedure have noted that dogs undergoing this procedure seem very "unhappy," "checked out" or "shut down," particularly in the initial stages. This is certainly consistent with learned helplessness, which might be expected to some degree in the acquisition stage when the learner must come to discover that calm and relaxed behaviors in the presence of fear- and anxiety-eliciting stimuli will result in increased distance. In this time, typically the trainer does not allow the learner to "check out." We discussed natural contingencies of behavior previously. It hardly seems natural to "act happy" in the face of even mild fear. If the learner were truly calm and relaxed, remember, then increased social distance should not be reinforcing. This is why it is vital to countercondition problem emotional responses.

This criticism can be levied against graded D+RSAA with CC procedures as well. If one begins a differential-reinforcement-based procedure in the presence of an aversive stimulus, be it via positive or negative reinforcement, the initial stages can potentially be unpleasant, depending on how intense the stimulation is, for the learner as they struggle, experimenting with behaviors to win access to the reinforcer. One way that positive-reinforcement-based procedures can minimize this that negative reinforcement cannot is to train the desired behavior ahead of time and install it gradually in the stimulus situation. Another way that positive reinforcement can minimize this effect that negative reinforcement cannot is in the distance used or intensity of aversive stimulation (see Figure 2). This was referred to above. To elaborate, in graded D-RSAA, the stimulus must be close enough to be a problem stimulus, at least close enough that it will be aversive and escape will be reinforcing, and the more aversive the stimulation, the more effective will be the reinforcer. With a graded D+RSAA with CC procedure, the learner should be at such a distance that they attend to the stimulus but do *not* yet experience it as aversive. This is possible because all we rely on is it being perceived so that it can act as a discriminative stimulus and also become associated with pleasant stimuli. At this distance, escape would not be reinforcing but positive reinforcement of desirable behaviors can be reinforced. This is the case because the reinforcer intensity will be high; the treats or play will be salient because they are not tied to the distance of the aversive stimulus. The positive reinforcer acts as a reinforcer when the problem stimulus is at even a nonaversive intensity of exposure. As you can see in Figure 2, you can start a graded D+RSAA with CC procedure at a lower level of aversiveness and not only begin installing a desirable behavior but also begin the counterconditioning process. In this way, positive reinforcement *can indeed* be said to be less aversive than negative reinforcement, contrary to some claims. It is important to remember, though, that the intensity of exposure required for a graded D-RSAA to begin to work—that is, only mildly aversive, and not yet intense enough to generate intense emotionality—is not extremely harsh.

Even if, technically, graded D+RSAA with CC can be slightly less aversive than graded D-RSAA, this does not mean that graded D-RSAA is necessarily exceptionally harsh and/or always inappropriate even for trainers who prefer to work with as few aversives as possible.

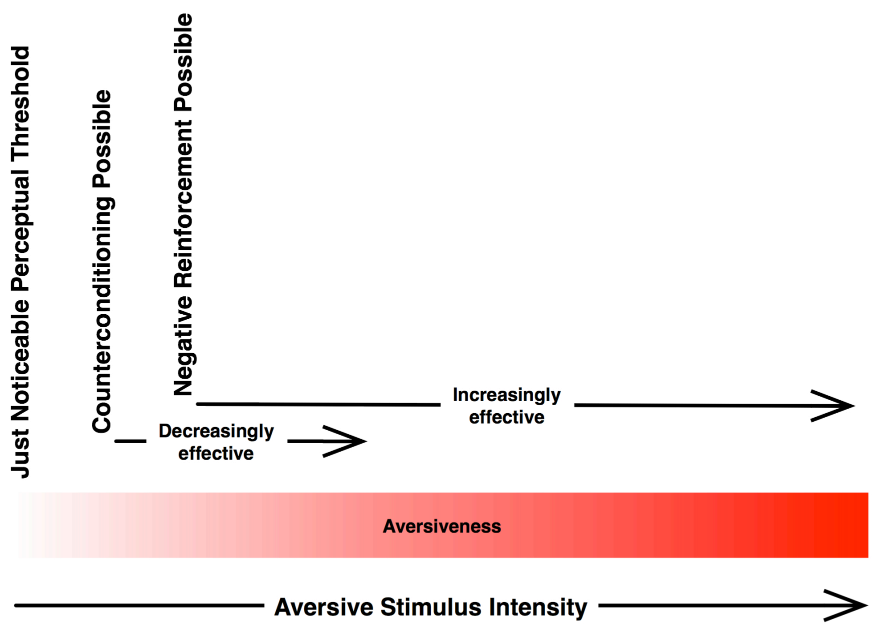

Figure 2. Aversive stimulus intensity diagram showing the range and direction of effectiveness of counterconditioning versus negative reinforcement.

Does Graded D-RSAA Involve Flooding?

Some critics have argued that graded D-RSAA is actually flooding, although this is not common now that the true nature of the procedure is being more clearly disseminated. Flooding is a highly unpleasant procedure for the learner and can easily result in fallout such as learned helplessness. In flooding, the learner is exposed to the feared stimulus and not able to escape until they cease responding to it, whereas, in negative reinforcement, the learner can avoid or escape the evocative stimulus by performing nonaggressive behaviors instead of aggressive behaviors (granted, a counter-prepared or "unnatural" behavior set in that situation). Flooding is achieved through respondent extinction of the conditioned emotional response. A flooding-like situation could arise in graded D-RSAA in the initial stages if extinction trials are not avoided. In the initial stages of shaping, the learner does not yet know what behavior, if any, will allow them to escape the aversive stimulation. If, at this stage, the learner is exposed to aversive stimulation at an intensity that elicits emotionality and the extinction of aggressive operants rule is instated, a flooding-like arrangement is set in place. In graded D-RSAA, sensitized responses are supposed to be avoided, and, to the extent that they are, this flooding-like situation is avoided along with the emotionality it generates and the fallout that would likely result (but the aggression contingency is not "disproved" either, though). During the maintenance stage, the avoidance behaviors are well known and this does not occur. Many trainers have observed that graded D-RSAA is often rushed by inexperienced or unskilled trainers (something certainly applicable to positive-reinforcement-based approaches too, although the consequences of this are less dire) and the dog seems to be "checked out," "unhappy" or otherwise exhausted. It is possible that this is sometimes a form of learned helplessness resulting from what, to the learner, seems to be a noncontingent, seemingly uncontrollable aversive experience. But it must be remembered that this only occurs in the initial acquisition stage and only if the extinction trials are not avoided as they are supposed to be. This can only occur where the procedure is not carried out well. It is appropriate to point to potential consequences of misapplication of a procedure and the likelihood of misapplication, but it must be remembered that this is not a characteristic of the procedure when carried out properly. The reason I raise this issue here is not only because some critics seem to think the procedure relies on flooding, which it does not, but also because this is potentially a seriously problematic consequence for misapplication.

The Role of Emotional Motivation, Emotional Responses and Respondent Conditioning in Problem Behavior and Behavior Change Programming

Proponents of graded D-RSAA argue that, initially, emotional responses may have motivated the aggressive operants but quickly operant conditioning takes on the primary role. This, I believe is a problematic position because, as will be elaborated below, motivation remains important in the contingency as long as the reinforcer maintains its reinforcing capacity. Without the emotional motivation to escape or avoid certain stimuli, the consequences *cannot* act as a reinforcer. The behavior–consequence sequence does not exist in isolation. Without the antecedent condition of fear, there is no reason for escape or avoidance to be a valuable reinforcer. If escape or avoidance acts as a reinforcer, then it is implied that the emotional motivation remains an important component of the contingency. Contingency involves antecedents, behaviors and consequences, and the antecedent is not merely the discriminative stimulus but also the motivating operations. Of course, consequences are also important but only within the context of the motivating operations that make one consequence more or less valuable than some other consequence.

Proponents of graded D-RSAA procedures often point to the notion that aggressive behaviors are operants and so an operant approach must be used to address them. The issue is not that simple, though. The contingency for "fear"-based aggressive behaviors (see Figure 3) involves conditioned emotional responses as part of the antecedent conditions that set the occasion for and motivate the aggressive operants that are then reinforced. These conditioned emotional responses are made up of respondents, and their motivating power is an important part of the sequence. The mere fact that aggressive behaviors themselves are goal-directed behaviors does not mean that only consequences are important in changing the behaviors because this ignores the antecedent conditions that motivate them. A more comprehensive strategy is to manipulate both the antecedents and the consequences in order to change the behavior. Conditioned emotional responses are changed through counterconditioning,[4] which then makes the aggressive operants irrelevant/obsolete. Simultaneously, the consequences can be manipulated and other, alternative or incompatible behaviors can be made more likely. "Pleasant" consequences result, rather than mere ceasing of "unpleasant" ones. This comprehensive approach of addressing both antecedents and consequences with only "pleasure"-eliciting stimulation seems likely to promote more reliable, if not also quicker, results.

[4] They are also changed with flooding (based on respondent extinction) and habituation, although counterconditioning is generally prefered because it moves past mere "getting used to the thing" and actually makes the "thing" pleasure or relaxation eliciting.

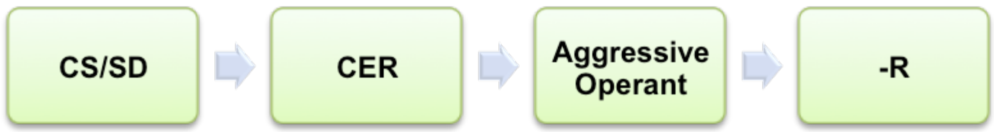

Figure 3. Common contingency in a "fear"-based aggression case. The conditioned stimulus elicits a conditioned emotional response that then motivates escape or avoidance operants that are then negatively reinforced. The conditioned stimulus is also the discriminative stimulus for the operant, indicating a likely schedule of reinforcement for certain behaviors.

While some proponents argue that, because the behaviors are operant and that because emotional responses are not important in a well-developed behavior pattern, one ought to use an operant procedure to change them, others may take a very different and contradictory approach.[5] They argue that emotional responses *are* important in the contingency but that, while graded D-RSAA is carried out, calm and relaxed emotional responses "come along for the ride," as it is often colloquially put. To the extent that this is the case, respondent conditioning *is* an important part of the procedure. Either habituation or counterconditioning is taking place, likely mere habituation. If this is the case, then negative reinforcement is less proportionately prominent in the procedure than often claimed. Conceivably, as the procedure progresses, the learner habituates and escape/avoidance consequences become less effective, which is not necessarily a problem since the motivation for escaping or avoiding decreases at the same time as the negative reinforcer loses its reinforcing capacity. It seems much more plausible to acknowledge the importance of emotional motivations throughout the "life" of the behavior rather than just initially in its development and also the important role of habituation rather than negative reinforcement in this procedure. The entrenched purist will not be willing to make this concession as it weakens the role of negative reinforcement in the procedure, but conceding the point seems unavoidable. If it is the case that habituation is an important contributor, then it begs the question of why negative reinforcement is required. Why not implement a positive-reinforcement procedure that can achieve habituation and even counterconditioning[6]?

Some proponents argue that emotional responses cannot be changed directly—that only by changing the behaviors first will emotional responses change. Certainly there is a complex causal relationship between emotional responses and operants. But, as pointed out above, the classic works of Watson and Rayner (1920) in directly changing the emotional responses of Little Albert, and Jones (1924) directly changing the emotional responses of a boy named Peter, demonstrate that we can change emotional responses directly (with respondent rather than operant conditioning). It seems to me that counterconditioning is a more efficient way to change emotional responses than changing them indirectly through graded D-RSAA through shaping prosocial behaviors and these behaviors influencing the actual emotional responses involved (like smiling when you are sad to try to feel better). It seems more likely to me that habituation is playing the major role in changing emotional responses in graded D-RSAA in any case, and habituation is direct.

More Empirical Research is Required

Although there is some supporting research for negative reinforcement as an effective

[5] Contradictory to the first argument in that one accepts while one negates the importance or presence of emotional motivations.

[6] Not merely "getting used to it" but the stimulus coming to elicit beneficial emotional responses.

intervention procedure in humans (e.g., Azrin, Holz, Hake, & Ayllon, 1963; Kodak, Miltenberger, & Romaniuk, 2003; Marcus & Vollmer, 1995; Vollmer, Marcus, & Ringdahl, 1995), there is, at present, very little research published in peer-reviewed journals on the effectiveness of graded D-RSAA procedures in aggressive behavior in dogs. Granted, research on human subjects does provide some support for the procedure being applied to dogs since different species learn through operant conditioning in similar ways. As the procedure becomes more popular, there will likely be research with dog subjects published but it is important to understand that one research project is not usually sufficient to explore the full range of questions regarding a procedure. Research needs to be replicated in order to help justify confidence in the results. Furthermore, it is rare that individual experimental studies rule out all other rival hypotheses (such as habituation effects) or that they look at long-term reliability or even generalization reliability in real-world situations. Confidence in a procedure comes with replication and full exploration of the parameters of the procedure and its effects.

Discussion and Conclusion

While some claims made by proponents of graded D-RSAA procedures have merit, others are at least questionable. Conversely, stanch rejection of the procedure as being excessively harsh and aversive is probably not credible either. More reasonable seems to be a middle ground. Because graded D-RSAA necessarily relies on aversive presentation of the problem stimulus, it can be said to be more aversive generally than a graded D+RSAA with CC or systematic desensitization procedure, which requires only mere perception of the problem stimulus. But, if graded D-RSAA is carried out at a minimally aversive intensity of exposure, it is not likely excessively aversive (perhaps on par with negative-punishment-based procedures like time-outs). Certainly, contemporary graded D-RSAA procedures are generally far less aversive than positive punishment and flooding procedures. Proponents of graded D-RSAA contend either that emotional responses are not important, or that they are important but must be changed indirectly through operant conditioning. But the procedure seems likely to involve an important habituation component. In any case, a graded D+RSAA with CC procedure changes the operants and the emotional responses directly and simultaneously. Graded D-RSAA makes use of natural reinforcers, which can contribute to making generalization smoother and more reliable, but with graded D+RSAA with CC, the emotional responses change, making the original escape reinforcer obsolete, and other strategies exist for working through generalization. There is a concern that, while the operants change in graded D-RSAA, the emotional fear responses remain intact and that long-term reliability is in question. This has not been verified, although it seems a plausible hypothesis. Proponents of graded D-RSAA often compare their procedure to poorly executed systematic desensitization, but this is an unfair comparison and it ignores other alternatives such as graded D+RSAA with CC. They argue that graded D-RSAA takes less time than systematic desensitization, but this has not been empirically determined and does not seem plausible anecdotally.

This is not to suggest or imply that there is not a place for graded D-RSAA in behavior change programming. Assuming the consultant is dedicated to the least aversive approach available for resolving the problem behavior, graded D-RSAA may not make the best choice as the first option. It may be reserved for intractable cases, for which other approaches have proven less effective than is needed. In some cases, it is not viable to achieve a great enough distance between the learner and the problem stimulus and hence a low enough intensity of exposure in order to achieve graded D+RSAA with CC. Remember that for counterconditioning to occur, the stimulus should not be perceived as aversive to the learner. Where it is not possible to achieve a nonaversive exposure to the stimulus, graded D-RSAA may be a viable and minimally aversive approach. In that case, one could use it as a way to get a "foot in the door," so to speak, and switch as soon as possible to a graded D+RSAA with CC strategy. Graded D-RSAA should only be performed, in my opinion, by professional behavior consultants who are very skilled at reading learner communication signals, and who are flexible. In my experience, trainers often have a tendency to work learners through graded D-RSAA too quickly, causing the learner stress. This must be guarded against with any procedure utilized.

I have come to the following conclusions: Is graded D-RSAA effective at decreasing "fear"-based aggressive behaviors? Sure. Is it highly aversive? Generally no, it avoids intense emotionality. Is it as minimally aversive as systematic desensitization or graded D+RSAA with CC? Not generally, although the difference may or may not be clinically significant. Does it avoid fallout associated with aversive stimulation such as countercontrol and learned helplessness? Likely yes. Is it superior to a graded D+RSAA with CC procedure? My conclusion, based on the issues outlined above, is generally no. Does graded D-RSAA have a place in minimally aversive behavior change programming? Yes, but not as a first option unless it is impossible to arrange for nonaversive exposure to the problem stimulus. Is it a panacea? No! Is it abusive as some argue? Not if done properly by a skilled professional under the right circumstances.

Acknowledgements

I would like to thank Jean Donaldson, B.S., Laurel Scarioni, CPDT Andina Faragher, Ph.D. and Angelica Steinker, M.Ed. for content reviewing the manuscript. The critiques were extremely helpful.

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Neurology of Learning: An Understanding of Neurology as the Basis of Learning and Behavior in the Domestic Dog

Christina Bond, CAP3, Dip.ACBS, BSc, MBA

Bond, C. (2008). Neurology of learning: An understanding of neurology as the basis of learning and behavior in the domestic dog. *Journal of Applied Companion Animal Behavior, 2(1)*, 50–96.

Introduction

The plasticity of the dog's neurological system provides an ideal medium for learning. Neurology is the basis on which the principles of learning are defined. Aspects of learning principles, such as attention, contiguity (close proximity in time), reinforcement (a consequence that strengthens the behavior), repetition and association have their bases in the neurological structures that consolidate, store and retrieve learning as memory.

The effect of stimulation, in the form of experience, is of particular importance to neurological development during the dog's critical development periods. Stimulation causes neural activity, resulting in neural growth. Neural systems that are not stimulated during development periods atrophy and die, or otherwise fail to develop normally.

A fundamental understanding of the dog's neurological system provides first principles on which to construct effective socialization and training plans, and to adjust these plans as the results of learning are observed.

Learning Principles

Learning is a process by which experience leads to long-lasting changes in behavior. The predictive mechanisms of the brain help determine what the dog will attend to, and therefore what the dog will perceive and respond to (Ratey, 2001, p. 350).

The natural environment is in constant change. Some changes are cyclic and predictable, such as day and night. Other changes are sudden and unpredictable, such as unusual weather patterns that cause changes in food availability. As an adaptive mechanism, the ability to learn allows an animal to adjust to predictable and unpredictable circumstances that occur during its lifetime (Siiter, 1999, p. 107). Learning provides behavioral plasticity that provides an animal with the flexibility to cope with an ever-changing environment (Domjan, 2003, p. 252).

Some behaviors, such as the nuzzling instinct in newborn pups, are *innate*; they occur without any history of learning and are intrinsically reinforcing (Coppinger & Coppinger, 2001, p. 202). Although such behaviors are under the control of neural programs that are primarily genetically wired, they can become more refined through learning, and may even fail to form if the environment does not provide relevant learning experiences during the critical development period for that skill (Coppinger & Coppinger, 2001, p. 118; Roberts, 1998, pp. 268–269). For example, a young predator may have instinctive hunting skills (track, stalk, chase, kill) but these skills are refined through practice.

The most common methods for behavioral change used in dog training are respondent conditioning and operant conditioning (Roberts, 1998, p. 126). Both of these are based on associative learning processes: the joining of combinations of stimuli and/or responses in space and time (Roberts, 1998, p. 121).

Respondent Conditioning

Respondent behavior is reflexive, based on innate or previously learned behavior, which is elicited by a stimulus (Roberts, 1998, p. 135). *Respondent conditioning* results from the pairing of a conditioned stimulus (CS) with an unconditioned stimulus (US), so that the CS elicits the same response as the US (Domjan, 2003, p. 66).

Once a CS has been conditioned to predict something the dog wants, such as a morsel of food, it can be used to act as a secondary reinforcer for operant behavior (Roberts, 1998, p. 134). A secondary reinforcer is a stimulus that has been conditioned so that the dog expects a primary reinforcer (something innately reinforcing for the dog) to follow. An example of a secondary reinforcer in dog training is the clicker, a small plastic device that creates a clicking sound when pressed. A clicker can be conditioned as a secondary reinforcer by clicking, and then presenting a small piece of food within half a second of the click. The dog will anticipate food upon hearing the click and is likely to orient to the handler …and, of course, salivate in preparation for food. Once conditioned, the clicker can be used as a secondary reinforcer, to mark behaviors when they occur.

A *conditioned emotional response* (CER) can be created by associating an object (place, person, etc.) with something that elicits emotion, such as joy, fear, anger or anxiety. The presentation of that object then elicits that emotion (O'Heare, 2007, p. 229).

Factors that affect the success of respondent conditioning include novelty (newness) and salience (relevancy to the dog) of the CS, salience of the US, contiguity of CS–US presentation, context of the training environment and biological preparedness (innate behavior resulting from genetic factors).

Operant Conditioning

Operant behavior is goal-directed behavior through the use of skeletal muscles (O'Heare, 2007, p. 235, p. 254). Operant behavior is *emitted*; the animal chooses to perform the behavior (Roberts, 1998, p. 135). Reinforcement is contingent upon a specific response to a specific stimulus, called a *discriminative stimulus* (Domjan, 2003, p. 149).

In *operant conditioning*, the frequency or magnitude of a behavior is either increased or decreased through consequences such as positive reinforcement, no reinforcement, or punishment. Operant learning is measured as an increase or decrease in the probability, latency (time lag between the stimulus and response), speed and strength of response to the discriminative stimulus (Roberts, 1998, p. 135).

Specific discriminative stimuli and specific types of reinforcers may either support or interfere with operant conditioning by eliciting species-specific innate behaviors (O'Heare, 2007, p. 254). For example, use of food to reinforce nose-touch to a target may elicit licking or mouthing instead of nose-touch of the target.

Stimulus control is achieved when the dog can discriminate between two stimuli and respond appropriately (Roberts, 1998, p. 143). For example, the "sit" behavior is under stimulus control when the dog responds to a "sit" hand signal given in a consistent manner by the trainer. Stimulus generalization occurs when the dog responds appropriately to a stimulus that has been altered (Roberts, 1998, p. 142). For example, a visual generalization is learned when the dog responds to a "sit" hand signal given by various people, where the aspects of the cue (speed, arch of the arm, shape and position of the hand, etc.) vary.

Operant conditioning works for dogs because they are motivated to maximize positive outcomes and minimize aversive outcomes. Dogs are constantly performing behaviors, so reinforcing the behaviors we like will cause dogs to choose to repeat those behaviors. Because operant conditioning teaches the dog he can control the environment through his actions, learning itself becomes intrinsically reinforcing (Lindsay, 2000, p. 247).

In dog training, operant conditioning can be used to (Domjan, 2003, p. 137):

- increase the likelihood of a behavior in response to a specific stimulus (or cue), and therefore produce dependability of response
- produce uniformity of response

- encourage variation of response, or creativity of response, toward shaping new behaviors.

Operant conditioning is based on the *three-term contingency*: associations between the antecedents, behavior and consequences (O'Heare, 2007, p. 235). Because the dog is learning these associations during operant conditioning, respondent conditioning is also taking place (Domjan, 2003, p. 192).

Factors that affect the success of operant conditioning include novelty and salience of the discriminative stimulus, contiguity of response and reinforcement, and salience of the reinforcer. Edward Thorndike's principles of learning apply to operant conditioning. These include (Craighead & Nemeroff, 2002; Thorndike, 1911; "Principles of learning," n.d.):

- **Readiness** — Is the dog physically and psychologically prepared to learn the behavior?
- **Exercise** — Has the dog practiced the behavior?
- **Effect** — Does the outcome reinforce the behavior?
- **Primacy** — Did the dog perform the behavior the first time he encountered the stimulus?
- **Intensity** — Emotion facilitates learning, as long as it focuses attention but does not distract the dog from the associations to be learned. Did the stimulus and behavior reinforcer evoke emotion? Was it sharp, clear, vivid, dramatic, and/or exciting to the dog?
- **Recency** — Has the behavior been practiced recently?

Memory

Goal-directed behavior involves perception, memory retrieval and comparison, the ability to process and predict the consequences of a response to a particular stimulus in a particular context, and motor skill. All of these processes require memory.

In a theoretical model, there are two basic types of memory. *Long-term memory* is information stored either innately or from previous learning. *Working memory* is the combination of information retrieved from long-term memory and environmental information (both internal and external) acquired through the senses (Roberts, 1998, p. 16).

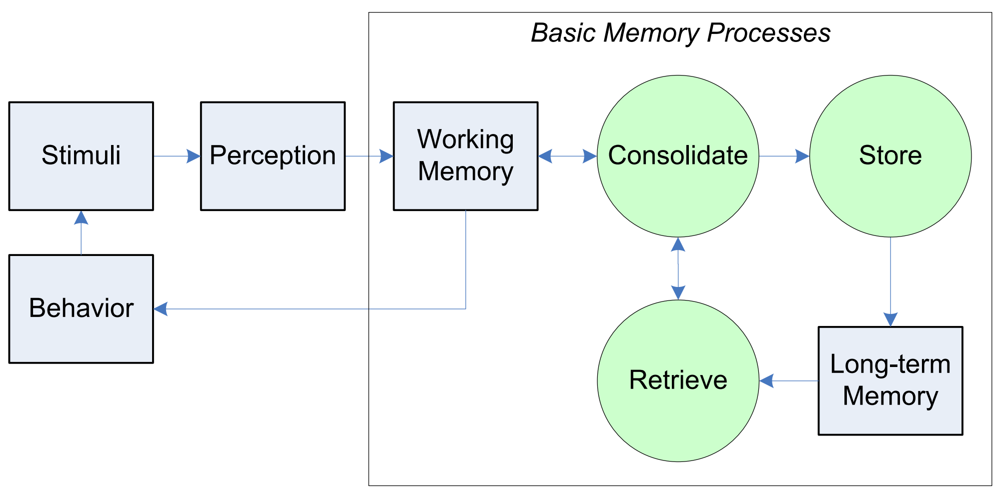

Figure 1: A model of memory flow

Goal-directed behavior involves perception of the current environment, acquisition of memories from prior similar events, feedback from emotional systems, an understanding of oneself in space, the ability to move oneself in a way that will avoid unwanted events and obtain wanted events (behavior), and storage of memories for reference in future similar events (LeDoux, 2002, p. 265; Rodrigues, Schefe, & LeDoux, 2004, p. 80). Working memory allows the dog to bring all this together.

Working memory is processed in the frontal lobes, and is used in registering current activity while retrieving and holding information stored in long-term memory (Ratey, 2001, p. 194, p. 309). Working memory is only temporary. Thoughts in working memory disappear in a short time. To be recalled, they must have been consolidated and stored in long-term memory (Rodrigues et al., 2004, p. 80).

Thorndike's principles of learning apply to working memory and long-term memory. For example, an event can be stored in long-term memory if it is highly salient to the learner, particularly if emotions are involved ("intensity"). Also, most long-term memory requires repetition ("exercise") (Rodrigues et al., 2004, p. 81).

Not all memories are stored long term. Interference with working memory disrupts its transition to long-term memory (Rodrigues et al., 2004, p. 81). For example, teaching a dog several new behaviors in one training session can cause interference in one behavior by another behavior (Roberts, 1998, p. 64). Simple or similar tasks are not as prone to interference as complex or disparate tasks (Roberts, 1998, p. 84). Because of this, the best training plans (except for very simple tasks) may be those that teach only one new behavior, allowing the dog time between training sessions for learning consolidation before teaching a second new behavior.

The Neurological System

Learning and behavior are functions of the neurological system, which is comprised of the *central nervous system* (CNS) and *peripheral nervous system* (PNS). The CNS consists of the brain and spinal cord. The PNS consists of nerves located outside the brain and spinal cord (Norden, 2007, Part 1, p. 19).

All mammalian neurological systems are similar, with minor differences that help the animal specialize for survival in its particular niche. For example, a human brain has a larger cortex and areas specialized for language and speech, whereas a canine brain has a larger olfactory bulb and more olfactory receptors specialized for processing scent (LeDoux, 2002, p. 303; Lindsay, 2000, p. 79). The *continuity hypothesis* suggests that psychological and behavioral continuity exists across mammalian species, due to similar neurological system physiology (Roberts, 1998, p. 4, p. 15).

The Functions of Basic Brain Structures

The brain is separated into two *hemispheres*, right and left (Norden, 2007, Part 1, p. 19). The motor cortex in the left hemisphere is connected to, and therefore controls, nerves routed to the right side of the body, and the motor cortex in the right hemisphere controls the left side of the body (Norden, 2007, Part 1, p. 61). These hemispheres are connected by a bundle of neurons, a *commissural pathway*, called the *corpus callosum*, which allows for coordination of thought and movement (Norden, 2007, Part 1, p. 50).

For the purpose of understanding basic evolution, the brain can be subdivided into three areas: the *hindbrain*, *midbrain*, and *forebrain* (LeDoux, 2002, p. 35; Norden, 2007, Part 1, p. 21).

- The hindbrain and midbrain are evolutionarily older, more primitive areas of the brain. Components within these areas support basic functions necessary for life. For example, the *reticular formation* supports heart rate, breathing, sleep/wake cycles and attention, and the *rostral colliculus* supports visual reflexes, such as reflexive lunging in response to sudden, fast movement across the dog's visual field (Norden, 2007, Part 1, p. 21, p. 29, p. 50; Part 3, p. 55).

- The forebrain is the most recently evolved area of the brain, and supports complex behavior such as thinking and problem solving (LeDoux, 2002, p. 35; Norden, 2007, Part 1, p. 21).

The brain is composed of hundreds of functionally distinct, interdependent components (Norden, 2007, Part 1, p. 49, p. 53). This article covers only the most prominent and well-studied structures critical to learning and behavior.

The cortex, amygdala and hippocampus are three particularly important brain regions involved in learning and behavior (LeDoux, 2002, p. 295).

- The *cerebral cortex* is a large area of the brain, the majority of which is involved in the processing of sensory information (Norden, 2007, Part 1, p. 81). The cortex is divided into four lobes (O'Heare, 2007, p. 103). The *frontal lobe* supports planning, calculating and understanding consequences (Norden, 2007, Part 1, p. 66; O'Heare, 2007, p. 103; Ratey, 2001, p. 148). The *occipital lobe* processes visual information, the *temporal lobe* processes auditory information, and the *parietal lobe* processes other sensory information (O'Heare, 2007, p. 103). Parts of the frontal and temporal lobes are also involved in emotion and memory (Norden, 2007, Part 1, p. 66). Two areas of the frontal lobe, the *prefrontal cortex* and *orbitofrontal cortex*, are involved in impulse control (O'Heare, 2007, p. 103). Working memory is predominantly handled by the prefrontal cortex (Norden, 2007, Part 3, p. 25). The *basal ganglia*, located in the forebrain, are involved in the *extrapyramidal motor system*, which processes habitual movement (Norden, 2007, Part 2, p. 179; Part 3, p. 26).

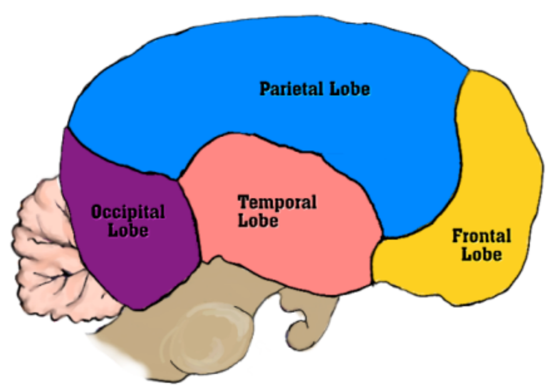

Figure 2: Lobes of the cerebral cortex

- The *amygdala* is a small, almond-shaped structure. It is acted on by various neurotransmitters and hormones, and has a role in regulating autonomic, endocrine, somatosensory, reproductive, memory, sleep, orientation and other functions (Ratey, 2001, pp. 311–312). The amygdala plays a central role in the expression of fear, aggression and other emotional behaviors (Norden, 2007, Part 2, p. 123). In dogs, the amygdala has been associated with predatory and social behaviors (O'Heare, 2007, p. 102).
- The *hippocampus*, connected to the amygdala through neural circuits, is activated for storing memory, including peripheral components of memory such as temporal and environmental contexts related to events (Domjan, 2003, p. 285). The hippocampus also processes spatial memory (LeDoux, 2002, p. 114). It functions as a convergence zone, where memories stored in various areas of the brain converge into

working memory (LeDoux, 2002, p. 318). Neurons in the hippocampus can be generated throughout life (Nicholls, Martin, Wallace, & Fuchs, 2001, p. 494).

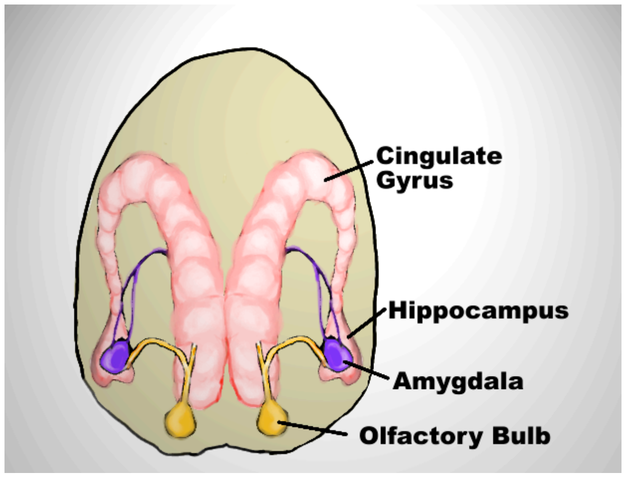

Figure 3: Amygdala and hippocampus

Other components of the brain are also important for learning and behavior.

- The *cingulate gyrus* is a ring of gray matter above the corpus callosum, which projects from the cortex to the hippocampus. It integrates other parts of the brain, and plays a role in social motivation, emotion and movement (Ratey, 2001, pp. 318–319).
- The *thalamus* is a sensory filter that is connected to the *anterior cingulate gyrus* (Ratey, 2001, p. 318). The thalamus coordinates sensory and emotional inputs, and is a gateway to the cerebral cortex, the part of the brain involved in cognitive functions, such as problem solving.
- The *hypothalamus*, located below the thalamus, is part of the hypothalamic–pituitary–adrenal (HPA) system. This system regulates the sympathetic (fight or flight) and parasympathetic (rest and relaxation) systems (Norden, 2007, Part 2, p. 123; O'Heare, 2007, p. 102). The hypothalamus also regulates the body, maintaining homeostasis. For example, thirst and appetite are driven by the hypothalamus, acting to keep the body hydrated and fed (Norden, 2007, Part 1, p. 29, p. 49).
- The *cerebellum* is located at the base of the brain, at the rear of the brainstem. The cerebellum is essential for learning and behavior because it is responsible for coordination of learned-skilled motor movement, as well as cognitive, spatial and memory functions (Norden, 2007, Part 1, p. 30; Ratey, 2001, p. 148).
- The *pons*, located in front of the cerebellum, is the gateway between the cerebellum and the rest of the brain. Motor movement is initiated in the cortex, then travels through the pons to the cerebellum, which coordinates the movement by sending signals down the nerves in the spinal cord connected to the appropriate muscles (Norden, 2007, Part 1, pp. 30–31).
- The *ventral tegmental area* (VTA) is a set of neurons in the midbrain that are involved in the endogenous reward system (Norden, 2007, Part 2, p. 123).

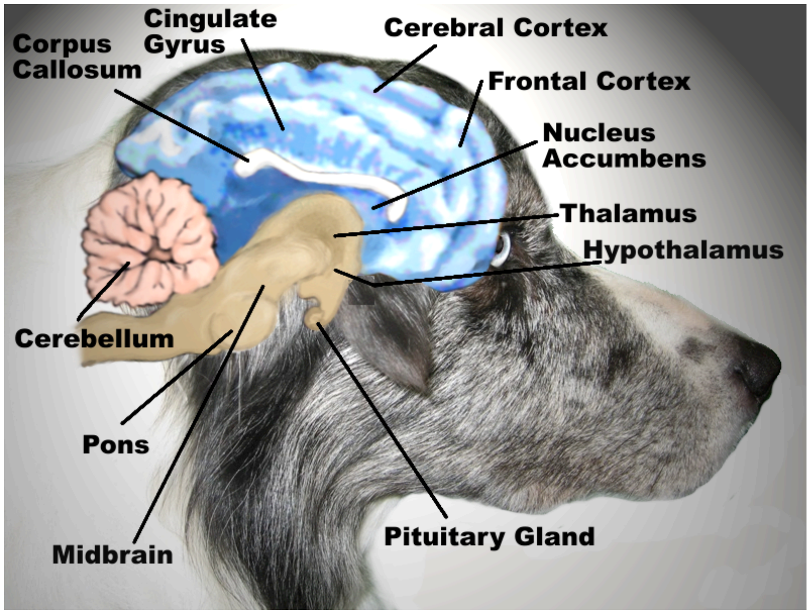

Figure 4: Basic components of the canine brain

Neurons and Synapses

The neurological system consists primarily of elongated cells called *neurons*. There are approximately 150 different types of neuron, making it the most diverse type of cell in the body (Norden, 2007, Part 1, p. 35).

The general description of a neuron is as follows, although different types of neuron vary according to their function. The core of the neuron is the cell body, or *soma*. This is similar to the soma of other cells. Sprouting from the soma are branching fibers called *dendrites*. From these branches bud small protuberances called *dendritic spines*. Exiting from one end of the soma is an elongated projection called an *axon*. A ridge between the cell body and the axon, called the *axon hillock*, controls impulses flowing from the dendrites down the axon. The axon is covered with an insulating material called a *myelin sheath*, which facilitates fast transmission of nerve impulses.

Neurons obtain structural support from *glial cells*, the majority of cells that compose the brain. Glial cells also produce myelin sheathing, form the blood–brain barrier that is vital to brain function, and absorb and dispose of cellular debris (Lindsay, 2000, p. 75).

The axon of one neuron meets the dendrites of other neurons, without actually touching. This space between the axon and dendrites is called the *synaptic cleft*, or *synapse* (Kalat, 2004, pp. 32–36). Neurons communicate by sending electrochemical signals, which run down the axon and across the synapse to adjoining neurons (LeDoux, 2002, p. 41). These messages excite or inhibit adjoining neurons (O’Heare, 2007, p. 105).

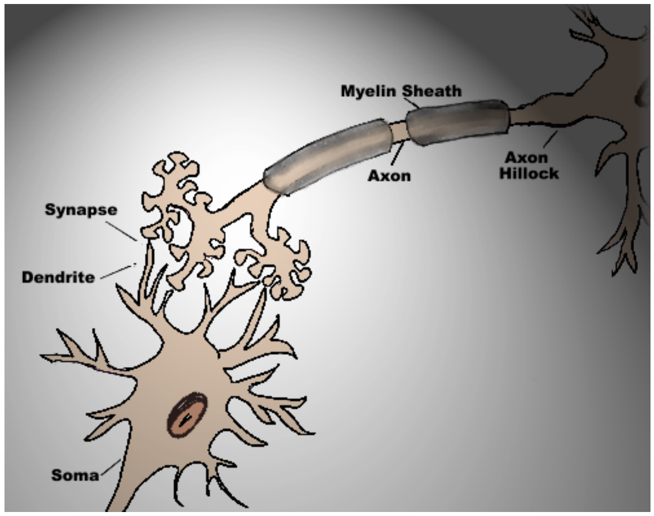

Figure 5: Neurons

One neuron can have numerous axons and dendrites. This allows messages to be sent by one neuron and received by many, or sent by many neurons and received by one (LeDoux, 2002, p. 42). This *convergence* is necessary for consolidation of information from various senses, and to synchronize memory and movement (LeDoux, 2002, pp. 315–318).

Neurons network with other neurons in the brain and spinal cord, as well as various sensory receptors (gustatory, somatosensory, olfactory, visual and auditory) throughout the body. Messages coming to the brain from the body use the *afferent system*. Messages traveling from the brain to the body use the *efferent system* (O'Heare, 2007, p. 105).

There are trillions of synaptic connections in a mature mammalian brain (Norden, 2007, Part 1, p. 111). Groups of neurons that are linked together form a *circuit*. This allows a given neuron to support more than one function (Ratey, 2001, p. 167). Complex circuits form *functional systems*, which perform specific functions such as seeing or hearing (LeDoux, 2002, p. 49).

There are two categories of neuron involved in messaging: *interneurons* and *projection neurons*. Interneurons send messages within their local circuit, and can be excitatory or inhibitory. Projection neurons make up *projection pathways*, which send excitatory messages to other circuits (LeDoux, 2002, pp. 49–50; Norden, 2007, Part 1, p. 61). Projection pathways synchronize separate areas of the brain, allowing the system to function as one (LeDoux, 2002, p. 61). For example, various areas of the cortex are connected by bundles of axons called *association pathways* (Norden, 2007, Part 1, p. 59).

Synaptic connections between neurons give the brain an ability to change in response to the environment (LeDoux, 2002, p. 9). This plasticity forms the foundation of learning and behavior (Norden, 2007, Part 3, pp. 23–25).

Patterns of activity in the brain cause synapses to be formed, strengthened or weakened (Nicholls et al., 2001, p. 480). These patterns of activity result from internal stimuli, such as sensations the dog has of his body moving through space, and external stimuli, such as olfactory or visual stimulation (LeDoux, 2002, p. 3). In a literal sense, experience changes the brain.

Although the majority of learning involves the brain, simple forms of learning can occur in the neural tissue that lies below the brain (Domjan, 2003, p. 156). In addition, some responses (particularly reflexive responses) occur without the involvement of the brain (Ratey, 2001, p. 156).

Neurotransmitters and Hormones

Processes in the neurological system are mediated by hormones and neurotransmitters, a complex mix of chemicals that affect learning and behavior. These chemicals are synthesized from other chemicals, which are either produced by the body or obtained through the dog's diet (O'Heare, 2007, p. 105).

Neurotransmitters facilitate message transmission between neurons. *Glutamate* and *gamma-aminobutyric acid (GABA)* are the two major neurotransmitters in the mammalian brain (Norden, 2007, Part 1, p. 137).

- Glutamate is an amino acid, used by the brain for many functions. For example, it acts as a building block for peptides and proteins, helps detoxify the brain of ammonia, and elicits firing in a postsynaptic neuron (LeDoux, 2002, p. 53). Glutamate is an excitatory neurotransmitter.
- GABA is an inhibitory neurotransmitter. Unchecked excitation can damage or destroy neurons. To counterbalance excitation, inhibitory neurons release the neurotransmitter GABA, which decreases the firing in postsynaptic cells, thereby resetting the circuits (Norden, 2007, Part 1, p. 137). This balance of excitation and inhibition provides a means of directing brain activity (LeDoux, 2002, pp. 50–53).

Not all results of excitation involve excitation of the system. For example, serotonin excites GABA inhibitory cells in the amygdala, which inhibit amygdala projection cells, resulting in inhibition (LeDoux, 2002, p. 315). Serotonin can, therefore, have a calming effect. In addition, a neurotransmitter can be excitatory or inhibitory depending on the properties of the postsynaptic receptor. For example, dopamine is excitatory at some synapses and inhibitory at others (Norden, 2007, Part 1, p. 138, p. 146).

GABA and glutamate are fast-acting neurotransmitters. Other neurotransmitters, called *modulators*, have a prolonged and widespread action. Modulators prime various areas of the brain, preparing for processing across multiple senses and various areas of the brain. This facilitates an event that affects multiple stimuli to be understood and learned as one experience (LeDoux, 2002, p. 313).

Modulators include *peptides*, *monoamines* and *hormones*.

- Peptides include *endorphins* and *enkephalins*. Endorphins and enkephalins are triggered by pain and stress, and act as natural painkillers.
- Monoamines include *serotonin*, *dopamine*, *epinephrine* and *norepinephrine*. Some monoamines, such as epinephrine, can facilitate arousal, while others, such as serotonin, can reduce anxiety and increase impulse control (O'Heare, 2007, pp. 105–108). The monoamine acetylcholine is required for muscle movement, including heart and lung function (LeDoux, 2002, pp. 56–59). Dopamine is called the "learning neurotransmitter" because it depolarizes neurons, preparing them to fire. Dopamine is required for motor coordination, attention and the experience of reward (O'Heare, 2007, p. 105; Ratey, 2001, pp. 120–123). Dopamine is also involved in the experience of pleasure and in addictive behavior (Norden, 2007, Part 1, p. 149; O'Heare, 2007, p. 105). Too much dopamine activity can lead to impulsivity or irritability (O'Heare, 2007, p. 117).
- Hormones include *cortisol*, *oxytocin, estrogen* and *testosterone*. Hormones are excreted into the bloodstream by the *endocrine system* and act on target organs (O'Heare, 2007, p. 107). Hormones also affect memory and emotion (LeDoux, 2002, p. 60). For example, oxytocin is a peptide hormone released by the hypothalamus that plays a role in social bonding (Norden, 2007, Part 2, p. 137).

Different dog breeds, and different individuals within a breed, have differing amounts of the various neurotransmitters in their neurological systems, and slightly differing brain structures. This can account for varying temperaments and activity levels in their behavior (Coppinger & Coppinger, 2001, p. 197).

The Making of Memories

Categories of information and motor activity are stored across various neural circuits. This redundancy mitigates risk of memory loss; if a few cells in the circuit die, the remaining cells carry on the work. This is referred to as *equipotentiality* (MacLean, 1949, cited in LeDoux, 2002, p. 99).

The excitation and inhibition of neural circuits constitute the encoding of associations, emotion and muscle movement into learning, memory and behavior (Domjan, 2003, p. 68; Norden, 2007, Part 1, p. 135). Each time a behavior occurs, neural circuits organize themselves to better support that behavior by changing their connective patterns (Ratey, 2001, p. 11).

Action Potentials

Neurons either fire or they don't fire. The activation of a particular firing pattern can inhibit or excite other firing patterns, leading to complex learning and behavior (Ratey, 2001, p. 195). Neurons that become more positively charged are *depolarized*, leading to *excitation*. Neurons that become more negatively charged are *hyperpolarized*, leading to *inhibition* (Norden, 2007, Part 1, p. 126).

Ions such as sodium (Na^+), potassium (K^+) and chloride (Cl^-) are distributed in the neuron in a way that makes the inside of the cell more negatively charged than the outside. This creates the neuron's *resting potential*. This ionic balance is important for maintaining neuron health (Norden, 2007, Part 1, p. 124).

Stimulation of the neuron causes the inside of the cell to change (Norden, 2007, Part 1, p. 138). When glutamate binds to a neuron's postsynaptic receptor, a passage opens in the receptor that allows positively charged ions to move inside the neuron. This changes the chemical balance between the inside and outside of the cell (LeDoux, 2002, p. 55). When a neuron is stimulated to a level that crosses the axon hillock, it generates an electrical signal that travels down the axon. This is called an *action potential* (Norden, 2007, Part 1, p. 123).

The action potential produces an influx of calcium (Ca^{2+}) that causes vesicles in the presynaptic terminal to fuse with the cell membrane. This triggers vesicles of neurotransmitter to be released from the presynaptic terminal (Norden, 2007, Part 1, p. 111, p. 124). Neurotransmitter molecules bind with receptors on the postsynaptic membrane. This initiates ionic changes in the postsynaptic terminal. If enough neurotransmitter is taken up by an adjoining neuron, it will result in an action potential in that neuron, and so on. Through this cascade effect, the message travels electrochemically through the neural circuit (Norden, 2007, Part 1, pp. 125–126).

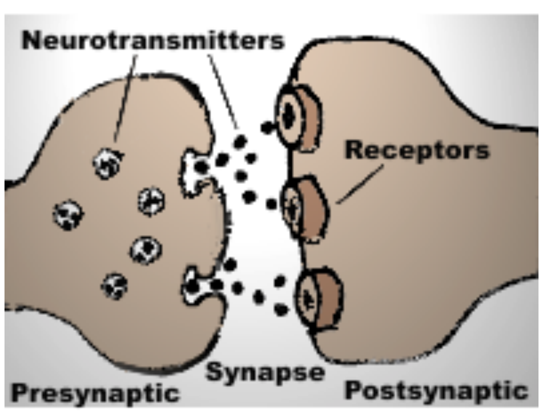

Figure 6: Synapse

Any neurotransmitters that remain in the cerebral fluid are taken into the presynaptic terminal by transporter molecules and recycled (used again), or destroyed by glial cells. This ensures that excitation does not continue indefinitely (Norden, 2007, Part 1, p. 121).

When GABA binds to a neuron's receptor, negatively charged ions move inside the neuron. This reduces the effectiveness of the positively charged ions collected as a result of glutamate. When GABA is present, more glutamate is required for an action potential to result (LeDoux, 2002, p. 55). In this way, GABA and glutamate balance electrochemical activity.

Long-Term Potentiation

The firing of a neuron is a temporary event. When a stimulus is presented, neural circuits fire in response to that stimulus. Those same circuits continue to fire after the stimulus has gone, preserving the perception of the stimulus in working memory. As time passes, the neurons begin to cease firing, and the thought is lost from working memory (Ratey, 2001, p. 113).

For example, you begin to teach your puppy to sit using a lure. After five repetitions of the behavior, your puppy sits on a hand signal without a lure. An hour later, you cue your puppy to sit using a hand signal, but he doesn't respond. The association of the "sit" response to the hand-signal stimulus is no longer in working memory, and may not yet be stored in long-term memory. This is because permanent physiological changes need to occur in order for memory to be stored long term. These physiological changes are known as *long-term potentiation (LTP)*.

During an action potential, calcium enters the cell. Enough calcium activates *kinases*, enzymes that stimulate genes to produce proteins that strengthen the synapse, and also releases *neurotrophins*, growth chemicals that nourish neurons and cause them to sprout new branches, to form new synaptic connections (LeDoux, 2002, p. 153). As a result, several basic changes occur that increase the firing potential of the neural circuit supporting the memory or behavior (Norden, 2007, Part 3, pp. 28–29; Sapolsky, 2005, pp. 19–23):

- More neurotransmitters are produced in the presynaptic neuron.
- More receptors are created in the postsynaptic neuron, and more dendritic spines sprout, increasing the neuron's capability of gathering neurotransmitters.
- The postsynaptic neuron increases in width, to better transmit the message downstream.
- More neurons are recruited for the task, and in some cases more neurons are formed.

For working memory, kinases act on proteins that are readily available in the cell (Ratey, 2001, p. 195). However, changes that build long-term memory require a specific protein that is not freely available, and therefore must be synthesized by the cell (Ratey, 2001, p. 195; Rodrigues et al., 2004, p. 81). Specifically, a protein called CREB activates the cell to synthesize other proteins that cause long-term changes to the neuron, further stabilizing the connections (LeDoux, 2002, pp. 149–150; Ratey, 2001, p. 195).

LTP is specific to the synapses involved in the potentiating experience. Therefore, a neuron can participate in the storage of various bits of information, through various synaptic connections with multiple other neurons (LeDoux, 2002, p. 141).

The more often a neural circuit is fired, the more physiological changes occur, and the more permanent the learning becomes (Ratey, 2001, p. 191). This is why repetition is so important for learning.

Storage and Retrieval of Long-Term Memory

Memory consolidation occurs during sleep (LeDoux, 2002, p. 107). The neural circuits in the hippocampus that fire during learning of a specific new behavior also fire during the period of sleep that follows the learning. It appears that a period of sleep called rapid-eye-movement

(REM) sleep assists in the formation of long-term memory (Ratey, 2001, p. 188).

Memory, particularly of complex behavior, is initially stored as synaptic changes in the hippocampus and frontal cortex. Each time the stimulus is repeated, the memory is reinstated in the cortex, and the neural circuits supporting the memory grow stronger. Multiple reinstatements of the memory cause synaptic changes in the cortex. In addition, behaviors that are practiced to proficiency, particularly simple motor behaviors, begin to be processed lower in the brain, in the basal ganglia, brainstem and cerebellum (Ratey, 2001, p. 158). As the work is taken over by the cortex and lower areas of the brain, the hippocampus is freed for other processing (LeDoux, 2002, p. 107).

Because encoded memory is distributed across various neural circuits, it needs to be mapped to be retrieved. Neural circuits are mapped by various areas of the brain, such as the hippocampus, cerebellum, and basal ganglia (Ratey, 2001, pp. 142–143).

Once retrieved, memories of various aspects of an event need to be amalgamated. For example, memory of scent may be retrieved from one area of the brain, and memory of sound from another area. The hippocampus is involved in retrieval and consolidation of memories (Ratey, 2001, pp. 185–186, p. 194).

Functional Systems of Behavior

Many different functions are required to sustain life. Each function is supported by specific systems of behavior, which consist of interconnected neurological components (Norden, 2007, Part 1, p. 49). These systems provide the animal with a means to find and consume food, seek mates, or detect and avoid danger (LeDoux, 2002, p. 303). A few of the most vital systems involved in learning are the attention system, perception systems, the motor system and the limbic system.

The Attention System

At any given moment, a dog's perceptual systems are receiving a multitude of various inputs. It would be impossible for the dog's memory systems to process and store all of these inputs. Attention is the serial process by which the dog attends to only one input at any given moment, allowing processing and response to that input (Roberts, 1998, p. 28, p. 34).

Attention is required for learning to occur (Ratey, 2001, p. 123). Attention is given when a stimulus is surprising or relevant to the dog in that environment at that time. Attention is a serial process; if a dog's attention is divided, he will find learning more difficult (Roberts, 1998, p. 52, p. 62).

The attention process is comprised of (Ratey, 2001, pp. 115–120):

- **Arousal**: The animal becomes more alert. This is controlled by the reticular activating system, connecting the frontal lobes, limbic system, brainstem and sense organs.
- **Orientation**: The animal involuntarily orients to, and focuses on, the stimulus. This involves various brain components. For example, the posterior parietal cortex helps the animal to disengage from other stimuli. The basal ganglia and frontal parietal attention circuits help the animal shift the focus of attention to the new stimulus. Neurons in the thalamus inhibit other distractions.
- **Novelty detection**: The hippocampus compares the stimulus with stored memories to check its novelty. A stimulus or outcome that is novel, or otherwise triggers an emotional reaction such as surprise or excitement, will cause the hippocampus to store the memory (Lindsay, 2000, p. 238).
- **Assessment**: The frontal lobe uses the comparison to identify an appropriate response, and allows the animal to sustain attention. In the temporal lobes, the caudate nuclei and basal ganglia act to filter out background "noise," both internal and external, so that attention can be maintained. Meantime, the anterior cingulate gyrus helps coordinate the attention system and allows the animal to distribute attention when needed.

Attention is required for learning. Because of this, new learning is more easily introduced in a familiar environment, so the animal is not distracted by novel environmental stimuli (Lindsay, 2000, p. 209).

A novel stimulus attracts attention, leading to a stronger association (Roberts, 1998, p. 156). Once the stimulus is no longer novel, the association is less likely to be learned. Because of this, the first memory of a novel stimulus–stimulus or stimulus–response association is the strongest. This is referred to as *first-order learning*. First-order learning parallels Thorndike's "primacy" principle of learning.

If two stimuli are presented simultaneously, attention will be given to the stimulus of most interest, and association with that stimulus is likely to be learned. The more salient stimulus competes for attention with the other stimulus, so the association with the second stimulus is less likely to be learned. This is called *overshadowing* (Roberts, 1998, p. 146). For example, if a dog is taught to sit using a hand signal and the word "sit" simultaneously, the dog will likely learn the hand signal cue but not the word cue. This is because body postures are more relevant to dogs than language, so the hand signal will overshadow the verbal cue. To avoid overshadowing, one cue should be taught at a time.

If a verbal cue has already been learned, and the hand signal is given at the same time as the verbal cue, the hand signal will not be easily learned due to an effect called *blocking*. Attention to the previously learned cue blocks the learning of the new cue (Roberts, 1998, p. 147). To avoid blocking, the new cue should be given first, then the old cue. This allows the dog to pay attention to both the new and old cues, and begin to anticipate the old cue when the new cue is presented, leading to learning of the association between the new cue and the behavior.

In dog training, attention is often viewed as "watching". However, attention does not necessarily require watching. If that was the case, then blind dogs would not be able to learn.

Perception Systems

Perception is stimulation of the senses, which causes neural circuits to form and strengthen, leading to learning (Ratey, 2001, pp. 48–109).

Perception is not just the input collected by the senses. It is also the processing of that input by the brain (Ratey, 2001, p. 53). The sensory system provides the dog with a means to obtain input both from within his own body and from the world around him (Norden, 2007, Part 1, p. 172). The brain transforms these inputs into meaningful information and behavior (Lindsay, 2000, p. 74).

Environmental stimuli are received through the sense organs and relayed to the nervous system, where they are analyzed. The eyes do not see; they are receptors that transmit light waves to the brain, which builds a picture based on this transmission, filling in areas where information was not received. The ears do not hear; they transmit sound waves to the brain, which builds sound (Norden, 2007, Part 1, p. 55; Part 2, p. 18). What a dog sees and hears is a result of receptors, innate knowledge, learning history and the current state of his neurological system.

Each of these perceptual systems experiences a different world; a different aspect of a single experience. Working memory binds these perceptions together as one experience (LeDoux, 2002, p. 308).

Sensory capability is different in humans and dogs (Beaver, 1999, p. 43). In order to truly understand why a dog behaves the way he does, you would need to experience the world through his perception systems (Grandin, 2005, pp. 28–67). That is, not just through his eyes or ears, but through the brain components that process these senses.

It is not possible for a human to smell what a dog smells, hear what a dog hears, or see contrast, color and movement the way a dog sees. But we can make an attempt to understand the dog's senses, view the world from the dog's angle, and try to imagine why the dog behaves as he does (Grandin, 2005, pp. 1–67).

The Somatosensory System

Somatosensation (touch) is the earliest used, and possibly the most important, of all canine senses (Fogle, 1990, p. 26). A puppy's natural reflex of pushing his head into warm objects helps him keep close to his mother and littermates, and helps him find the source of milk (Beaver, 1999, p. 55). Without a sense of touch, the newborn pup would not survive.

Somatosensation relies on various specialized receptors that include thermoreceptors, chemoreceptors, mechanoreceptors and proprioceptors. These receptors carry information such as heat, itch and pain to the thalamus, which transmits it to the *primary somatosensory cortex*. This gives the dog information about both external and internal environments (Norden, 2007, Part 2, pp. 32–33).

Thermoreceptors are responsive to heat and cold. Chemoreceptors are responsive to chemical stimulation. Nociceptors are responsive to noxious or painful stimulation (mechanical, chemical or thermal) that may damage body tissue. Nociceptors elicit species-typical escape responses. They relay information through two pathways: the fast pain system and the slow pain system. The fast pain system results in immediate response because it travels directly to response systems in the brain, bypassing the limbic and learning systems. The fast pain system is associated with startle reaction, and is not affected by pain-relieving chemicals such as endorphins. The slow pain system, associated with throbbing or other constant pain sensation, travels through the limbic system, which causes a secretion of pain-relieving chemicals such as endorphins (Lindsay, 2000, pp. 150–152).

Mechanoreceptors are responsive to physical changes, such as pressure or the stretching of skin produced when hairs, such as the dog's vibrissae, are moved (Lindsay, 2000, pp. 150–151). Unlike humans, the dog has vibrissae (facial whiskers) above his eyes and on the sides of his muzzle. These areas of the skin have a high volume of blood supply and nerve endings, allowing dogs to sense air flow, current, and the shape and texture of objects (Fogle, 1990, p. 27). A disproportionate amount of the cortex is devoted to processing information received through whiskers (Norden, 2007, Part 2, p. 35).

Dogs respond differently to touch depending on socialization, prior learning, general physical condition, and current emotional state (Lindsay, 2000, p. 150). Generally, when a person gently strokes or massages a familiar dog, relaxation occurs. Massage stimulates nerve pathways, lowering levels of stress hormones such as cortisol and epinephrine (Ratey, 2001, p. 362). Tactile stimulation increases the activity of the vagus nerve, a cranial nerve that influences heart rate and food absorption (Ratey, 2001, p. 363). Chemicals such as oxytocin and endorphins are released by the hypothalamus into the pleasure centers of the brain (Norden, 2007, Part 2, pp. 145–146). Oxytocin is a chemical known to facilitate the bonding of mother and child, and endorphins cause a state of euphoria (Ratey, 2001, p. 245, pp. 328–330).

Proprioceptors are responsive to body movement and position. Proprioceptors give the dog a perception of his body's position and allow him to coordinate movement (Lindsay, 2000, p. 152). The dog receives kinesthetic feedback from these receptors in muscles, tendons and joints (Roberts, 1998, p. 122). This provides fast moment-to-moment information about the body's movements and its orientation relative to the location of its different parts (Lindsay, 2000, p. 152). Balance is maintained by a combination of proprioceptors that provide information about the body's orientation in space, and hair-like receptors in the inner ear that bend in various directions when displaced by cochlear fluid when the head changes position. This gives the brain information about the orientation of the head relative to the direction of gravity (Lindsay, 2000, pp. 152–153).

Proprioceptive input stimulates brain cells. If a motor skill is practiced often, it will change the structure of the somatosensory cortex as neurons are recruited for the task. For example, violin players have additional area in the somatosensory cortex devoted to their fingers (Norden, 2007, Part 3, p. 31).

Physical exercises that stimulate proprioception can teach the dog body awareness. For example, lay a ladder on the ground and lead the dog slowly through it length-wise, on a loose leash or off leash. Or lay a dozen poles on the ground, as for cavalettis, but unevenly spaced and slightly skewed so the dog needs to pick his way through carefully, and send the dog through slowly. The poles can be raised slightly by setting the ends on crushed aluminum cans (Zink, 2006, Part 6).

The Visual System

Because they have evolved to hunt at dusk or dawn, dogs have less need for acute focus and color vision than do humans, and a greater need for low-light and movement vision (Beaver, 1999, p. 46). Otherwise, a dog's eyes are similar to a human's.

Light rays pass through the cornea and lens via the pupil. The eye focuses these rays onto the *retina*, a sheet of neural tissue at the back of the eye. Because the lens is convex, it reverses and inverts the image. But the brain will later correct this image (Norden, 2007, Part 1, p. 167).

The retina is made up of two types of visual receptors: rods and cones. Rods are specialized for low-light conditions, and receive information about contrast and movement. Cones receive information about color and detail. A dog's eye has fewer cones (color receptors) than a human's. Therefore, dogs are unable to uniquely identify certain colors in the spectrum that can be identified by the human eye (Beaver, 1999, p. 47; Lindsay, 2000, p. 128).

Because a dog's retina is comprised predominantly of rods, which are responsible for light collection, it is capable of collecting more light than a human retina. The dog's eye also contains a reflective surface behind the retina called the *tapetum lucidum*, which reflects light that enters the eye and causes a greater sensation of light (Beaver, 1999, p. 46; Lindsay, 2000, p. 130). When color differentiation is low and light-gathering capability is high, changes in contrast become more obvious than changes in color (Grandin, 2005, p. 43).

Compared with humans, dogs have poor close vision and reasonably good distance vision (Fogle, 1990, p. 33). Dogs are unable to focus on objects closer than 33–50 cm (Beaver, 1999, p. 46). Several factors affect the dog's ability to focus. Dogs have fewer cones, which are responsible for depiction of detail (Norden, 2007, Part 1, p. 167). Because a dog's eye collects more light, the retinal image becomes fuzzier (Beaver, 1999, p. 46). Unlike a human eye, a dog's eye does not have a *macula lutea*, which would enhance visual acuity (Beaver, 1999, p. 46). Dogs also have a larger lens-to-globe ratio than humans, making near focus more difficult (Beaver, 1999, p. 46). Functionally, the level of farsightedness in dogs is insignificant for their survival, because it would not affect the dog's ability to hunt (Beaver, 1999, p. 46).

A dog's eyes are set more on the sides of the head, less forward-looking, than a human's eyes. Because of this, a dog has a wider field of view than a human. Depending on the breed, the field of vision is about 240 to 290 degrees for a dog, but only 180 degrees for a human (Beaver, 1999, p. 46). This large field of vision allows the dog to easily scan his surroundings.

Overlap of vision from both eyes, at the front of the face, provides binocular vision and depth of field. Although dogs generally have better binocular vision than prey animals, they have less binocular vision than humans (Lindsay, 2000, pp. 130–131). In most breeds, the eyes are set closer to the sides of the face and less toward the front, providing about 40 to 60 degrees of overlap between the right and left eyes (Lindsay, 2000, pp. 130–131). Therefore, a dog's binocular vision is limited to a small angle in front of him (Lindsay, 2000, p. 131). In addition, dogs have about half as many uncrossed nerve fibers (needed to support binocular vision) as humans (Beaver, 1999, p. 46).

As predators, dogs are tuned to movement. Having more rods than cones causes the dog's eyesight to have less visual detail, but an increase in contrast and movement sensitivity, compared with the human eye (Lindsay, 2000, p. 130). A dog's wide field of vision also makes him more sensitive to peripheral movement (Fogle, 1990, p. 33). This attention to movement may explain why dogs have an "acute sensitivity to movement and subtleties of gesture" and are able to recognize individuals at a distance (Lindsay, 2000, p. 132). Typically, dogs are able to recognize moving objects at 810–900 meters, but stationary objects at only 585 meters (Beaver, 1999, p. 48).

Eyesight does not end with the collection of light. Axons from the retina form the optic nerve and transport information about received light rays to the thalamus. This, in turn, transports visual information to the visual cortex, where the image is processed (Norden, 2007, Part 1, pp. 174–179; Part 2, p. 4, p. 17).

Interpretation, including filling in blank areas, is an important factor in construction of an image in the visual cortex. For example, the spot in the back of the eye where the optic nerve exits has no receptors, so that area of the image is blank. The brain fills in the area based on information received and previously learned (Norden, 2007, Part 1, pp. 174–179; Part 2, p. 4, p. 17). This is why the dog "sees" with his brain, not his eyes.

The Auditory System

As with sight, sound is a creation of the brain. Sound waves enter the ear, vibrating the *tympanic membrane* (ear drum). This vibration is transmitted by a chain of three tiny bones, which focus the energy on the inner ear. The liquid in the inner ear transmits these waves across *hair cells*, auditory receptors in the inner ear. Auditory neurons increase or decrease their firing in response to this stimulation. The auditory nerve carries messages from the ear to the thalamus, which sends these messages to the *primary auditory cortex* in the temporal lobe. The auditory cortex interprets sound into meaningful information, such as pitch, tone, intensity and direction (Norden, 2007, Part 2, pp. 19–20).

Dogs can hear sounds in a broadly similar fashion to humans, except that dogs can hear at longer distances, have larger pitch ranges and are better able to locate the sound source. In addition, more of the dog's brain is devoted to sound than a human's brain is (Fogle, 1990, p. 31). Dogs can hear with much better source-location accuracy, because the pinna (outer ears) are controlled by muscles that allow the dog to move them individually, scanning the environment and collecting sound from various directions.

Locating sound relies on complex brain calculations based on the minute time differences between the sound waves reaching each of the ears (Lindsay, 2000, p. 134). If the location of a sound is not equidistant from the two ears, it will arrive in the closer ear slightly before the opposite ear. This difference in sound arrival time is in the order of millionths of a second (Lindsay, 2000, p. 134).

Hearing is used to communicate, locate group members, and find prey (Serpell, 1995a, p. 260). An important function of hearing in dogs is the ability to avoid danger. Intensity of sound helps determine the immediacy of danger, so auditory sensors are well connected to the limbic system. The auditory system is connected to the thalamus and cortex. These are connected to the amygdala, which in turn connects with the brainstem areas that control fear responses. When a dog hears a loud or sudden sound, the amygdala determines the intensity of sound through its connection with the thalamus (the quick route), and activates a startle response if appropriate. The slower route, through the cortex, is then engaged to assess appropriate action (LeDoux, 2002, pp. 121–123).

The Olfactory System

The sense of smell is an important sense for dogs (Thorne, 1995, p. 107). A dog's olfactory sense is used for detection of prey animals, social functions such as scent marking, food identification and other, less understood functions, such as scent rubbing (Beaver, 1999,

p. 55; Lindsay, 2000, p. 130, p. 137, p. 141; Thorne, 1995, p. 108).

A dog's sense of smell is approximately 10,000 times as sensitive as a human's (Beaver, 1999, p. 52). His sense of smell is so powerful and precise that a dog can detect a variety of substances at concentrations up to one hundred million times lower than humans can perceive (Thorne, 1995, p. 107). This is due to physiological differences in the olfactory perception system.

In dogs, the olfactory epithelium (the surface inside the nasal cavity that contains scent receptor cells) has up to 250 million receptor cells (depending on the breed). In humans, the olfactory epithelium contains only about 5 million receptor cells per nasal cavity (Lindsay, 2000, p. 137). Dogs also produce far more nasal mucus (the medium used to capture scent molecules) than humans (Fogle, 1990, p. 36).

The sniffing action (a disruption to the regular breathing pattern) causes air to be taken into the nostril and passed over a bony structure called the *subethmoidal shelf* (a structure humans don't have) on its way to the scent receptors. Air above the subethmoidal shelf is retained when the dog expires air, allowing scent molecules to accumulate. Scent molecules are dissolved in mucus, which sticks to the receptor cells in the olfactory epithelium (Fogle, 1990, p. 36).

Unless the scent is directly in front of the dog's nostrils, there is a minute time delay (in the order of tenths of a millisecond) between scent molecules entering one nostril and reaching the other nostril, allowing the dog to calculate the general direction of origin of the odor (Lindsay, 2000, p. 143).

The dog's brain is specialized for olfaction. In humans, the olfactory bulb is about the size of a raisin and is connected to the scent organs through fibers entering from the front. In dogs, the olfactory bulb is about the size of a plum, and is connected to the scent organs through fibers entering from the sides, above and below (Beaver, 1999, p. 52). Neurons in the olfactory bulb can be generated throughout life (Nicholls et al., 2001, p. 494).

Signals from scent molecules are registered by olfactory receptors and travel to the olfactory bulb. These signals travel to the *primary olfactory cortex*. From there, signals travel to the thalamus, which transmits them to the orbitofrontal cortex for associative processing. The signals also travel directly from the olfactory bulb to the amygdala, hippocampus and other areas of the brain. In this way, scent bypasses higher cognitive function for faster access to centers that process emotion (Lindsay, 2000, p. 79).

Dogs have a second olfactory system called the *vomeronasal organ* (VNO) (Beaver, 1999, p. 54). The VNO is located in the back of the palate. Ducts flow from the mouth, behind the upper front teeth, into the VNO (Lindsay, 2000, p. 145). Flehman behavior (licking, mouth smacking and tongue flicking) opens the ducts to allow pheromones, particularly those related to sex hormones, to access the VNO (Beaver, 1999, p. 54; Lindsay, 2000, p. 145).

The olfactory system is directly connected to the amygdala, allowing scent to arouse memory and emotion (Ratey, 2001, p. 62, p. 331).

The Gustatory System

In dogs, taste is important for food selection and digestion. For an omnivorous animal like the dog, the ability to safely select a variety of foods provides nutrition for survival in times of scarcity (Thorne, 1995, p. 111). Taste also triggers the appropriate digestive juices in the gastrointestinal system (Lindsay, 2000, p. 149). This prepares the dog's digestive system for action.

Taste for humans and dogs is apparently similar and includes sweet, salty, bitter and sour (Beaver, 1999, pp. 50–51). However, the sense of taste in dogs is not as refined as in humans. Dogs have only 1,706 taste buds, whereas humans have around 9,000 (Fogle, 1990, p. 28).

Taste is functioning at birth and is closely related to the sense of smell; both are chemical senses (Fogle, 1990, p. 28). Taste preferences are innate, but are also affected by experience, including prenatal experience. Amniotic fluid and the milk from a lactating bitch my contain food flavors that affect early food preferences (Thorne, 1995, p. 109). If a dog is not exposed to novel foods early in life, he may develop preferences for familiar foods and avoid novel foods (Fogle, 1990, pp. 28–29; Lindsay, 2000, p. 148).

Taste is mediated by an area of the hindbrain called the *nucleus of the solitary tract*, which connects with neurons from the taste buds spread across the tongue, and nerves from the gut that report on the state of the stomach and intestines, such as nausea. Taste buds are washed with a coating of saliva that brings the taste receptors to baseline (no firing, so no taste). When a tastant is mixed with saliva, it can either excite or inhibit taste receptors, and a taste sensation is generated (Lindsay, 2000, p. 146). Information from the taste buds is transmitted through cranial nerves to specific areas of the brain. Many of these pathways go to cortical areas responsible for the conscious experience of taste.

One specific pathway, which carries information to the amygdala (a part of the emotion-processing system in the brain), may be responsible for taste aversion (Lindsay, 2000, p. 146). Taste aversion is an unusual conditioned response, in that the association can occur even if nausea is experienced much later (hours rather than seconds) after the stimulus is experienced (LeDoux, 2002, p. 127). Pairing of taste with nausea, and detecting novel tastes, are likely the function of several areas, including the thalamus, amygdala and taste areas of the cortex. These are connected by projection neurons to an area of the midbrain called the parabrachial nucleus, to which the solitary tract projects neurons (LeDoux, 2002, p. 128).

The Motor System

Movement is central to behavior because it allows the dog to act on the world around him (Norden, 2007, Part 2, p. 126; Ratey, 2001, p. 148). The motor system, which controls movement, can be divided into three subsystems (Norden, 2007, Part 2, pp. 62–63):

- The *pyramidal motor system* primarily initiates motor movement. Neurons in the motor cortex project axons that synapse with motor neurons in the spinal cord.
- The *extrapyramidal motor system* controls subconscious motor programs and some forms of learning. Neurons in the motor cortex act as feedback circuits, projecting to other areas of the brain, such as the basal ganglia and cerebellum, to send information about intended movement.
- *Indirect corticospinal pathways* are involved in foundational functions for movement, such as maintenance of background tone in antigravity muscles. Neurons in the motor cortex project axons to areas such as the brainstem, which then project to the spinal cord.

In order for the dog to move his right leg, the left cortex sends signals through the various subsystems to coordinate the movement. Signals of the intended movement travel through the pons to the cerebellum, which combines that information with sensory input, such as proprioceptive input, to coordinate the movement (Norden, 2007, Part 2, pp. 76–77). Signals are sent down the spinal cord to the motor neurons that project their axons to the muscles of the right leg. Excitatory signals cause a specific set of muscles to contract, and inhibitory signals cause the opposing muscles to relax. As a result, the limb moves (LeDoux, 2002, p. 41; Norden, 2007, Part 1, pp. 54–55).

Learning a motor skill involves multiple senses and multiple areas of the brain (Ratey, 2001, p. 204). For a dog to learn to trot in heel position requires the use of his ears to listen to verbal cues, eyes to see the terrain, somatosensory organs to know where his body and limbs are, and muscles in the legs to perform actions in a synchronized manner. What appears to be a simple behavior to teach involves orchestration of the auditory, visual, somatosensory and motor systems.

Two primary areas of the brain that support motor movement are the cerebellum and the motor cortex (Ratey, 2001, p. 163).

The cerebellum is a critical component of the motor system. Its importance is highlighted in that, although it is a fairly small portion of the brain, it contains about half the brain's neurons (Norden, 2007, Part 2, p. 76). The cerebellum collects information about the body's movement and position in space, to support equilibrium and posture, regulation and timing of motor movement, and learned skilled motor movement (Norden, 2007, Part 2, p. 76; Ratey, 2001, p. 163). The learning of fine motor skills involves special cerebellar neurons, called *Purkinje* neurons, which synchronize movement (Norden, 2007, Part 2, p. 77).

When a motor activity is performed often, it recruits a greater area of the brain for its processing (LeDoux, 2002, p. 304). In this way, what a dog does changes the topography of his brain. The neurons in the motor cortex reconfigure themselves with each new motor skill (Ratey, 2001, p. 165). For example, in a study of monkeys taught to maintain hand contact with a rotating disk, the brain regions responsible for touch at the fingertips reorganized; additional neurons were recruited to better support the behavior (Jenkins & Merzenich, as cited in Ratey, 2001, p. 170).

"Motoring through" is a process by which the animal practices the basic motor skills needed to perform the task. The animal learns the behavior through patterning (repetition of a behavior or chain of behaviors), which strengthens neural connections needed to perform that task (Ratey, 2001, pp. 298–299).

Within 6 hours of practicing a new motor skill, the learning can be consolidated and moved from the prefrontal cortex to areas of the brain responsible for permanent motor skills, such as the premotor cortex, posterior parietal cortex and cerebellum. It may be that teaching a second motor skill within this 6-hour window, while the brain is attempting to consolidate the learning of the first motor skill, may impair the learning of the first motor skill (Ratey, 2001, p. 179). More research is needed to support this theory. However, the optimal training plan may be one that teaches a single new motor skill, and then practices already learned motor skills, rather than teaching more than one new motor skill in a single day.

Physical Exercise

The most obvious benefit of motor movement is performing goal-directed behavior, to obtain what is needed and avoid what is aversive or dangerous. But movement is beneficial in other ways.

Physiological changes in the brain are required to support learning. Exercise supports these physiological changes by improving blood circulation and lung function, thereby increasing oxygenation, release of glucose, and removal of waste products (Ratey, 2001, p. 35, p. 359).

Learning complex movements strengthens neural circuits in the cerebellum, which can improve balance, coordination and social skills (Ratey, 2001, p. 360). Feedback from motor activity produces neurological development that prepares the brain for further learning (Ratey, 2001, p. 179).

Prolonged rhythmic motor activity, such as 20 minutes of trotting, helps bring the sympathetic and parasympathetic systems into balance. Exercise increases levels of norepinephrine, dopamine and serotonin. This promotes a sense of wellbeing by decreasing pain and providing a feeling of elation, and results in an increase in social responsiveness, motivation, attention and reward-seeking behaviors (Ratey, 2001, p. 314, pp. 360–361). Regular exercise (5 days per week, 1 hour per day) over a period of time (6 weeks or longer) can produce more stable physiological results (O'Heare, 2007, p. 334).

The Limbic System

The limbic system is involved in learning, memory, emotion and executive function (Norden, 2007, Part 1, p. 50). Mood and temperament are subject to limbic system activity (Norden, 2007, Part 2, p. 137). It is the limbic system that gives the dog his unique personality and allows him to engage with the world around him.

The dog's ability to make decisions, such as in goal-directed behavior, is dependent on functions of the limbic system (Norden, 2007, Part 2, pp. 126–127). Therefore, the limbic system plays an important role in learning.

This system allows the dog to associate emotion, such as pleasure or fear, with various stimuli (Norden, 2007, Part 2, p. 129). If a training session is pleasant, the pleasant emotions are associated with the learning. Place preference, for example, is created when an animal experiences positive reinforcement often in a certain place, and therefore seeks out that place (LeDoux, 2002, p. 245). A positive CER can be created by associating an object (place, person, etc.) with something that elicits anticipation or joy, causing the presentation of that object to elicit the same pleasant emotion.

A negative CER can be created by associating an object (place, person, etc.) with something that elicits pain or fear (Roberts, 1998, p. 128). If a training session is unpleasant or evokes fear, unpleasant or fearful emotions are associated with the learning. If the training session involves both pleasant and unpleasant emotions, both of these are associated with the learning (Rosales-Ruiz, 2007, January).

The limbic system is a complex "super system" that integrates many areas of the brain (Norden, 2007, Part 2, p. 126). It is organized as complex feedback circuits that provide moment-to-moment mood regulation. A few primary components of the limbic system are the amygdala, ventral tegmental area (VTA), hippocampus, hypothalamus, thalamus, nucleus accumbens, orbitofrontal cortex and reticular formation (Norden, 2007, Part 2, pp. 123–136; Ratey, 2001, p. 227). The limbic system is situated alongside the cerebellum and basal ganglia, which are responsible for control of basic movement, primitive reactions, and learned reactions that have become automatic (Ratey, 2001, p. 162).

Various neurotransmitters are involved in the limbic system, including glutamate, GABA, serotonin, dopamine and norepinephrine (Norden, 2007, Part 2, p. 137). Neuromodulators that support the limbic system include opioids and oxytocin (Norden, 2007, Part 2, p. 137).

The limbic system can be activated more quickly than the frontal cortex (Ratey, 2001, p. 314). When the limbic system is active, the frontal cortex is suppressed. Areas of the brain that process learned behaviors—higher brain areas—are suppressed and the areas of the brain that process automatic behaviors—lower brain areas—are activated (Ratey, 2001, p. 172). The dog becomes less able to learn, and less able to process and perform already learned behaviors that have not yet become automatic, and more likely to perform a freeze, flight and/or fight response. This is because the release of norepinephrine and dopamine in the frontal cortex inhibits its activity (Lindsay, 2000, p. 112, cited in O'Heare, 2007, p. 104). Therefore, a dog in a highly emotional state, such as fear, aggression, anxiety or overexcitement, does not learn well.

Alternatively, when the frontal cortex is active, the limbic system is suppressed (O'Heare, 2007, p. 104). If a dog practices known behaviors, the learning areas of the brain become active and the primitive survival-response areas of the brain are inhibited (Norden, 2007, Part 3, p. 59). This is why keeping a dog working on operant behaviors helps reduce emotional reactivity, as long as the dog is not already in an emotionally aroused state.

Sympathetic and Parasympathetic Nervous Systems

A dog's *threshold* is the point at which the dog becomes emotionally aroused. Neurologically, emotional arousal causes the release of various neurotransmitters and hormones that prepare the dog for action. Physiologically, emotional arousal causes responses such as tensing of muscles as the dog becomes ready for action, increase in heart rate and breathing, and pupil dilation. Thresholds vary depending on the breed, individual, learning history, and current internal state (levels and combinations of various hormones and neurotransmitters).

Emotional arousal is mediated by the *sympathetic* and *parasympathetic* nervous systems. These two systems work together to maintain homeostasis in the body, providing the dog with the ability to perform behaviors for survival in a changing environment. Nerves belonging to each of these systems regulate internal organs, preparing them for imminent behavior patterns in response to certain stimuli—for example, responding appropriately in social situations, fleeing from danger, or digesting food (Ratey, 2001, pp. 171–172, p. 229).

The sympathetic nervous system prepares the body for emergency action, such as freeze, flight or fight. In a stressful situation, the sympathetic nervous system is activated. This, in turn, activates a system called the *hypothalamic–pituitary–adrenal* (*HPA*) axis, which controls the release of stress hormones. The hypothalamus releases a peptide called *corticotrophin-releasing factor* (*CRF*). This causes the pituitary gland to release *adrenocorticotrophic hormone* (*ACTH*), which causes the *adrenal glands* (anterior to the dog's kidneys) to release epinephrine (adrenaline) and cortisol into the bloodstream. Epinephrine results in increased alertness, muscle stimulation, increased heart rate, and other physiological changes that provide a means of defense.

Cortisol acts on various parts of the body to cope with stress (Ratey, 2001, pp. 171–172, p. 229). When it reaches the brain, cortisol binds to receptors in the hippocampus. In a normal individual, the hippocampus will respond by sending signals to the hypothalamus to stop releasing CRF, which halts the release of cortisol. The hypothalamus activates the parasympathetic nervous system, which prepares the body for ongoing regenerative activities such as digestion and immune response. Chemicals that calm the body, such as dopamine, are released. The heartbeat slows, digestion resumes, and the body is returned to its normal state (Norden, 2007, Part 3, pp. 148–149; Ratey, 2001, pp. 171–172, p. 229).

The sympathetic and parasympathetic systems generally maintain homeostasis. However, some animals can be more nervous (have a more active sympathetic system) and some more calm (have a more active parasympathetic system) (Lindsay, 2000, pp. 79–89). A more active sympathetic system results in a lower stress threshold.

Emotion

Emotion is a core function of the limbic system. Through emotion, the limbic system guides reasoning and supports social intelligence (Ratey, 2001, p. 292, p. 310).

Emotional information influences attention and working memory processes, thereby biasing decision making (LeDoux, 2002, p. 253). In this way, emotion plays an important role in learning and in executive function (Norden, 2007, Part 1, p. 56).

Emotional arousal causes attention to be focused on the event, and activates areas of the brain involved in processing of that type of event. Emotionally charged information travels from the thalamus to the amygdala through a direct pathway, bypassing the cortex. This inhibits other areas of the brain; resources are redirected to the emotionally arousing event. In this way, any learning that occurs is relevant to the current emotional situation (LeDoux, 2002, pp. 320–322).

Emotion systems learn by association based on respondent conditioning: one stimulus acquires the emotionally-arousing qualities of the other stimulus. The amygdala, temporal lobes, posterior medial orbital cortex and frontal lobes work together to attach emotional significance to stimuli (Ratey, 2001, p. 313).

Response to emotion systems can become operant when the animal chooses to take action to either avoid or approach the stimulus (LeDoux, 2002, p. 303). Components interconnected with the limbic system, such as the anterior cingulate gyrus, are involved in motivation and choice behavior (Ratey, 2001, p. 165).

Memories of emotional events are processed independently of the events with which they are associated (Ratey, 2001, p. 211). This makes the encoding and retrieval of emotionally charged memories different from that of non-emotional memories (Ratey, 2001, p. 209).

There is a close relationship between emotion and movement (Ratey, 2001, p. 162). Both these words have their roots in the Latin word *movere*, meaning "to move" (Ratey, 2001, p. 227, p. 247). Movement resulting from emotional input is under different control from movement resulting from activity of the cortex (Ratey, 2001, p. 175). Outward movements that result from emotion include everything from facial expression to erection of body hair to fleeing from predators (Ratey, 2001, p. 228).

Pleasure

The *endogenous reward system* is responsible for the subjective experience of pleasure. This system detects novelty and assigns emotional value to rewarding stimuli. Operant responses are motivated by reinforcers because of the endogenous reward system (LeDoux, 2002, p. 246).

Learning and motivation are intertwined (LeDoux, 2002, p. 237). Motivation is goal directed, and learning is the means of knowing how to achieve a specific goal (Ratey, 2001, p. 247).

Goal-directed behavior involves many areas of the brain, for processing perception of both internal and external stimuli, assessment using current and stored information, and the motor ability to respond. Goal-directed behavior involves decisions based on emotion (Ratey, 2001, p. 244). A behavior that leads to positive reinforcement, for example, evokes pleasure in the endogenous reward system, so that behavior becomes operant (Norden, 2007, Part 2, p. 173).

The endogenous reward system is activated during events that bring pleasure and contribute to a sense of wellbeing, such as when seeking food or a mate, or during aerobic exercise. Anticipation paired with uncertainty results in the greatest activation of the endogenous reward system (Norden, 2007, Part 2, p. 174). This is why intermittent schedules of reinforcement are effective in maintaining a learned behavior.

Feelings of anticipation and pleasure are caused by monoamines in the areas of the brain that make up the endogenous reward system (Norden, 2007, Part 2, p. 164). The system is governed by a group of neurons that contain dopamine. This includes the VTA, nucleus accumbens, and orbitofrontal cortex (Norden, 2007, Part 2, pp. 164–166). The nucleus accumbens is connected to the amygdala and is involved in the control of movement—a link between emotion and motivation (LeDoux, 2002, p. 247).

Acquisition of something rewarding, including the reinforcement of avoiding an aversive, is associated with dopamine activity. Dopamine invigorates behavior by activating motor systems, and directs behavior by activating the amygdala and other motivational systems, such as the endogenous reward system (LeDoux, 2002, p. 249; Norden, 2007, Part 2, p. 171). Because of its role in the endogenous reward system, dopamine is important for the associative functions of learning.

The hypothalamus, septum and nucleus accumbens are several such pleasure centers, and each of them use dopamine as a neurotransmitter (Ratey, 2001, p. 243). The VTA consists of dopamine-containing neurons in the midbrain that are involved in the endogenous reward system (Norden, Part 2, p. 123).

Dopamine is more involved in anticipatory behaviors, such as seeking food or mates, than in actual consumption (LeDoux, 2002, p. 246). A reinforcer can, therefore, be made more valuable when it is accompanied by anticipation—for example, marking the behavior with a clicker, then immediately beginning the act of delivering the food slowly. Alternatively, the food can be rolled on the floor to encourage a chase, as long as this does not distract the dog from the learning. These techniques make the act of delivering the food, in and of itself, highly reinforcing for the dog (Laurence, 2007).

Other pleasure neurotransmitters involved in the endogenous reward system are serotonin (a monoamine) and endorphins (Ratey, 2001, pp. 116–117).

The nucleus accumbens is connected to the limbic system, midbrain and forebrain. The outer shell of the nucleus accumbens, part of the extended amygdala, appears to be important in attention, motivation and learning (Ratey, 2001, p. 244).

The nature of the expected reinforcer defines the nature of the dog's "central emotional state" (Domjan, 2003, pp. 193–194). Punishment elicits a central emotional state of fear, whereas positive reinforcement elicits a central emotional state of hope. Fear and hope drive very different species-specific behavior systems; therefore, the consequence is an important consideration in operant conditioning.

Motivation is a means to achieve desirable goals and avoid undesired situations (LeDoux, 2002, p. 238). This is the basis of operant learning.

The senses perceive internal and external stimuli. The cingulate gyrus assesses the stimuli, with the help of the limbic system, and compares the results to stored memory. Conflicting goals are assessed, and the dog chooses to inhibit or exhibit behavior in order to seek positive reinforcement or avoid punishment (Ratey, 2001, p. 248).

Fear

Fear has an important biological role in keeping the dog safe from injury or death. Fear response has special attributes to support this biologically important role (LeDoux, 2002, p. 124; Lindsay, 2000, pp. 219–220):

- Some fears are biologically prepared and can be learned in one pairing, particularly as a result of an event that is—from the dog's subjective perspective—traumatic.
- Fear is easily generalized to other, similar, stimuli.
- Fear learning endures, possibly for a lifetime.
- Fear responses are elicited, not emitted. They occur reflexively (LeDoux, 2002, p. 236).

Sensory cells, such as auditory, olfactory and vision receptors, are closely connected to the amygdala. Innate associations of specific responses to specific stimuli are held in the brainstem, which is also connected to the amygdala, providing reflexive response. Direct connections flow from the amygdala to rapid response systems, which provide immediate control of the body. These systems initiate physiological changes such as increased heart rate and release of stress hormones, resulting in activation of the defense system (LeDoux, 2002, p. 161, pp. 288–289; Norden, 2007, Part 3, p. 53).

The amygdala ignores most input, through inhibition of cell firing produced by GABA. What is ignored and what is not depends on both innate and learned associations. When a stimulus is detected that signifies a biologically significant event (such as danger), enough glutamate is released to overcome the inhibitory effects of GABA, and the projection cells begin to fire. This initiates firing of cells in other parts of the brain, resulting in response. This excitation also results in firing of GABA cells, leading to an increase in GABA, which eventually calms the system down. Serotonin facilitates inhibition by exciting GABA cells, resulting in an increase in GABA (LeDoux, 2002, pp. 61–63, pp. 86–87). Different dogs can have different thresholds of arousal, in part because GABA production differs.

In an emotionally charged situation, a specific stimulus often stands out (LeDoux, 2002, p. 215). It is not always the stimulus that caused, or has any connection with, the emotional situation. With associative conditioning, intentional or otherwise, a stimulus can acquire the ability to elicit strong excitation of the amygdala, overriding the GABA produced in the lateral nucleus. This opens a floodgate of emotional reactivity (LeDoux, 2002, p. 215). Because of the power of associative conditioning, physical punishment, or any other consequence that causes pain or fear, should be avoided.

Because of the biological importance of the defense system, if a dog is above fear threshold, it is ineffective and inhumane to expect him to perform an operant behavior contrary to his defense mechanisms. For example, asking the dog to sit, heel or lie down and ignore the threat will only serve to reduce his trust in the handler and his environment and increase negative associations. It is more effective to remove the dog from the stressful situation and allow his body to return to homeostasis before requesting operant behaviors, then manage the environment so that he is unlikely to experience fear (L. Clifton-Bumpass, personal communication, October 18, 2007).

The Effect of Stress on Learning

Mild stimulation of the sympathetic nervous system triggers the release of noradrenaline, which facilitates memory consolidation (Joels, Pu, Wiegert, Oitzl, & Krugers, 2006, p. 154). Because of this, a small amount of stress having continuity and context with the association to be learned can focus attention, facilitating learning (Joels et al., 2006, p. 152).

Although minor stressors can facilitate learning, traumatic or chronic stress causes physiological changes that impede learning (Joels et al., 2006, p. 154). Traumatic or chronic stress results in high levels of cortisol. Cortisol before or during an event can suppress LTP (Joels et al., 2006, p. 164).

A super-LTP moment, when a multitude of detail is stored in memory (called "flashbulb memory"), can be created during a traumatic event. However, the cost to the dog's ability to learn overall is high (Ratey, 2001, p. 192). Traumatic events can lead to chronic stress, which damages the nervous system.

Dogs that are exposed to traumatic or repeated stressful events, such as use of any stimulus that elicits pain, fear or anxiety, can maintain chronic levels of stress. Under chronic stress, the body's ability to maintain homeostasis begins to fail (Norden, 2007, Part 3, p. 149). Dogs under chronic stress are incapable of higher-level learning.

During chronic stress, cortisol remains elevated in the bloodstream. This causes increased neural activity. Neurons in the hippocampus bind with cortisol, leading to overexcitation. These neurons are depleted of glucose, which leaves them susceptible to damage caused by glutamate during the increased neural activity. Dendrites shrink and the neurons begin to die. In addition, neurogenesis (production of new neurons) ceases. As a result, the hippocampus shrinks. Working memory and spatial memory, which rely on the hippocampus, are adversely affected (LeDoux, 2002, pp. 278–279; Norden, 2007, Part 3, p. 149; Ratey, 2001, p. 211, p. 218).

Elevated levels of cortisol cause other damage as well. Neurotrophic factors, required for cell growth and synapse maintenance, decrease (LeDoux, 2002, p. 280). The body's immune system becomes depressed, DNA repair mechanisms decrease, and autoimmune mechanisms increase (Norden, 2007, Part 3, p. 149). Cortisol modulates serotonin's ability to excite GABA cells; therefore, elevated cortisol results in increased fear response (LeDoux, 2002, p. 64).

Traumatic or chronic stress also causes other chemical imbalances, such as depleted levels of serotonin, a chemical responsible for mood regulation. In both dogs and humans, this can result in disrupted sleep cycles, decreased immunity, inability to think rationally, oversensitivity to pain, lethargy and inability to experience reward or pleasure (O'Heare, 2003, pp. 13–26).

As a result of traumatic or chronic stress, learning and higher thought processes are temporarily suspended (O'Heare, 2003, p. 19). The prefrontal cortex becomes less active, as control of the neurological system is taken over by the defense system (Norden, 2007, Part 3, p. 59).

Impulse Control

Impulse control is choice behavior. Impulse control is learned when the dog begins to understand that self control is reinforced, and that delaying gratification is highly reinforcing (O'Heare, 2007, pp. 330–331).

Impulse control, and the ability to understand the consequences of behavior, involve the orbitofrontal cortex (Norden, 2007, Part 2, p. 132). Because activation of the limbic system suppresses processing in the frontal cortex, impulse control is difficult when the dog is in a highly emotional state. In order to practice impulse control, and avoid practicing impulsive behaviors, the dog should be kept below emotional thresholds. Emotional thresholds include excitement as well as fear.

Impulse control is an innate skill that is used, for example, in stalking behavior. As with any other skill, the neurons and muscles used for impulse control develop through practice. Dogs learn impulse control, not by practicing quiet behavior, but by practicing impulse control and then being allowed to achieve either the reinforcer they seek, or a reinforcer of higher value (Laurence, 2007).

Dogs can be taught to practice impulse control by tapping into stalking behavior through play exercises. For example, in the "whippits" play exercise, a toy is tied to the end of a rope attached to a lunge whip. The dog is allowed to chase the toy, but is only allowed to catch the toy if he stops to stalk it. When the dog stops to stalk, the toy lies still. If the dog is still for a moment or two, the toy jumps within the dog's reach (Laurence, 2007).

Teaching the dog basic skills such as focus, puzzle solving and body awareness will help him develop cognitive abilities that can be utilized instead of emotional responses, helping him learn to mediate his own level of arousal in any given situation (Laurence, 2007).

Dogs can display self control in many social situations. For example, when encountering an unfamiliar dog, person or situation, a dog may stop to consider a situation before moving forward. These "ponder" moments can be marked and reinforced using clicker training, causing them to become part of the dog's repertoire, therefore making self-control behaviors more probable.

Ponder moments can be used as a starting point to teach puppies an awareness of, and appropriate responses to, human body language (Laurence, 2003). By marking and reinforcing the correct response to a specific type of body language, the trainer can teach the puppy to recognize when a person is approachable and when a person should be ignored. For example:

- A person walks toward the puppy with arms folded or shoulders squared, perhaps striding quickly, not making eye contact. The puppy is clicked when he shows any "ignore" behavior, such as backing up a step, sitting quietly, or looking away.
- A person walks toward the puppy with arms outstretched or relaxed, and faces the puppy, perhaps making cooing "cute doggy!" sounds. The puppy is clicked and reinforced for interactive behavior such as moving forward a step, sitting, or making eye contact with the person.

Clicker-avid dogs sometimes find that throwing behavior is more reinforcing than stillness. To avoid continuous offering of behaviors, and to encourage impulse control, still behavior should be reinforced as often as necessary to make it a reinforcing choice (Laurence, 2005).

The Neurology of Critical Development Periods

How the brain develops is *epigenetic*: a result of both genetic and environmental influence (LeDoux, 2002, p. 82). It is thought that genes account for less than half of any given behavioral trait (LeDoux, 2002, p. 91). Because of the brain's plasticity, particularly in the formative period but also throughout life, environment plays an important role (LeDoux, 2002, pp. 66–67). Genes are switched on or off in response to environmental conditions. Genes make proteins, and these proteins affect the activities of other genes (LeDoux, 2002, p. 93).

Genes predispose, but they do not predetermine, how the brain becomes wired (LeDoux, 2002, p. 296). For example, dogs may be predisposed to predatory behaviors such as chase, grab and bite. But if livestock-guarding dogs that show predatory behavior are removed from livestock (and so are not allowed to practice the behavior) during the window of neurological development for this behavior in their breed (about 6 months of age), the behavior will fail to develop and they can later be returned to the herd (Coppinger & Coppinger, 2001, p. 221). Practicing the stimulus–response of eye-stalk behavior during the time the neurons that support this behavior are forming builds a stronger eye-stalk behavior. Without this practice during that window of time, eye-stalk behavior may not form.

A *critical development period* is a window of time during which specific stimuli produce long-term effects on behavior and effects that are resistant to change (Serpell & Jagoe, 1995, p. 82). If exposure to certain types of stimuli does not occur during a critical development period, specific learning opportunities are lost (Beaver, 1999, p. 137). Once the window closes, normal development cannot occur for that particular perceptual system or skill. Missed development in one area can affect other areas, causing them to develop abnormally (Norden, 2007, Part 1, p. 101).

The inherent plasticity of the neurological system allows changes in brain structure to continue on a moderate scale throughout a dog's life. However, early development is a time of substantial growth in the brain's structure. This growth includes the organization of neurons (the brain's gray matter) and the formation of myelin (the brain's white matter). This initial development provides a lifelong foundation for learning. It is why early exposure to as many varied stimuli as possible, including new people, environments, sights, sounds and smells, is critical to a pup's successful integration into society (Fields, 2008, pp. 56–57; LeDoux, 2002, p. 96; Lindsay, 2000, p. 35).

In the early stages of life, the brain is organizing itself, forming connections in response to both internal and external stimuli (Ratey, 2001, p. 23). As the brain takes shape, neurons multiply, segregate, and then differentiate into about 150 types. The tips of growing axons form growth cones (Nicholls et al., 2001, p. 497). As each axon elongates, it navigates toward its final destination, guided by chemical trails formed by glial cells that act as attractants or repellants (Nicholls et al., 2001, pp. 501–502). As they travel to various sites in the body, axons connect with other neurons or sensory cells along the way. For example, the axon of a visual neuron may grow from the visual cortex, located at the back of the brain, to meet a visual receptor, located behind the eyes. The axon of a muscle neuron may grow from the spinal cord to innervate a leg muscle (Nicholls et al., 2001, p. 501), and so on. Chemicals in the environment, both internal and external, can affect the growth of these neurons (LeDoux, 2002, pp. 68–69).

There are critical periods of neural development when growth and survival of neurons require proteins known as *growth factors*. Once the neurons are mature, growth factors are needed to regulate vital chemicals such as norepinephrine (Nicholls et al., 2001, p. 512).

After the axons have formed, they are *myelinated* (surrounded by a fatty protective coating called a myelin sheath) by glial cells (Norden, 2007, Part 1, p. 35). Myelination, which protects the neuron and increases the speed of the signal moving down the axon, occurs during the formation of the nervous system, and is not complete until long after birth (Norden, 2007, Part 1, p. 97, p. 125). The amount of myelination, and the nodes between myelin along the axon, dictate the speed of signal transmission. In this way, information reaches consolidation areas of the brain at precisely the correct time to form correct associations (Fields, 2008, p. 59).

Myelination in different areas of the brain occurs at different ages. Generally, myelination proceeds from the back of the brain to the front. Myelination of the frontal lobe does not take place until just prior to adulthood (Fields, 2008, p. 56). This is one reason juveniles lack impulse control.

More practice of a particular skill, especially at a young age while the brain is largely forming, produces more myelination in the areas of the brain that support that skill. Those areas become "packed" with myelin. Once an axon has been myelinated, the changes that can occur are limited (Fields, 2008, p. 57).

The mammalian brain has billions of neurons. Before birth, an animal has more neurons than it needs. In early life, *regressive events* occur: neurons that are weak, or that don't have proper connections with other neurons, are pruned. As a result, only about half of the original neurons survive. Regressive events occur as a result of both environment and genetics, to fine tune the neurological system for the functionality it needs in the current environment (Norden, 2007, Part 1, p. 135). Pruning of unused neurons and strengthening of stimulated neurons continues, on a smaller scale, throughout life (LeDoux, 2002, p. 74; Norden, 2007, Part 1, p. 107; Ratey, 2001, p. 26).

The internal and external environment affect whether or not certain neurons will live and others will die, which connections the surviving neurons will take, and so on. Stimulation, through experience, provides the nutrients neurons need to survive (Ratey, 2001, pp. 23–26). When an action potential occurs, the postsynaptic cell releases molecules called *neurotrophins*, which promote survival and growth of a neuron. Neurotrophins are taken up by the presynaptic cell, strengthening it (LeDoux, 2002, pp. 80–81). With stimulation, axons and dendrites branch and sprout new synaptic connections. Without stimulation, a neuron does not receive neurotrophins. Without neurotrophins, the neuron will retract and die. This is referred to as "neural Darwinism" (Edelman, 1987, cited in LeDoux, 2002, p. 73). Neural evolution is economical: it ensures that only the neurons necessary for the neurological system to function in the animal's environment survive, and that these neurons have the space and nutrition needed to continue to survive (Ratey, 2001, p. 280).

Perception is an important part of experience. Experience, through stimulation of all of the animal's senses, is particularly important during the critical periods of development. Each sense has its own time window for development, during which the neurons that connect to the sensory organs are organizing themselves. Use of the sense during the development window strengthens the neurons that support that sense, defining the ability to use that sense for the remainder of the animal's life. Senses that are enriched with a variety of stimulation during development will form stronger connections, with more synapses (Ratey, 2001, p. 35, p. 40).

If there is a disturbance in one of the senses during the period when that sense is being formed, it could impair development of that sense (Ratey, 2001, p. 54). For example, if one eye is covered with an eye patch during the development of sight, the neurons destined for the covered eye will retract and die. The neurons destined for the uncovered eye, which is receiving stimulation, will take over the territory left vacant by the neurons that retracted. If the covered eye does not receive stimulation during development of neural connections for sight, it will never gain the ability to see (Hubel & Wiesel, 1962, cited in LeDoux, 2002, pp. 76–77).

The adult brain has a subtle plasticity, supporting learning as a result of experiences throughout life (LeDoux, 2002, p. 96). The immature brain has extensive plasticity. Because the brain continues to grow and organize itself until just past puberty, behaviors are more easily learned at a young age. What the dog is exposed to during the formation of the neurological system affects that formation (Ratey, 2001, p. 340). Animals raised in enriched environments have significantly more synapses than those raised in a bare environment (Norden, 2007, Part 3, p. 31). This is why experience, through exposure to various stimuli during the critical periods of a puppy's life, is so important. These experiences help determine which neurons survive and thrive, and which axons are more heavily myelinated.

Critical Development Periods of the Domestic Dog

The critical periods of development identified for dogs can be identified as prenatal, neonatal, transition, socialization and juvenile. The age during which each period occurs varies between breeds and individuals, and some of these stages overlap (Serpell & Jagoe, 1995, p. 83). There are also adult and geriatric phases. However, these are not generally considered as critical as the other five periods, because the basic formation of the neurological system occurs from the prenatal period through puberty.

Prenatal Period

The prenatal period occurs while the pup is in the womb. Neurons are generated, and their basic patterns develop before birth (Norden, 2007, Part 3, p. 17).

Transplacental maternal influences affect the formation of the fetal nervous system (Serpell & Jagoe, 1995, p. 80). For example:

- Pups may be more reactive if the bitch is subjected to stressful experiences during pregnancy. This is thought to be caused by the effects of stress-related hormones, such as corticosteroid, on the developing fetus (Serpell & Jagoe, 1995, p. 80).
- Androgens in the womb, either from the mother or from male siblings, have been found to promote masculine traits in the offspring of female rats and mice. There may be a similar effect in dog pups (Serpell & Jagoe, 1995, p. 80).
- The gustatory receptors (taste buds) are developed before birth. Chemicals present in the amniotic fluid can affect these receptors, affecting the pup's food preferences (Thorne, 1995, p. 108).

Because of potentially lifelong effects on a pup's health and behavior, pregnant bitches should be kept in a low-stress environment and fed a variety of nutritious foods.

Neonatal Period

The neonatal period occurs from birth to approximately 2 weeks of age. During the neonatal period, the eyes, ears and motor skills are not yet fully developed, so the puppy uses his sense of touch, smell and taste to experience the world (Serpell & Jagoe, 1995, p. 80).

For innate behaviors to develop properly, they must be practiced within the critical development windows. For example, a puppy prevented from nursing within the first hours of birth may not develop the ability to nurse (Coppinger & Coppinger, 2001, p. 220).

For perception to develop normally, pups need to experience a variety of stimuli during the neonatal period. Puppies handled daily and exposed to noxious physical stimuli, such as cold, for short periods were found to develop coats faster, grow faster, develop motor skills and problem-solving ability earlier and open their eyes earlier. When tested in strange situations at a later age, pups exposed to various stimuli in the first 5 weeks of life were more confident, had better resistance to stress, were more emotionally stable and learned more easily. This suggests that early exposure to minor stressors produces adaptations in the dog's pituitary–adrenocortical system that allow him to cope more effectively in stressful situations (Serpell & Jagoe, 1995, p. 81).

During the neonatal period, breeders should have a program of puppy handling to encourage the pups to develop stability and resilience. Once a day for 3 minutes, each pup should be briefly exposed to mild stressors such as cold temperature and gentle back-and-forth rocking (Lindsay, 2000, p. 37).

Transition Period

The transition period occurs at the age of about 10 to 16 days and lasts for about a week. This period consists of a rapid transformation during which the patterns of neonatal behavior are replaced by more mature traits (Serpell & Jagoe, 1995, p. 81).

During the transition period, the eyes and ears open and the pup begins to gain motor skills such as the ability to crawl forward and backward, stand, walk and play-fight with littermates. He begins to show tail wagging and other social signals. He also begins to defecate and urinate without stimulation (anogenital licking) from his mother (Serpell & Jagoe, 1995, p. 81). The pup may also begin to stray from the nest box and eat solid food (Beaver, 1999, p. 138).

As with humans, some memories formed when the pup is very young may be subject to infantile amnesia (Roberts, 1998, p. 199).

Socialization Period

The socialization period occurs roughly between 3 and 12 weeks of age (Beaver, 1999, p. 138). There is a peak sensitivity between 6 and 8 weeks of age (Serpell & Jagoe, 1995, p. 83).

The socialization period is marked by maturation of physical, neurological, and behavioral features (Beaver, 1999, p. 138). The pup's brain begins to develop in the womb, and continues developing after birth. There are morphological changes during the puppy's first 6 weeks of life, such as increasing brain size. There are also physiological changes, such as the appearance or disappearance of various reflexes (Beaver, 1999, p. 69).

Between 2 and 5 weeks of age, the pup's hearing and sight develop. The eyes and ears open at about 2 weeks of age, and myelinization of the visual and auditory cortex begins (Beaver, 1999, pp. 44– 45, p. 72).

From 3 to 5 weeks of age, pups actively approach novel objects, including other dogs or people. Above 5 weeks of age, they become more wary of novel objects. This wariness peaks at about 12 to 14 weeks of age (Beaver, 1999, p. 138).

Social behaviors, such as attention- and care-soliciting, are learned during the period between about 4 and 14 weeks of age (Serpell & Jagoe, 1995, p. 83). Bite inhibition is also learned during the socialization period. As puppies play with each other, a hard bite from one pup will cause the other pup to yelp and immediately stop playing. The other pup learns that, in order to continue play, he must control bite pressure (Beaver, 1999, p. 59).

During this period, dogs form primary social attachments (Serpell & Jagoe, 1995, p. 81). The socialization experience determines the species with which the dog identifies. For example, livestock-guarding dogs housed with sheep during the socialization period develop a lifelong social bond with sheep (Coppinger & Coppinger, 2001, p. 104). If a puppy is exposed to other dogs and to humans during the socialization period, the pup will identify with both species (Serpell, 1995, p. 246). A dog who is not socialized during this period will be socially handicapped for the remainder of his life (Beaver, 1999, p. 140).

Some hunting and herding dogs develop predatory behaviors, such as eye–stalk–chase, during the socialization period. With these breeds, predatory behaviors such as eye–stalk are incorporated into social play (Coppinger & Coppinger, 2001, p. 116, p. 204).

Pups normally experience various stages of fear during the socialization period. The onset of wary or fearful behavior is thought to be a response to the start of stable learning (Beaver, 1999, p. 139). Pups initially begin to experience wariness and fear between 8 and 10 weeks of age. However, the onset and duration varies between breeds, and between individuals, due to individual development rates (Coppinger & Coppinger, 2001, p. 115). Pups not exposed to various stimuli during the socialization period develop neophobic responses that carry through adult life (Serpell & Jagoe, 1995, p. 96).

During this period, dogs develop lifelong coping mechanisms for novel stimuli. To provide a strong social foundation, breeders and dog guardians should plan controlled exposure to as many different types of stimuli as possible, beginning at about 3 weeks of age. The socialization plan should include exposure to various sounds, scents, environments, people and other dogs.

If possible, guardians should visit the litter of pups from the age of 5 weeks onward, handling the chosen pup to allow bonding to occur (Coppinger & Coppinger, 2001, p. 113). To avoid weight loss and increased risk of disease, and to ensure social skills are developed through interaction with the litter, pups should not be adopted until they are over 6 weeks of age (Beaver, 1999, p. 140).

Between the age of 8 and 12 weeks, puppies should be exposed to circumstances and conditions they are likely to encounter as adults (Serpell & Jagoe, 1995, p. 83). Exposure of as little as a couple of 20-minute sessions per week is sufficient for socialization to occur (Serpell & Jagoe, 1995, p. 82). During fear periods, exposure to novel stimuli should be reduced to a level where the pup is able to quickly recover and investigate. Fear periods should be avoided when planning necessary traumatic events, such as adoption or vaccination (Beaver, 1999, p. 139). In addition to social skills, pups should be given opportunities to continue to develop perception skills. For example, various surfaces to walk on and safe but challenging objects to climb help develop proprioception (Laurence, 2007).

Although there is a risk of exposure to disease during the first few months of life, the lifelong benefits of socialization outweigh the risk. Puppy parties can be organized to facilitate socialization. Parties should include a variety of novel stimuli, such as people with costumes and hats, children, elderly people, wheelchairs, balloons and umbrellas (Dunbar, 2003).

Pups learn lifelong skills during the socialization period, such as attention, self control and dog communication. Basic training during this period should include positive reinforcement of attention and impulse control. Puppies should be socialized in puppy classes with instructors that are knowledgeable in domestic dog behavior and learning theory.

Play builds social bonds, enhances social skills, relieves stress, strengthens physical coordination and hones motor skills (Ratey, 2001, p. 181; Zink, 2006, Part 7). Play between puppies/dogs that are familiar with each other is recommended. However, free play between puppies that are not familiar should be carefully considered. This is because the situation cannot be controlled, so the learning cannot be controlled (Laurence, 2007). Puppies who are bullied, even on a few occasions, can learn to be fearful. Puppies who bully successfully can learn to be more efficient bullies. Unless dog-to-dog play is what that dog's normal environment provides, puppies need to learn to communicate with each other, but not necessarily to play with unfamiliar dogs. It is far better to socialize puppies in a controlled manner—for example, by reinforcing polite and appropriate forms of greeting.

Juvenile Period

The juvenile period begins at about 12 weeks of age and lasts until sexual maturity (Beaver, 1999, p. 140).

Near the start of the juvenile period, the primary socialization window comes to a close, and the pup may become less tolerant of change. However, socialization should continue through the juvenile period to keep social behaviors strong (Beaver, 1999, p. 140).

Predatory motor patterns such as eye, stalk, chase and bite begin to display at about 7 months of age in most breeds (Coppinger & Schneider, 1995, p. 27). However, some breeds exhibit predatory behaviors much earlier. For example, border collies can begin to exhibit eye–stalk at around 8 weeks of age (Coppinger & Coppinger, 2001, p. 314).

During the juvenile period, social, physical and psychological skills are practiced and perfected. For example, the male dog may begin to raise his leg to urine mark (O'Heare, 2005, p. 31).

Puberty occurs between 6 and 18 months, slightly later in males than in females (Beaver, 1999, p. 200). At around 6 to 8 months, males experience a surge of testosterone (Lindsay, 2005, p. 306). Sex hormones are critical to the dog's development, such as growth plate closure of the long bones and modulating emotional reactivity. Because of this, neutering (spay or castration) before maturity (approximately 14 months of age) is not recommended (O'Heare, 2007, p. 347; Zink, 2006).

Behavior during the juvenile period, particularly as the dog becomes sexually mature, may be overly energetic and erratic, so the dog may have difficulty practicing self control. Hormone levels may play a role, since intact adolescent males produce several times the amount of testosterone as normal adults. Females, also, have hormonal fluctuations as they prepare for their first season (Diamond-Davis, 2004). During puberty, the prefrontal area of the brain is reorganized under the influence of hormones (Norden, 2007, Part 3, p. 17).

As with the socialization period, basic training during the juvenile period should include positive reinforcement of attention and impulse control. During this time, management of the dog and his environment should be used to avoid practice of undesired behaviors (Laurence, 2007).

The Neurology of Learning Principles

Attention (and therefore learning) can be affected by establishing operations, antecedents, salience of the stimulus and value of the reinforcer.

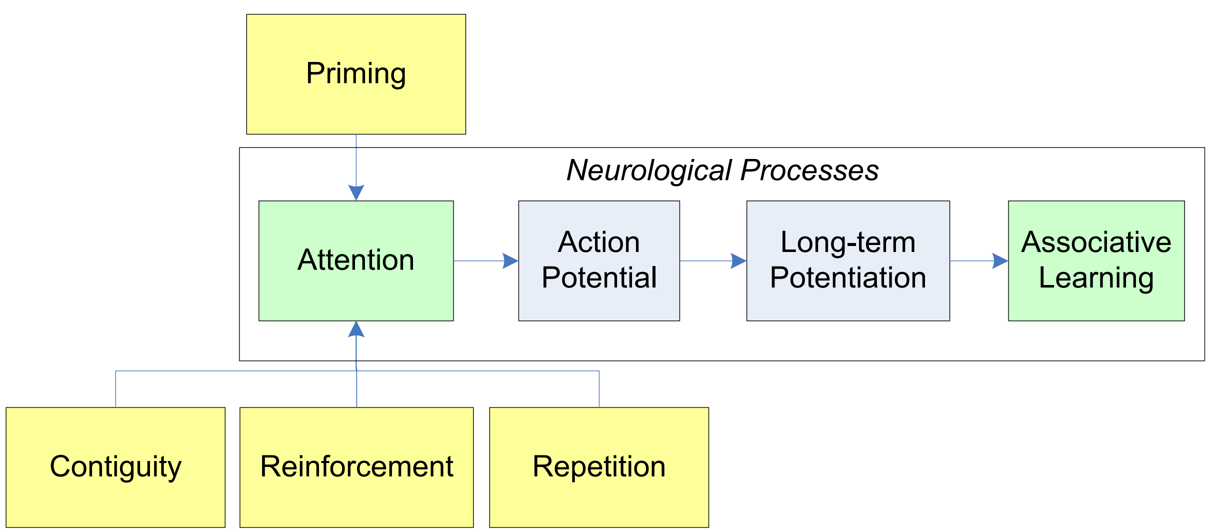

Figure 7: The neurological basis of learning principles

Associative Learning

Associations are vital for survival, because they allow the dog to predict different outcomes of certain responses in certain contexts (Roberts, 1998, p. 122)—for example, associating the scent of prey with hunting behaviors, and associating the scent of estrus with mating behaviors. Because of its evolutionary importance, association is a core function of the neurological system.

The memory of one event includes multiple components of perception, distributed throughout the brain (Ratey, 2001, p. 199). The various components of perception are glued together as one consolidated memory by the process of association, which allows the dog to link together stimuli that occur contiguously in time and space (Roberts, 1998, p. 165). For example, when the trainer praises the dog, she may also look at him with soft eyes, stroke his head gently, and say "good dog." The dog's memory of the trainer praising him may include visual, auditory, olfactory and somatosensory information.

Associations are made between stimuli, as well as between the absence of stimuli (Roberts, 1998, p. 133). Contextual stimuli, such as the surrounding environment, can also be included in the association of an event. This is because the hippocampus, which is aware of unattended background stimuli, is synaptically connected to the brain systems that mediate conscious awareness (LeDoux, 2002, pp. 131–132).

Certain associations are contraprepared, so learning them is more difficult. For example, dogs are biologically prepared to provide a predatory response to sudden, fast movement. However, "sit" is not part of the normal predatory response. Therefore teaching "sit" in response to a jerky, fast hand signal is not as easy as teaching sit in response to a calm, slow hand signal.

Associations are most easily learned when stimuli are contiguous (occur closely in time), are either similar or contrasting, occur frequently and are salient to the subject, such as when reinforcers result (Roberts, 1998, pp. 122–123). Some associations, particularly those that are biologically prepared or are linked with perceived life-threatening situations, can be learned in one experience. This is called *one-trial learning* (Roberts, 1998, p. 168).

Once an association is made, it can become generalized to other members of the same stimulus or response categories (Roberts, 1998, p. 358). This is the process of generalization. A cue is generalized if the dog is likely to perform the response if the cue is altered (Roberts, 1998, p. 142). For example, the dog sits when a verbal cue is given by various people.

There are various types of association. For example, cognitive mapping refers to the association of stimuli in space, and sequential mapping refers to the sequential association of stimuli (Roberts, 1998, p. 121).

Dogs have the ability to learn the order of events. This is called *serial learning*. Serial learning is important for motor function, which involve precise sequences of muscle activation (Roberts, 1998, pp. 266–267). In serial learning, the first response becomes a cue for the second response, which becomes a cue for the third response, and so on (Roberts, 1998, p. 268). Serial learning is apparent in any behaviors that involve sequences of movement—for example, dog sports such as obedience, agility, freestyle and flyball. Although dogs can respond to sequential and contextual cues, they may or may not be aware (have a "map") of the entire sequence (Roberts, 1998, p. 276).

Dogs can also learn associations based on both absolute and relational properties (Roberts, 1998, p. 163). For example, dogs can learn to choose a specific article out of three (absolute association) or to choose the article that is the same as the one presented (relational) (Ramirez, 2007).

Not all learning is immediately apparent. Some behaviors can be learned even though it appears no learning has taken place. This is called *latent learning*. Spatial learning provides a good example of this (Roberts, 1998, p. 160). While the dog is investigating new surroundings, he may be building a cognitive map. This learning may be apparent only later, when something of value is available to the dog for navigating this environment.

Hebbian Plasticity

Donald Hebb's theory of neural plasticity, referred to as *Hebbian plasticity*, explains the phenomenon of associative memory in terms of synaptic connectivity. For example, neuron *N* is postsynaptically connected to two other neurons: *S*, a strongly connected neuron, and *W*, a weakly connected neuron. Neuron *N* is likely to fire when *S* fires, but not when *W* fires. However, if both *S* and *W* fire together, *N* will fire, which will strengthen connections from N to both S and W. This strengthens W, and leads to a pairing of S and W (LeDoux, 2002, pp. 135–137).

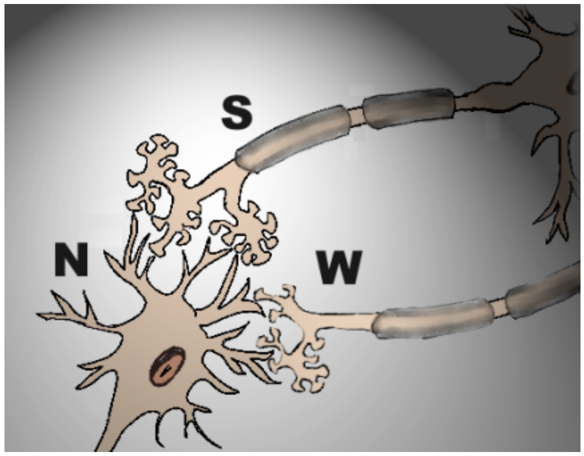

Figure 8: Hebbian plasticity supporting associative learning

Continuity and context are important because hormones and neurotransmitters need to be released near the relevant neural circuits involved in processing the memory, at the time the neurons are firing, in order to facilitate long-term potentiation (Joels et al., 2006, pp. 154–155).

Responses can be primed through this phenomenon, because the connection between two neurons is strengthened if the postsynaptic neuron is already active when the presynaptic neuron fires (LeDoux, 2002, pp. 135–137). The speed of perception can be increased by this type of priming (Roberts, 1998, p. 42). For example, a novel sound will prime the dog to better hear subsequent sound.

If certain contextual cues are strongly associated with specific behaviors, the dog will be primed to perform those behaviors in that context. For example, the sight of a tunnel or the sound of a teeter banging can prime a seasoned agility dog for an agility run. Unfortunately, contextual priming often backfires if the dog becomes so overwhelmed with excitement that he cannot follow basic handler cues.

Due to the neurology of association, the discriminative stimulus, response and reinforcer are connected in the dog's mind. Careful and thoughtful planning of the cue, behavior and reinforcement (including placement of the reinforcement) will help build correct behavior (Laurence, 2007). For example, if a behavior such as left-side heelwork is reinforced by feeding from the right hand, the dog may position his head in front of the handler to receive the food from the right hand after the click. The head coming around to the front of the handler will become part of the heelwork behavior. If this is an unwanted behavior, then it should be avoided in training.

Choice of a cue for a behavior should be made with the dog's perceptions in mind. Something that is salient to the handler may not be salient to the dog. For example, in teaching the dog to select a specific object from a group of objects, color may be salient to the handler. However, contrast or scent may be much more salient to the dog.

A set of small, consistent cues, taught to proficiency, is the most effective means of initiating behavior. Be complementary, not contradictory, in your body postures when working with the dog. Cues as subtle as the balance of the body can be used, if trained. For example, in heelwork, the careful and consistent turning of the shoulders (before changing direction) should be enough to cue the dog that the handler is about to turn (Laurence, 2007).

Poisoning the Cue

Respondent conditioning, a powerful means of associative learning, can cause pairing of punishment with environmental stimuli at the time the punishment is delivered. This can lead to directed or generalized fear. For example, if the dog forges out of heel position to greet another dog, and the trainer responds by jerking the leash and commanding "heel!", the dog may associate any or all of the stimuli in the environment with fear and pain. Associated stimuli may include the sight and smell of the other dog, the sight and smell of the trainer, the sound of the cue "heel!", and the sights, sounds and smells of the general environment. This is how cues, including contextual cues, can become poisoned. Resulting negative associations can lead to fearful or aggressive responses to one or more of the stimuli at a later time. For example, the dog may learn to respond aggressively upon sight of other dogs. Poisoning of cues is not yet well understood. However, because of the associative properties of learning, it is wise to avoid punishment in training (Pryor, 2002).

Memory Retrieval

It is possible for a memory to be available, but not be accessible. If the cue was not strongly associated with the behavior, the cue may not prompt the behavior. Cues can be multidimensional, involving both external and internal stimuli. For example, ambient stimuli such as lighting, scent and background noise may be part of the contextual picture associated with a specific behavior. The reinforcer can also become part of the contextual picture.

A dog's internal state fluctuates throughout the day, in response to both the internal and external environments (Roberts, 1998, p. 193). Kinesthetic feedback, such as position and movement of the body in space, and physiological state, such as fluctuations in hormones and neurotransmitters that occur as a result of expectation, stress or *circadian rhythms* (daily cycles of biological change), can be associated with other stimuli or responses. When this occurs, these internal stimuli become part of the memory retrieval cue package for that response (Roberts, 1998, pp. 121–122, pp. 190–193). This is referred to as *state-dependent memory*; the inability to retrieve a memory learned in one state when in a different state (Roberts, 1998, p. 190). This is why the dog may be more likely to respond correctly to a cue at a certain time of day, and why antecedent control affects learning.

To avoid association of contextual cues, present the cue in varying contexts. To reactivate a memory that has become dependent on contextual cues, present the cue in the same context (place, time of day, etc.) and practice it there until it is fluent. Ideally, vary external states and variables that impact internal states (such as time of day) individually over time.

If the behavior is not yet fluent, it may require warm-up. Provide the associated reinforcer prior to beginning the session. Rehearse the behavior a few times in the context with which it has a strong association, then immediately move it to a different context. The neurons that support that behavior will be primed by association with the contextual environment and by repetition, and so will be more likely to fire in the new context (Roberts, 1998, pp. 182–184). Regular retrieval also strengthens a memory (Roberts, 1998, p. 199).

Extinction

Reinforcements that are given indiscriminately, however well intentioned, teach behavior that may subsequently need to be extinguished (Laurence, 2007). For example, giving a dog a treat because he looks "cute," or laughing at something a dog does that is "cute," may be reinforcing a behavior that is inappropriate in daily life. Extinction of that behavior later would rely on a strong emotional response of frustration to alter the dog's expectation (Roberts, 1998, p. 151). Because of this frustration, extinction is an aversive process (O'Heare, 2007, p. 252). In addition, extinction has limitations because it relies on new learning, not forgetting. This is why extinguished behaviors can re-emerge during a phenomenon called *spontaneous recovery* (Roberts, 1998, p. 146).

Priming

Priming parallels Thorndike's "readiness" principle of learning. When a dog is motivationally prepared to act, he is more likely to perform that behavior and performance of the behavior is satisfying (Lindsay, 2000, p. 237). Antecedent control is the manipulation of motivational states so that the animal is prepared for specific behaviors (Lindsay, 2000, p. 250).

Antecedent control is effective, in part, due to neural priming. Monoamines regulate neurotransmission between neurons, but only at currently active synapses (LeDoux, 2002, p. 314). Monoamines magnify the cellular response, encouraging learning of the event that activated that particular set of synapses (LeDoux, 2002, p. 314). Neuromodulators, such as monoamines, affect the resting state of neurons, and therefore either facilitate or inhibit an action potential (Norden, 2007, Part 1, p. 145).

Behavior, and stimulus–stimulus and stimulus–response associations, are a result of the firing of networks of neurons. Networks of neurons that fire together are primed to fire together again. Antecedent control causes physiological changes that prime specific networks of neurons, increasing the probability of specific behaviors.

Neural circuits that support particular behaviors can be primed by antecedent control (Ratey, 2001, p. 161). In addition, undesirable behaviors can be avoided by avoiding antecedents that precede the undesirable behavior, or by changing these antecedents to elicit desired alternative behaviors (O'Heare, 2007, p. 278). For example, counterconditioning can be used to elicit joyful or relaxation responses in the presence of a stimulus that previously elicited fear or anxiety (O'Heare, 2007, p. 281).

Three basic categories of antecedent control are *setting events*, *establishing operations* and *discriminative stimuli* (O'Heare, 2007, p. 235).

Setting Events

Setting events, which can occur some time before the behavior, set the context for the behavior, making it more or less likely to occur (O'Heare, 2007, pp. 235–236). For example, stressors such as loud noise, even hours before training, may change the dog's physiological state so that he is more likely to react aggressively to physical prompting or other annoying events. Dogs deficient in serotonin may be prone to aggressive behavior. Aerobic exercise and supplementing the diet with 5-hydroxytryptophan (5-HTP), which is the precursor to serotonin, can increase serotonin, reducing the likelihood of aggressive behavior (O'Heare, 2007, p. 276).

Motivating Operations

Motivating operations cause reinforcers to become more or less valuable (O'Heare, 2007, p. 236). Motivating operations can be divided into two categories: *abolishing operations* and *establishing operations*. Abolishing operations temporarily decrease the effectiveness of a specific consequence. For example, feeding a dog his full meal before training using food treats as reinforcement will reduce the dog's motivation to perform the behavior. Establishing operations temporarily increase the effectiveness of a specific consequence. For example, training a hungry dog just before feeding time, and allowing the dog to sample the food treat to initiate the training session, will activate the dog's behavioral state for feeding, increasing motivation for food (O'Heare, 2007, p. 249).

A CER can become a motivating operation (O'Heare, 2007, p. 277). For example, a dog that has been trained using only positive reinforcement will associate the training context (handler, training area, training equipment such as the leash and clicker) with a joyful emotion, so will be motivated to approach and interact with the handler. A dog that has been trained using punishment, which entails aversion, pain or fear, will associate the training context with fear, so will be motivated to avoid or escape the training environment. A dog trained using both positive reinforcement and punishment will be conflicted between motivation to approach and motivation to avoid or escape.

Discriminative Stimuli

Discriminative stimuli are stimuli that, based on a history of reinforcement, allow the animal to predict that a reinforcer is likely to follow a specific behavior (O'Heare, 2007, p. 236). For example, the dog will respond by sitting when the handler says "sit" if that verbal cue has preceded the sit behavior on previous occasions, and the dog has been reinforced following the sit behavior. If a behavior is likely to occur following presentation of the discriminative stimulus, that behavior is under *stimulus control* (Roberts, 1998, p. 143).

The type of discriminative stimulus used for a specific behavior can affect the dog's motivation to perform that behavior. Some stimuli belong to a certain behavioral system, and therefore are a better choice as an antecedent for behaviors related to those behavioral systems (Domjan, 2003, p. 108). If the discriminative stimulus is relevant to the behavior, the learning will be better established (Ratey, 2001, p. 166).

The discriminative stimulus used affects the ease of learning the association between the discriminative stimulus and the behavior, and the discriminative stimulus and the reinforcer. For example, different auditory cues can elicit different states of behavior (McConnell, 2002, pp. 53–64):

- Short, repeated sounds (such as steady hand-claps) stimulate activity.
- Single, long, continuous sounds (such as the long, smooth "hoooooe" a horse rider might use to slow his horse) stimulate calm behavior.
- Sudden, short bursts of sound stimulate stopping behavior.

The magnitude of the discriminative stimulus can also affect the level of response, due to the level of attention the antecedent receives. For example, a soft clap of the hands may elicit a casual turn of the head toward the handler. A sudden, loud clap of the hands may result in a snap-turn of the head (Lindsay, 2000, p. 209).

If, at the start of training, the discriminative stimulus is a novel stimulus, it is more likely to gain attention and less likely to be overshadowed due to previous associations or learned irrelevance (Lindsay, 2000, p. 275).

Contiguity

Timing is critical for most associations. For example, if the dog chases a cat, then returns to the handler, and the handler scruff-shakes him, the dog will associate the cat with an exhilarating chase, and the handler with physical pain. The dog will be drawn to the cat, and repelled from (or conflicted by) the handler.

For a behavior to become operant, the dog must be able to predict what will occur if a specific stimulus is followed by a specific response (Roberts, 1998, p. 133). The start of reinforcement that begins immediately, within 0.5 seconds of the behavior, is more effective than delayed reinforcement. A delay between the response and the reinforcer disrupts learning because an animal can be performing many responses, and it is difficult for the animal to figure out which response earned the reinforcer (Domjan, 2003, p. 146). A marker that acts as a secondary reinforcer, such as a clicker, can be used to improve contiguity between the response and the primary reinforcer.

There are exceptions to the rule of contiguity in associative learning. Some associations may not require close contiguity. For example, taste aversion can be learned if nausea is experienced several hours after consumption (Roberts, 1998, p. 125).

Reinforcement

Reinforcement parallels Thorndike's "effect" and "intensity" principles of learning. Attention is required for a memory to be stored. Reinforcement causes the dog to be attentive. Therefore, a behavior that is reinforced is more likely to be learned. Aspects that affect the effectiveness of the reinforcer include the reinforcement schedule, value of the reinforcer, salience of the reinforcer, contiguity of the reinforcer, and contrast effect due to expectation. In addition, a phenomenon called the *Premack principle* can be used to build behaviors into reinforcers of other behaviors.

Reinforcement Schedule

A schedule of reinforcement is a rule that determines how and when a response, or set of responses, will be followed by a reinforcer. Schedules of reinforcement affect the animal's expectation levels and perception of reward, as well as the animal's choice of different response alternatives (Domjan, 2003, p. 162). Continuous reinforcement, where every occurrence of the target behavior is followed by a reinforcer, helps the animal know when it has performed the target behavior and when it has not. Continuous reinforcement is therefore ideal for teaching new behaviors. Intermittent reinforcement, where reinforcement is presented for some occurrences of the behavior but not all, is best for established behaviors because it inoculates the behavior against extinction (Roberts, 1998, pp. 148–151).

Value and Salience of the Reinforcer

A reinforcer that is novel or of high value or magnitude, or otherwise salient to the dog, will elicit attention, enhancing learning (Lindsay, 2000, p. 212). This is because a stimulus that is new, surprising, or of biological importance to the dog causes the hippocampus to choose to store the event in long-term memory, and therefore the association will be learned more quickly (Domjan, 2003, p. 117).

If a reinforcer of biological importance, such as food, is presented following a behavior, more neurons are recruited to support that behavior (Jenkins & Merzenich, University of California, San Francisco, cited in Ratey, 2001, pp. 170–171). Many dog trainers are too quick to wean the dog from reinforcement when teaching a new behavior. The physiology of learning, including the role of reinforcement in the learning process, is an important consideration when deciding when and how to move from continuous to intermittent reinforcement schedules. Reinforcement leads to accelerated learning and an increased level of retention (Roberts, 1998, p. 120).

Anticipation of a reinforcer maintains focus and is, in itself, reinforcing. Neurological aspects of anticipation can be used to increase the value and duration of reinforcement. For example, when the dog has performed the desired behavior, mark the behavior and begin the *process* of delivering the reinforcer immediately, but draw the reinforcement process out. Begin social reinforcement immediately following the click, using reinforcement through voice ("Gooood dog. What an excellent dog.") and facial expression. During this reinforcement, gradually move your hands toward the food treat pouch. Prolong the offering of the food reinforcer by breaking the tidbit into tiny morsels and hand feeding each piece accompanied by relaxed and pleasant verbal praise (Laurence, 2007).

Food and play are not the only reinforcers available to dog trainers. For social animals such as dogs, social approval and belongingness are reinforcing. Innate behaviors, such as predatory motor patterns (eye–stalk, chase, etc.), are intrinsically reinforcing, and so can be used as primary reinforcers in the form of fetch and tug games (Coppinger & Coppinger, 2001, pp. 202–205).

Certain behaviors naturally belong with a specific type of consequence because of the dog's evolutionary history (Domjan, 2003, p. 140). The expectation of a specific consequence can elicit specific species-typical responses. For example, expectation of food may elicit chewing or licking responses, and expectation of fast movement may elicit stalk-and-chase responses (Domjan, 2003, p. 199). If a stimulus elicits species-specific behavior compatible with the target behavior, learning will occur in fewer repetitions. However, if a stimulus instinctively elicits species-specific behavior incompatible with the target behavior, the stimulus can sabotage training of the target behavior (Domjan, 2003, p. 94). For example, use of a tennis ball to reinforce a sit behavior may instead elicit eye–stalk behavior, particularly in herding breeds. The dog may freeze and stare, rather than sit. Therefore, choosing a reinforcer that is relevant to the behavior supports learning (Ratey, 2001, p. 166).

Because of this, dog sports that require fast running are best reinforced with a stimulus that elicits a chase sequence, such as the fast, jerky movement of a fur-covered tug toy. Alternatively, behaviors such as obedience that require control may be best reinforced with hand-delivered food reinforcers, which elicit affiliative and consummatory responses.

Attention from the handler is reinforcing for the dog, because it predicts the opportunity to earn reinforcers (Laurence, 2007). However, excitement can be distracting, and therefore can inhibit learning. If a reinforcer generates too much excitement, it may distract the dog from the learning process. The dog may learn a simple task quickly, but may not be able to concentrate on learning a more complex task. When training, be calm during reinforcement. This will keep the dog calm and allow him to learn, rather than distracting him from the learning process (Laurence, 2007).

Contrast Effect

Switching reinforcers can affect the behavior, due to contrast effects caused by emotional reactions. If the dog expects a certain value of reinforcer, and a higher value reinforcer is presented, learning will increase because the comparator mechanisms in the dog's neurological system register a higher than expected reinforcer. This is called a *positive contrast effect*. If a lower value reinforcer is presented, frustration will result that can interfere with learning. This is called *negative contrast effect* (Roberts, 1998, pp. 152–153).

The value and relevance of the expected reinforcer affect the ease of learning. A dog will pay attention when a consequence is relevant (Lindsay, 2000, p. 275). Attention is required for learning to occur, and therefore the type of consequence affects the level of learning. As noted above, if a reinforcer generates a high level of enthusiasm, which could be distracting, a dog may learn a simple task quickly but may not be able to concentrate on learning a more complex task. If a reinforcer is of low value, but high enough to reinforce the response, use of that reinforcer will support learning (Lindsay, 2000, p. 249).

Context also plays a role in reward expectancy. The level of the response can be improved by the context of the situation. (Lindsay, 2000, p. 209) For example, a dog trained to sit for food treats is more likely to have a quick response to "sit" in places where treats have been commonly doled out, such as the kitchen or training area.

The anterior cingulate and orbitofrontal cortex allows the dog to compare the expected result with the actual result (Lindsay, 2000, p. 89; Ratey, 2001, p. 304):

- If the reinforcement is greater than expected, the experience will be surprising and pleasurable, and the behavior will be strengthened. Surprise causes an increase in learning (Roberts, 1998, p. 147).
- If the reinforcement is as expected, the experience will be pleasurable, and the behavior will be strengthened.
- If the value of the reinforcer was overpredicted, the dog will be disappointed, the experience will be aversive, and the behavior will be weakened.

With each consequence, the dog's expectations shift (Ratey, 2001, p. 304).

Delivery of the Reinforcer

Delivery of the reinforcer is an important aspect of learning. Delivery should be planned, so it can be used advantageously in training. For example, food delivered with speed, such as rolling it across the floor, elicits chase. This can increase the value of the reinforcer. Food delivered directly into the dog's mouth can have a more calming effect. In addition, if food is delivered with verbal praise, the quality and tone of the praise will affect subsequent behavior. For example, excited praise will cause more animated behavior, and calm praise will encourage more calm behavior (Laurence, 2007).

The position of the reinforcer is also an important part of the training plan. After each trial, reinforcer placement can be used to re-set the dog for the next trial. For example, in a "sit" behavior, the food can be placed on the floor one foot in front of the dog, causing him to stand. This positions him to perform another "sit" behavior (Laurence, 2007).

Premack Principle

If a reinforcer is of low value, but high enough to reinforce the response, use of that reinforcer will support learning (Lindsay, 2000, p. 249). Because of this, a response that is more likely to occur can be used to reinforce a response that is less likely to occur (Lindsay, 2000, p. 251). This is the *Premack principle*.

In dog training, a good example of use of the Premack principle occurs on an agility course. A dog taught to run through an agility tunnel may begin to find this a reinforcing event. The dog can then be taught to weave through a set of weave poles, then upon exiting the weave poles, be cued to run through a tunnel as a reinforcer.

The Premack principle can backfire if it is not well understood. This occurs in behavior chains where a desired behavior is preceded by an undesired behavior, or when a cue is given twice. A cue is an opportunity to earn a reinforcer. Therefore, a cue is, in itself, reinforcing. Cuing a desired behavior after an undesired behavior (or after a failed cue) reinforces not only the desired behavior, but also the undesired behavior (or failed response). For example, if you cue a sit and the dog jumps up, and then sits, you are reinforcing the chain of "jump up, and then sit" (Laurence, 2007).

Repetition

Repetition parallels Thorndike's "exercise" and "recency" principles of learning. Repetition builds and strengthens the neural connections that support learning (Lindsay, 2000, p. 248). Physiological changes occur when a behavior is repeated, making that behavior more likely to re-occur.

The motor cortex, with the help of the hippocampus, controls the performance of new motor skill. If a motor skill has been practiced to proficiency, it becomes automatic, and the processes that support it are transferred to *subcortical* (lower) areas of the brain, such as the striatum, cerebellum and basal ganglia. This frees the motor cortex and hippocampus for other processing (Ratey, 2001, p. 37, p. 157, p. 197). If a behavior has become automatic, it will be more difficult to extinguish. This is why it is important to use antecedent control to prevent the dog from practicing unwanted behaviors.

If the neurons that support a specific behavior are not used, their connections may gradually degrade, leaving that area free to process other behaviors (Ratey, 2001, p. 192). This is the "use it or lose it" concept. This is why it is important to continue to encourage the dog to practice desirable behaviors.

Although repetition is important for learning, a recent study (Meyer et al., 2007) involving dogs indicates that training once per week is more effective than training 5 days per week, when measured by the number of training sessions for behavior acquisition. For practicing a known skill, creating and maintaining muscle tone to support the skill may require practice several times per week. For example, trotting cavalettis to build a proper trotting gait (to avoid pacing) should be practiced 5 minutes per day, 6 days per week, for 3 months (Zink, 2006).

Short training sessions are more effective than long training sessions, since the animal can consolidate learning and return physically and mentally fresh. Short sessions also avoid satiation of the reinforcer, which supports motivation.

In some cases, thinking about performing a behavior causes the same neurons to fire as would fire if the animal performed that behavior. This is called neural mirroring, and occurs when a goal-directed behavior is rehearsed in the mind, such as when an animal watches another animal perform the behavior. Mirroring primes the brain to perform the behavior, because it stimulates the neurons that would perform, allowing rehearsal of the behavior. Mirroring has been proven in some species of monkey, as well as humans (Ratey, 2001, p. 147; Sylwester, 2002). Whether or not dogs have the capability to mirror, and for which types of behavior, would be a useful study. For example, dogs are social animals, and are masters at interpreting subtle body postures. Perhaps mirroring is one method dogs use to learn the meaning and intent of various body postures in other dogs.

Taproot Behaviors

Once a behavior becomes automatic, the memories that support that behavior can be stored for life (Ratey, 2001, p. 157). That is why it is easy to ride a bike as an adult if you rode bikes often as a child, even if you have not practiced in decades. It is also why a behavior that your dog has practiced is difficult to prevent: the behavior may have become so familiar that it is automatically performed in response to certain external or internal stimuli.

High levels of reinforcement, and a long reinforcement history, can be used to create *taproot* behaviors: responses that are so familiar they have become automatic. A practice record for taproot behaviors would look something like Figure 9. The primary (most valuable) behavior is listed in the middle of the practice record, with the secondary behaviors either side, and the tertiary behaviors on the outside (as in Figure 9). For each training session, an "X" is marked on the chart for the practiced behavior. Eventually, the practice record begins to appear as a taproot, with the primary behavior being the strongest, because it has the longest reinforcement history (White, 2005).

Come	Down	Watch Me	Sit	Heel
X	X	X	X	X
X	X	X	X	X
X	X	X	X	X
X	X	X	X	
X	X	X	X	
	X	X	X	
		X	X	
		X	X	
		X		
		X		
		X		

Figure 9: Example of "taproot behaviors" practice record

Taproot behaviors have a strong reinforcement history, with high rates of reinforcement, such that the dog performs them almost as an automatic response on cue and they are generalized to virtually all environments. These behaviors become so familiar that performing them feels comfortable to the dog, so they become intrinsically reinforcing. The dog is likely to choose taproot behaviors in times of social pressure or other stress.

Methods of Teaching

Our knowledge of the plasticity of the neurological system can be used to select the most effective method of teaching, to optimize learning. There are several common methods used in dog training to initiate a specific behavior: *physical prompting* (also called *molding* or *modeling*), *luring* and *shaping*. Physical prompting and luring are directed learning, whereas shaping is self-initiated learning. These three methods result in different neurological responses, and therefore result in different learning.

Physical Prompting

Physical prompts, such as pushing the dog's haunches down to teach him to sit on cue, do not support optimum learning. As muscles practice movement, the neurological network connected to those muscles strengthens (Zink, 2006). When a dog is pushed into position, neurons that control the opposing muscles are activated. In addition, the learning process may be disrupted because the physical pressure of hands on the dog's body can cause the dog to attend to that pressure, distracting him from the behavior of sitting (Arden, 2007, p. 26).

Luring

Luring is a quick way to prompt a behavior, to prepare the dog for repetitions of that behavior. However, the dog may attend to the lure rather than the behavior that is being taught. Because of this, lures should be faded in the first two or three repetitions, to allow the dog to initiate and attend to the behavior rather than the lure (Alexander, 2003, p. 76).

Shaping

Self-initiated behavior is more strongly learned than directed behavior, because the animal attends to the initiation of that behavior (Laurence, 2005). This is why *shaping by successive approximations* (shaping) is such a powerful tool. Shaping is a process in which a complex behavior is broken into a simple succession of behaviors that approximate the final behavior. The dog is reinforced for the first approximation of the behavior until he has learned it, then reinforcement is withheld until the dog performs the second approximation of the behavior, and so on until the complex behavior is performed (Roberts, 1998, p. 135). In shaping, the level of frustration should be kept to a minimum by thin-slicing the criteria so that the dog experiences minimal negative contrast effect for each criteria shift. If the dog is not earning a reinforcer every second or two, the criteria are not sliced thinly enough for success.

Dogs that are provided with the opportunity to learn regularly through shaping become more adept at learning; they become a partner in the learning process as they "learn to learn." Shaping provides very mild amounts of frustration as the dog attempts to identify the behavior that earns the reinforcer. This builds the dog's coping skills and promotes confidence. Shaping also promotes impulse control because the dog must think before acting, in order to perform the behavior that earns the reinforcer (O'Heare, 2007, p. 343).

Learning exercises the brain, increasing blood capillaries and glial cells that feed the metabolic needs of the neurons (Ratey, 2001, p. 193). Intellectually challenging activities, such as shaping, stimulate neural activity, which creates and strengthens neural connections (Ratey, 2001, p. 43). This builds a more resilient brain (Ratey, 2001, p. 37, p. 364).

Teaching to Actualize Potential (TAP)

The neurological system has amazing plasticity, particularly during its formation, but also throughout life. This plasticity has the advantage of allowing the dog to learn behaviors that are functional in his environment. The same plasticity has the disadvantage of allowing the dog to learn behavior that is dysfunctional. This is why effective training plans, which consider the physiology of learning, are so important.

All dogs are born with a genetic package. The environment, which includes learning experiences, can allow the dog to achieve the full potential that his genetic package allows. An understanding of the physiology of the neurological system, which supports the principles of learning, gives us the knowledge to teach the dog in a way that will allow him to actualize his potential.

Actualizing potential relies on optimum learning conditions, which involve antecedent control and *microshaping* (shaping minute muscle movement to build responses of particular muscle groups) to ensure that the dog only practices desirable behaviors, building finished behaviors in layers of minute motor skill. Erroneous behavior is avoided altogether, to avoid practicing and learning unwanted behavior. This takes more planning for the trainer, but is more effective and humane for the learner (Laurence, 2007). This is called *errorless learning*.

Errorless Learning

Thorndike's operant conditioning was based on trial and error to build neural connections and form behavior. Errorless learning is an improvement on Thorndike's methods, allowing neural connections to be built without error, and therefore without the need to unlearn and relearn aspects of the behavior.

Errorless learning takes more effort on the part of the trainer, but makes the process of learning easier for the learner. This method is called the *constructional approach*, because the process constructs the desired repertoires one small slice at a time, rather than eliminating incorrect repertoires (Rosales-Ruiz, 2007, p. 33).

Why go to the effort required for errorless learning? Firstly, if erroneous behavior is learned as part of the overall behavior, each error needs to be removed individually by withholding the click until that error is not presented. This is difficult for the trainer and aversive for the dog. While removing erroneous behavior, other errors may be practiced and reinforced. Secondly, practice of imperfect behavior causes that behavior to re-emerge later, especially under stress (Laurence, 2007). And finally, "correct behavior is not simply what remains when erroneous behavior has been chipped away" (Skinner, 1968, cited in Rosales-Ruiz, 2007, p. 33).

In short, the most solid and fluent behaviors are built through practice of minute layers of perfect behavior. Just as in the formation of a pearl, each fine layer is laid down and solidified, acting as a foundation for the subsequent layer.

Errorless learning is accomplished by creating a training plan that breaks the behavior down into tiny slices of criteria, and setting up the environment in such a way that the learner can only perform each slice of behavior correctly. If the trainer is able to manage all the relevant variables to perfection, learning each slice of the perfect behavior may be attained in just one reinforcement (Rosales-Ruiz, 2007, p. 31).

When the dog performs the slice of behavior perfectly, and that behavior is marked immediately and then reinforced, the networks of neurons that fired when performing that behavior will strengthen and become more likely to fire in response to the same contextual cues. With repetition of the perfect behavior (and only the perfect behavior), more neurons will be recruited into the circuits that support that perfect behavior. With perfect practice, the perfect behavior will become automatic. Under stress, such as in competition, that perfect behavior will prevail, because only the perfect behavior will be associated with the cue.

Starting a young dog with errorless learning provides enormous potential, due to the extensive plasticity of the immature brain. However, applying errorless learning at any age has benefits.

Building an Errorless Learning Plan

To build a plan for errorless learning, decide on the end goal: What will the behavior look like? Then take that picture and slice it thinly, into micro-criteria. This is called *microshaping* (Laurence, 2008).

In microshaping, the learning process is considered *at least* as important as the end behavior. The trainer invests time in a skill-building process that requires minimal practice because it practices perfect execution of the behavior. Reinforcement rates in errorless learning are 95 to 100%. Because of this, dogs only practice the perfect behavior, so there is no need to extinguish other behaviors, such as superstitious behavior, that could otherwise be practiced as part of the target behavior. The errorless learning process keeps even the most sensitive dogs enjoying the learning game, and results in very solid behavior (Laurence, 2008).

When shaping for errorless learning, set up the environment for the specific behavior you want. For example, choose a quiet and clean area free of distractions such as enticing scents, loud or unusual sounds, and movement. Carefully analyze the movement of the behavior, from smallest slice to finished product. Think about the perspective of the dog, and how he will perceive all aspects of this environment. With this understanding, plan where you will place yourself, any objects used for training, the dog and the reinforcer (which will be used to re-set the dog to repeat the behavior). In this way, you will set up the dog to perform the thin slice of behavior perfectly each time. Perfect practice makes perfect behavior.

A dancer learns a move as an entire pattern. The pattern includes movement of various parts simultaneously. For example, arm and leg movement are practiced simultaneously. The moves are practiced slowly to ensure they are learned correctly. That way, the moves become a single event and are never disjoint. Therefore, when breaking down criteria for a behavior, the thin slices of behavior should include the muscle groups that will be moving simultaneously. This allows the groups of muscles to work together to form an automatic response that includes movement of the entire group of muscles (Laurence, 2007).

Muscles that are not accustomed to performing a specific function will tire quickly. In addition, a brain that is performing a new function will tire quickly as it runs out of fuel stores. Watch the dog for muscle fatigue and keep practice sessions short when teaching a new skill. Ten 1-minute sessions are better than one 10-minute session (Laurence, 2007).

It takes time and practice to build muscle and synapses. Don't move to the next criteria level until the current level is 90–100% fluent. That is, the dog performs the behavior immediately and correctly 9 out of 10 times, over a period of three training sessions.

Add the final cue (verbal, physical or object) only when the behavior is finished and fluent. That way, the cue will prompt the finished behavior, rather than a previous version, or incomplete, behavior (Laurence, 2007).

When adding a cue, be aware of every movement you are making. Are all the movements part of the cue? Minimize what is not part of the cue, so the dog becomes aware of the cue. Once the cue is learned, vary what is not part of the cue to generalize the cue (Laurence, 2007).

Remember the "readiness" principle. Don't give a cue unless the dog is ready and able to perform the behavior.

Be consistent with your criteria. Only click a behavior if it has been cued and meets the full criteria (Laurence, 2007). For example, if the dog is barking while he is backing, and barking is not part of the "backing" behavior, then don't reinforce that behavior.

An Example of Errorless Learning

An example of errorless learning would be teaching trotting heelwork as follows (Laurence, 2007):

1. Stand still and reinforce the dog in the heel position. Set up the environment so the dog is likely to remain in heel position, rather than building a chain of standing in the wrong position, then moving to the correct position. Deliver the reinforcer in a way, and at a rate high enough, that encourages the dog to remain in a perfectly straight heel position.
2. Concurrently, but during separate training sessions, teach the dog to trot in a circle following a target stick (where the target stick was taught previously).
3. Once both behaviors are on cue and have become practiced to proficiency, so that they are automatic and self reinforcing, combine them. The dog can now trot in heel position. This combination of simultaneous behaviors can now be put on a new cue.

Conclusion

Learning and memory make each of us, and each of our dogs, a unique individual. Synaptic connectivity is the essence of learning and memory (LeDoux, 2002, p. 134). This connectivity is a result of external and internal stimuli on the genes that create the proteins that make up our neurological system, and it is formed and re-formed to varying degrees throughout life.

Learning is an important skill for survival and quality of life. Dog training professionals who understand the factors involved in learning will be better skilled at formulating training plans for specific behaviors.

The two most commonly used types of learning in dog training applications are respondent conditioning and operant conditioning. Respondent conditioning, particularly in the form of counterconditioning fear, is a useful behavior modification tool. Respondent conditioning also provides the ability to use a secondary reinforcer as a marker, such as in clicker training. Operant conditioning teaches dogs that they can control their environment by performing certain behaviors.

Learning theory is underpinned by the physiology of the neurological system. The plasticity of the neurological system provides the foundation for lifelong learning. Memory is information that is encoded in the firing or nonfiring, increasing of firing rate or decreasing of firing rate, of neurons. Firing can be modulated or modified by the type of neurotransmitter, increasing or decreasing the amount of neurotransmitter released, modulation of neurotransmission by neuromodulators, and the presence of enzymes that remove neurotransmitters from the cerebral fluid (Norden, 2007, Part 3, p. 36). Simultaneous firing of networked neurons provides the basis for associative learning. The dog's neurological system changes structurally and molecularly in response to experience (Norden, 2007, Part 3, p. 37). Physiological changes occur as a result of learning, particularly during formative stages, but also throughout an animal's life.

Learning applies not only to the dog, but also to the handler. Dog training takes mechanical skill. The skills to be used should be practiced by the trainer before introducing the dog—in particular, the three core skills: observation, timing and decision making.

The brain is a complex system, made up of billions of neurons with thousands of ever-changing synaptic connections, acted on in various ways by mixtures of hormones and transmitters (Ratey, 2001, p. 358). The system functions 24 hours a day, 365 days a year, for the life of the animal. It is astounding that, for the most part, the system works as well as it does.

We, as caretakers of the domestic dog, should take due care of the dog's neurological system. The dog should be provided with a healthy balance of food, exercise and social interaction. Training, whether formal or informal, should always be enjoyable for the dog.

To allow the dog to reach his full potential, we should "Teach to Actualize Potential" (TAP). To TAP into learning, training plans are created that focus on errorless learning by splitting behaviors into easily achievable slices and practicing each slice to perfection before increasing the criteria by adding the next slice. In this way, behaviors are practiced perfectly, resulting in only perfect behaviors.

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