Teaching Bears

Complexities and Contingencies of Deterrence and Aversive Conditioning

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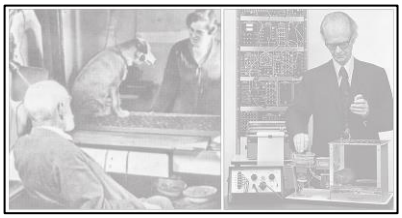
Executive Summary

During the last 40 years researchers and managers have increasingly deployed non-lethal methods to address conflicts between humans and bears, largely in response to mounting public demands for more humane treatment of wildlife. These non-lethal methods can be arrayed along a gradient characterized by the urgency of a conflict situation and the goals of involved people. During a bear attack, repelling the involved animal is paramount. Deterrence is more salient when people want a bear to leave a specific situation or even, more ambitiously, exhibit subsequent short-term avoidance. Aversive conditioning—also known as fear conditioning—is typically undertaken by wildlife managers with the intent of teaching a bear to avoid a broader spectrum of circumstances for longer periods of time. The delivery of painful or otherwise discomfiting stimuli is integral to all of these interventions. Handheld devices that deliver capsaicin spray, non-lethal projectiles, or cracker shells are typically used as repellents. These devices, along with trained dogs and aversive capture procedures, are characteristically deployed during hazing operations designed to both deter as well as aversively condition bears. Hazing and static mechanical devices such as electric fencing are both used in conditioning or deterrence, but with the former typified by the active real-time involvement of people and the latter by fixed devices that can function without people being present.



Conditioning almost invariably involves either sensitization or desensitization of an animal to specific ensembles of stimuli and cues, with the former typified by the direct triggering of somatic and emotional experiences, and the latter usually entailing cognitive processes that imbue more abstract representations of sensory experiences with the qualities of stimuli. These processes are intrinsically associative, in the sense that an animal learns to associate certain sights, sounds, and smells that are not explicitly painful or pleasurable with stimuli that are. This kind of learning is facilitated by the close juxtaposition of stimuli and cues in time and space, and also by moderately painful or pleasurable stimuli delivered at intermediate absolute frequencies. Extremely painful stimuli can produce immediate effects, such as the departure of a bear from a conflict situation. However, if sustained to the point where a bear experiences acute distress or even trauma, relentless punishment can impede associative learning processes, and even produce the phenomenon of "learned helplessness."

Conditioning and the entailed learning can either be positive, negative, or extinctive. Positive conditioning is also known as appetitive, and is commonly associated by bear managers with the phenomenon of bears learning to exploit human-associated foods; i.e., "food-conditioning." Negative conditioning is commonly referred to as aversive conditioning; when meted out by humans, often with the intent of teaching bears to avoid all humans and human facilities. However, this outcome depends on bears generalizing discomfiting experiences associated with a specific context to a broad range of more abstract situations or features that we humans think of as residences, campgrounds, or highways. Conversely, an ability to discriminate and mentally map cause and effect at a fine-grain (i.e., "tuning") can lead a bear to merely avoid specific situations or even specific people. Extinctive conditioning entails desensitization to certain ensembles of cues as a result of experiences that don't entail either painful or pleasurable reinforcements. This waning of reactivity is commonly referred to by bear managers as "habituation," usually in reference to the emergence of a bear's tolerance for humans.

Bears targeted for deterrence or aversive conditioning by bear managers are almost invariably subject to numerous incentives and disincentives that have little to do directly with humans, but are, rather, associated with conspecifics, foods, ambient conditions, internal imperatives, and past conditioning related to non-human factors. Most bears are motivated to avoid adult males because of the physical threat they pose, often manifest in the form of infanticide and even cannibalism. Adult males are capable of killing cubs as presumed means of increasing their odds of mating with unincumbered females and, in the process, alleviating some of the intense competition with other males for reproductive opportunities. Adult females accompanied by offspring are thus highly motivated to avoid potentially infanticidal males. But they also operate under energetic exigencies unlike those of other bears. Reproductive-aged females not only need to sustain dependent young through gestation and lactation, but also endure the energetic costs of lost foraging opportunities entailed by the pursuit of security. Perhaps paradoxically, humans can create an ideal niche for adult female bears if there are unexploited foods in human environs, adult males are disproportionately concentrated in the back-country, and interactions with people are consistently benign. The result can be a female bear that is highly tolerant of people and highly motivated to use human environs both as a means of accessing much-needed food and providing much-needed security for offspring.

Information from laboratory studies, research involving other animals, and ecological studies of bears offers a robust basis for informed predictions about constellations of factors that make deterring and aversively conditioning bears more or less likely to succeed. Bears that have learned to be tolerant of humans, with heightened needs for food and security from conspecifics (e.g., habituated adult females with cubs), and in areas with high densities of other adult bears differentially concentrated in the back-country will be least likely to translate hazing experiences into generalized avoidance of humans and human-infrastructure, especially if aversive conditioning efforts are poorly planned and executed. By contrast, bears that are inexperienced with humans or human-associated foods, with minimal security concerns, and with prerogative on foraging opportunities in the back-country (e.g., naïve adult male bears) will likely respond best to hazing, especially if done well by managers.

Unfortunately, research done specifically with bears offers little basis for either confirming or disconfirming these sorts of predictions, largely because of limited scope, a wide range of methods and evaluative standards, and the extent to which methods, contexts, and standards are consistently underspecified in published reports. Most bears targeted during these studies were apparently young males, although females were well represented in a few studies. Adult males were virtually never targeted, probably because they rarely offered themselves as targets. Promisingly, most bears departed a location after being hazed and rarely returned within the next 24 hours, creating an opportunity for managers to address human-related features of a conflict situation. However, the main conclusion of most researchers was that hazed bears were unlikely to avoid human environs for longer periods of times, especially if human-associated attractants remained available.

In contrast to this equivocal if not pessimistic conclusion regarding prospects for aversive conditioning, **there is ample evidence supporting the efficacy of managing people and human-associated attractants to prevent and resolve conflicts with bears**. In the balance, if coexistence of humans and bears is indeed the over-arching goal, hazing and aversive conditioning will invariably be a minor feature of management necessarily focused on engaging with and managing people.

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Photo by Tom Mangelsen

1. Introduction

A tolerant bear named Felicia by her fans walks across Wyoming's Highway 26
by Todd Stiles

I have long been interested not only in bear behavior, but also bear-human relations. Of relevance to this report, I have been intrigued by the complexities and contingencies of teaching bears to avoid people for over 35 years, dating back to when I was first exposed during the mid-1980s to systematic as well as *ad hoc* efforts to "deter" bears. Certainly, working closely with grizzly bears, as I did for 15 years, provided considerable practical motivation to avoid problematic interactions with bears as well as deter them if needed.

These interests remained dormant for several decades, but were recently resurrected by several newsworthy events in the Yellowstone region, notably the implementation of aggressive efforts by bear managers to haze—and presumably aversively condition—grizzly bears that routinely used roadsides to forage on natural foods. A number of these bears had used roadside habitats for years, and necessarily exhibited a high degree of tolerance for the humans that thronged in ever-greater numbers to see them. Several bears, notably one with the research number "399," were international celebrities.

I was especially intrigued by the justifications and goals offered by bear managers for these hazing efforts in interviews, private conversations, and official communiques (e.g., Germain 2021; U.S. Fish & Wildlife Service 2020, 2021). On the face of it, the official rationale did not comport with what I knew about bears and bear behavior, nor could I find any up-to-date, critical, and comprehensive examination of what we knew about deterring and conditioning bears, especially in context of the larger corpus of scientific literature relevant to such endeavors.

This report is my effort to fill the gap. Here I attempt to not only provide a comprehensive review of relevant research focused on bears, but also offer a conceptual framework rooted in a selective reading of research covering a suite of pertinent phenomena, including behavior modification and the intelligence and emotional lives of animals. Regarding these latter topics, I cannot pretend to be comprehensive given that the germane published research would fill entire libraries. Scholars devote their professional lives to uploading a mere fraction of this literature. However, the high-grade I offer here primarily invokes seminal texts as well as summaries, reviews, and meta-analyses that provide a good bridge to a compendious body of supporting research.

Briefly, I start by offering some background and history, including my personal experiences with hazing, deterring, and conditioning bears; move on to untangling the thicket of relevant jargon, terminology, and concepts; examine factors that have dominant effects on behavior modification; attempt to put all of this together in a synoptic conceptual frame with specific reference to bears; provide a selective overview of bear intelligence and sociality; and then, finally, review and try to make sense of research focused on hazing, deterring, and conditioning bears. For readers who would like to skip the technical content related to concepts and terminology in Section 3, reference is made to relevant portions of this section in later portions of the report, allowing readers to selectively delve into conceptual details as needed.

2. Some Background and History

Roping a Grizzly
by Charles Russell

Europeans and bears have had a fractious relationship in North America ever since colonists first arrived on the shores of this continent. The end result for most bears, most of the time, was death. This slaughter led to the near extirpation of grizzly bears (*Ursus arctos*) in what would eventually become the United States, amounting to the loss of roughly 98% of the bears we once had in roughly 97% of the area they once occupied—and all of this in a startlingly brief period of 80-100 years (Mattson & Merrill 2002). Most written accounts of encounters between Europeans and grizzly bears feature conflict, violence, and death, with the involved people portrayed as hero protagonists (Storer & Tevis 1955, Brown 1985, Gowans 1986). Even though European colonists may have noted the normal day-to-day behaviors of bears, they only rarely considered these observations worth committing to paper or, if so, often as a mere prelude to describing the moment when the observed bear was killed.

This dynamic slowly changed during the mid-1900s in the contiguous United States with the relegation of most remaining grizzlies to remote regions centered on Glacier and Yellowstone National Parks, within which bears were afforded at least nominal protections (Schullery 1980). Even so, grizzlies continued to be hunted outside of Park boundaries, and conflicts with humans continued to be spawned by unsecured human-related foods at campgrounds, townsites, and open-pit garbage dumps (Schullery 1980, Craighead et al. 1995). Although not radically transformative, these physical changes did constrain the literal and figurative arena within which lethal human-bear interactions occurred[1].

But perhaps the main reason people killed proportionately fewer of the bears they encountered during the early to mid-1900s was that Americans were becoming increasing benevolent towards

[1] The rate at which people kill bears is axiomatically a joint function of how often people encounter bears and the likelihood that the involved bear will end up dead—i.e., the lethality of the encounter (Mattson et al. 1996a, 1996b). Bears can persist in environments where they frequently encounter people, but only if the lethality of these encounters is low, as in protected areas such as National Parks.

wildlife[2], as well as increasingly concerned about the scarcity of wild animals[3]. There is little doubt that the scientists John and Frank Craighead played a major role in the transformation of attitudes related to grizzly bears. These two ruggedly handsome researchers and the grizzly bears they studied were featured in magazine articles and TV specials by National Geographic[4], the latter avidly consumed by a national audience glued to their newly-acquired television sets. The most important outcome for grizzly bears of these shifts in American values and perspectives was the institution of U.S. Endangered Species Act protections in 1975[5] that prohibited people from killing grizzlies other than in defense of life and property, with the important proviso that managers could still kill bears to ensure human safety or resolve conflicts that were otherwise deemed to be unresolvable.

And, indeed, wildlife managers in the contiguous United States continued to resolve conflicts between humans and grizzly bears primarily by killing the involved bears (Craighead et al. 1995), albeit at a decreasing tempo with implementation of a so-called "three-strikes" policy that emphasized removal of human-related attractants and movement of involved animals to a distant locale (U.S. Fish & Wildlife Service 1986). Contributing to the toll of dead bears, grizzlies that were highly tolerant of humans—that is, deemed to have "lost their fear"—were viewed by managers as a threat that often needed to be lethally dispatched (Gunther et al. 2015, 2018).

2.1. The Emergence of Repellents, Deterrents and Aversive Conditioning

Continued concerns about the plight of bear populations in North America, along with increasing public interest in individual bears, led to increased interest during the early 1980s in development of non-lethal methods to resolve or prevent conflicts between bears and people. Although there is little in writing that can be invoked to document this dynamic, my own experiences and observations dating back to the late 1970s leave me no doubt about its reality. A few innovative and compassionate bear managers may have previously experimented with methods for non-lethally repelling or deterring bears, but there is little or no record of such efforts, especially in contrast to ample documentation of bears being killed in droves to expeditiously deal with perceived problems (e.g., Craighead et al. 1995).

Emerging interest in non-lethal methods catalyzed some early efforts to test repellents and deterrents—that is to say, devices and methods for causing a still-live bear to depart from a situation that threatened people or property. Foremost of these were studies published by Gordan Stenhouse (Stenhouse et al. 1983, 1984), applied to polar bears (*Ursus maritimus*) and grizzly bears under field

[2] See the books by Steve Kellert (*The Value of Life*), Barry Lopez (*Of Wolves and Men*) and Thomas Dunlap (*Saving America's Wildlife*) for an examination of not only trends but also drivers of change in American's attitudes towards nature and wildlife.

[3] Affluent big game hunters no doubt played a role in promoting protection of game animals and heightening public concern about declines of wildlife populations, but their role has nonetheless been notoriously overstated in books such as those by Trefethen (1975) and Reiger & Corbin (1975) that are as much propaganda as they are history—a result of hunters needing to increasingly dramatize their heroic role in wildlife conservation as the public expresses increased skepticism about the legitimacy of sport hunting (Dizard 2003).

[4] The 1967 National Geographic Special entitled *Grizzly!* (https://www.youtube.com/watch?v=RngJFPKigoY) was perhaps the most widely watched television program of its era featuring grizzly bears—along with Frank and John Craighead.

[5] For the listing rule see: https://ecos.fws.gov/docs/federal_register/fr65.pdf

conditions in northern Canada, and by Carrie Hunt under the visionary direction of Chuck Jonkel, primarily applied to black bears (*Ursus americanus*) and grizzly bears at a captive facility in Montana called Fort Missoula (Hunt 1984)[6].

Sign with Counter Assault spray by Rich Landers

As part of her studies, Carrie identified capsaicin pepper spray as a potentially effective repellent[7], and then worked with Bill Pounds, founder of *Counter Assault*, to perfect the spray and a pressurized delivery device[8]. The combination came to be popularly known as "bear spray," and was first deployed under field conditions in the mid-1980s, including during a 1984-1985 backcountry study undertaken in Yellowstone Park by the Interagency Grizzly Bear Study Team during which focal bears were intentionally harassed (Schleyer et al 1984, Haroldson & Mattson 1985).

Much more ambitiously, one of the first documented efforts to "aversively condition" grizzly bears (see Section 3.5, below) was undertaken during the mid- to late-1980s in the Yellowstone region, spearheaded by Carrie Hunt, Collin Gillin, and Forrest Hammond (Hunt et al. 1987, Gillin et al. 1992). To my knowledge, this was the first undertaking with bears to deploy the classic concepts and terminology of Skinnerian operant conditioning (see Section 3.5), thanks largely to the involvement of Craig Peterson, who was trained in behavior modification. The effort was visionary, but also intrinsically problematic. It attempted to not just deter bears, but also "teach" them to avoid roads and campgrounds. Even more optimistically, the effort aspired to couple the discomfiting experience of a deterrent with what is traditionally called a "conditioned stimulus"—in this case, the call of a non-native bird (again, see Section 3.5)—all under field conditions. Given that something like this had never been done before with bears, the effort was tantamount to running before crawling, or even walking. Not surprisingly, the enterprise had very limited success, and highlighted the logistically demanding nature of aversively conditioning bears (Gillin et al. [1994]; also see Section 7).

2.2. Some Early Personal Experiences

When I showed up for work at the Interagency Grizzly Bear Study Team in June, 1979, I was issued a quarter-stick of dynamite (plus striker) along with an air horn. At the time, these were presumably considered the most effective devices for deterring a grizzly bear. I confess to being challenged by

[6] During the early 1990s Carrie also pioneered the use of Karelian dogs to deter bears from conflict situations, later part of a program called "bear shepherding" deployed under auspices her organization, Wind River Bear Institute.
[7] The terms "deterrent" and repellent" are used either interchangeably or with distinct meaning, although even for those who would like to create a bright line between to two terms, vernacular definitions suggest intergradation. Merriam-Webster defines deter as "to turn aside, discourage, or prevent from acting," and repel as "to drive back" or "to fight against." Repel suggests a situation where attack by a bear is imminent, whereas deter suggests a situation where the involved human is exercising greater agency, as in a hazing operation, or where the threat posed by a bear is less acute, as in a bluff charge. The distinction lies as much with the motivation and intentions of the involved bear as with those of the involved humans.
[8] https://en.wikipedia.org/wiki/Bear_spray

trying to imagine igniting and tossing a stick of dynamite at a grizzly bear while it charged me. Perhaps needless to say, the dynamite remained comfortably buried at the bottom of my pack for the entire field season.

By 1984 the tools and techniques of deterrence (see footnote 7) had advanced, resulting in the issuance of capsaicin pepper spray cans to all field personnel, barring, perhaps, the guys who carried large-caliber sidearms while trapping and handling bears. A pepper-spray can remained on my belt ready for use the remainder of the time I was involved in grizzly bear field work. Even so, I never used pepper spray, despite having numerous close encounters with grizzlies, several of which were unqualifiedly close calls. But pepper spray almost certainly saved the life of one person involved in the 1984 harassment study I mentioned above, who deployed the spray after being charged and bitten by an enraged boar that had been deliberately provoked while in a daybed. My dominant memories, though, are of cans that had lost pressure and emitted a drizzle rather than a burst of spray, or of people accidently discharging spray in their own faces.

As Steve French, an ardent observer of bears, quipped, “pepper spray isn’t brains in a can.” This comported with a central lesson of my experiences around bears. The best means of avoiding problems with bears was to be prudent and precautious, situationally aware, attuned to bear foods and habitats, knowledgeable of bear behavior, and as calm and collected as possible. I quickly learned not to leave odiferous foods out close at hand. A deterrent might be a defining factor, but only as a last resort.

Around the time that pepper spray became commonplace, Carrie Hunt was investigating the practicalities and efficacies of aversively conditioning bears under field conditions (see above), primarily using cracker shells and rubber projectiles as “negative stimuli.” I had the opportunity to personally observe some of her efforts, and was privy to conversations during which she and others involved in the project expressed their frustrations regarding the near-prohibitive logistical demands of the work, as well as their struggles dealing with intelligent problem-solving animals, each with a different personality. It was pretty clear, early on, what the study’s main conclusions would be (see Gillin et al [1994]).

At roughly the same time that Carrie was carrying out her investigations, Yellowstone Park rangers began *ad hoc* efforts to deter and condition grizzly and black bears, the majority of which were exploiting natural foods along roadsides. I witnessed some of the results, most of which were unqualified failures, including an adolescent grizzly who was eventually able to identify and avoid rangers carrying guns, even while in mufti, after first learning to discern and avoid official vehicles and uniforms. After a few painful experiences, the bear left the roadside when the man with the gun arrived, and then returned shortly after he had left. An adolescent black bear was so unwilling to abandon roadsides that he was literally pummeled to death with rubber projectiles fired by unrelenting rangers.

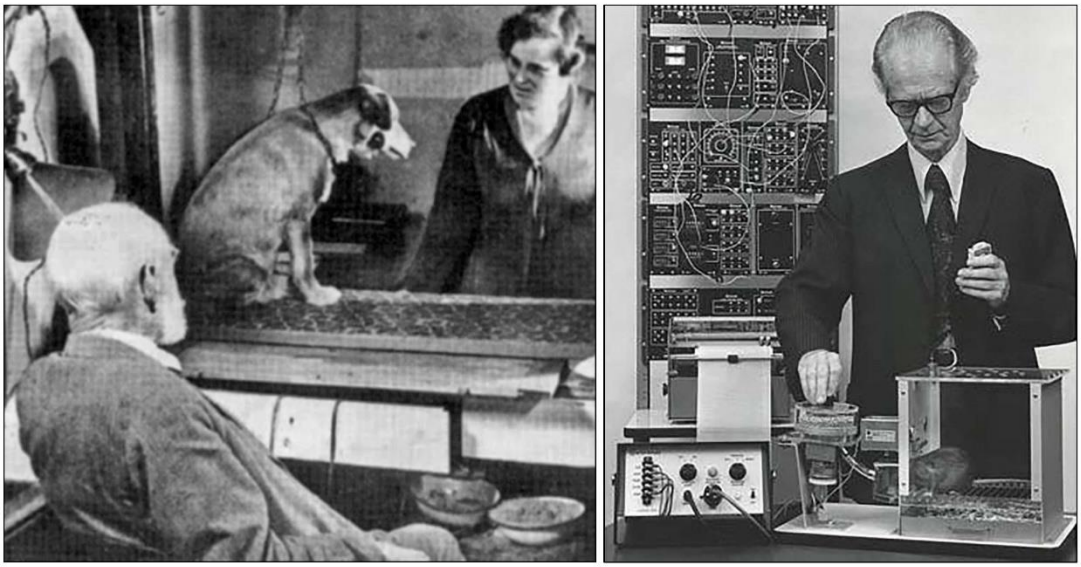
These personal observations and experiences, together with my investigations of grizzly bear foraging behavior (e.g., Mattson 2000) and human-bear relations (e.g., Mattson et al. 1987, 1992), left me with some lasting impressions. Most importantly, bears are sentient problem-solving creatures who are highly motivated to reproduce, obtain food, and find security—much like us. Moreover, people are often not the only threat perceived by bears. Other bears—especially adult males—are also commonly

seen as threats as well (see Section 5.3). The social world of bears powerfully configures *their own* assessment of opportunities and risks, perhaps more so than the presence and behaviors of humans—regardless of whether this *assessment* comports with the *real* risk of dying.

These are obviously my subjective impressions, grounded in evidence, but necessarily informed by speculation and a healthy dose of anthropomorphized projection. Even so, I contend that these kinds of evidence-based subjective constructions are critical to understanding and successfully interacting with bears. Moreover, there is overwhelming evidence that our emotional and cognitive lives are not all that different from those of bears (see Sections 3.7 and 5.1, below).

More to the point of this report, all of these personal experiences and subjective impressions inform what follows. But the first step in what follows is coming to grips with terminology and concepts.

3. Terminology and Concepts



Ivan Pavlov with a dog used in his experiments (left), B.F. Skinner with a rat in a Skinner Box (right)

As a wildlife researcher, I've been aware for many years that our collective understanding and use of concepts related to deterring and conditioning are muddled. If anything, the research reviewed in Section 7 amply confirms this state of affairs. The situation has not been helped by a veritable thicket of jargon, concepts, and terms used in foundational research related to behavior modification and learning. Authors such as Whittaker & Knight (1998), Bejder et al. (2009), and Hopkins et al. (2010) have attempted to sort through this complexity and offer standardized terminology, but have nonetheless done comparatively little to connect applications in bear management with the immense body of research on conditioning and behavior modification in animals and humans. Moreover, even these attempts at clarification have been, by my reading, incomplete or inconsistent. Several come across more as academic chest-beating than useful guides through the conceptual jungle.

What follows in this section is my attempt to make sense of the plethora of terms and concepts that apply to research on conditioning and behavior modification. I do not present this as a definitive reckoning, although I have cast the net broadly so as to encompass most relevant topics and a sampler of definitions and attempted clarifications—some of which are consistent, some of which are not. At a minimum, I have attempted to organize concepts and related terminology logically and hierarchically.

3.1 The Importance of Differentiating Laboratory from Field Conditions

Most of the research done on conditioning, learning, and behavior modification—at least for animals—has been conducted under laboratory conditions informed by the paradigm of experimental design (e.g., Bolles 1967, Brush 1971a, Davey 1981). An almost obsessive emphasis is placed on notions such as "stimulus," "cue," "reaction," "response", and "outcome"—with the researcher delivering stimuli and cues, and the animal exhibiting reactions and responses, yielding longer-term outcomes. In service of this framing, a substantial amount of ink has been spilled attempting to reach definitional and conceptual closure. Reification is widespread. Researchers often seem to assume that

these semantical human constructs have a 1:1 relation to reality, which inevitably leads to imponderables such as the difference between stimulus and cue; pain and discomfort; reflexes and reaction; or panic and fear.

Great lengths are taken by researchers to have complete control over stimuli and cues, discrete from reactions and responses of the subject animals. Stimuli and cues are varied in type, intensity, number, relative sequence, and associative predictability (Skinner 1938, Busch 1971a, Overmier & Archer 1989). Researchers also strive to sanitize the experimental environment of any extraneous influences, with "habitats" varied to either deprive the animal of access to or escape from stimuli, or offer different spatial and temporal configurations. All of these variations yield different types of conditioning regimes—with definitions of these regimes subject to some degree of debate. Rats, pigeons, and domestic dogs are the favorite focal species.

This paradigm is reductionist. It is certainly not holistic. For example, there is only rarely much credence given to the notion that "stimuli" and "cues" are fungible, and, moreover, that neither can plausibly be disentangled from the cognitive, perceptual, and autonomic system of the subject animal—with these systems, in turn, melded in a somatic/neurologic nexus[9].

The tidy, simplified, and tightly controlled conditions of a laboratory experiment, observed by a detached cerebral scientist, could hardly be more different from the complex, chaotic, and emotionally fraught field conditions typifying efforts to deter and condition bears. Moreover, bears operate in environments that are saturated with stimuli and cues that translate into information about numerous things—not just one cue about one thing. Nor do experiments with inbred rats readily extrapolate to the complex emotional and cognitive milieux of wild animals such as bears.

In short, extrapolation of not only the results of laboratory experiments, but also the terminology of laboratory researchers, must to be done with great care and considerable attention to differences between laboratory and field conditions—as well as cognitive and evolutionary differences of focal species (e.g., Barrett et al. 2019, Goumas et al. 2020).

That having been said, there are, in fact, many insights from laboratory studies of relevance to effectively, efficiently, and humanely deterring and conditioning bears. Judicious extrapolation remains the primary challenge, which is why I consider it worthwhile to try and make sense of the concepts and terminology deployed by laboratory scientists.

3.2 Cues and Conditioned and Unconditioned Stimuli

Perhaps the best place to start with terminology is by drawing heavily on authors such as Skinner (1938), Busch (1971a), and Davey (1981) to sort out notions that are foundational to most research on behavior modification: cues and stimuli, with a distinction for the latter between unconditioned and conditioned.

[9] Interestingly, this shift to the paradigm of reductionism is to some extent at odds with seminal work that catalyzed academic interest in animal learning, emotion, and intelligence, notably that of Darwin (1871), but also scholars such as Thorndike (1911). Pavlov (1927) and Skinner (1938) are undisputed harbingers of the often-fruitful turn toward reductionism and experimentation.

A **stimulus** can be approximately understood as anything experienced by an animal as *realized* or *anticipated reward* or *punishment*—pleasure or satisfaction in the first case, pain or discomfort in the second[10]. The key components are "realized" or "anticipated" and "reward" or "punishment." The realized facet can be in the form of a sensory, somatic, emotional, or cognitive experiences, typically in real time. The anticipated facet is intrinsically cognitive and emotional. In other words, a stimulus can be something as simple as an unanticipated physically painful somatic experience—as when a bear is hit with a rubber projectile shot by a manager—or as an anticipatory cognitive-emotional experience learned from experiences involving stimuli that are more overtly somatic or sensory in nature—as when a bear receives sensory input that it *associates* with past pain.

In theory, a **cue** is some sort of sensory information that has no initial *association* for an animal with pain, pleasure, punishment or reward. A cue starts out as being "neutral," albeit part of the operating environment that registers with animals such as bears typically through sight, sound, or scent. However, repeated spatial and temporal juxtaposition with overt stimuli can cause cues to become imbued with anticipation of pain, pleasure, punishment, or reward through *associative learning*. A cue could thus be the sight and sound of people around a house where a bear has eaten garbage in the past, or the sight and sound of people with guns who have previously delivered a painful projectile. Over time, a cue can, in itself, become a stimulus.

This last notion is foundational to the distinction between a conditioned stimulus (or CS as it commonly referred to in research on conditioning) and an unconditioned stimulus (US). An **unconditioned stimulus** is something that directly impacts an animal through senses or soma—something directly experienced as either pain, discomfort, or pleasure. Anything causing a bruise, burn, cut, or electric shock unambiguously qualifies, as often do foul tastes, bright lights, or exceedingly loud noises. A shock from an electric fence deployed around a beehive or pain inflicted by a rubber projectile qualify as unconditioned stimuli.

A **conditioned stimulus** is thus a cue that has become imbued through association and learning with some properties of an unconditioned stimulus. Because conditioned stimuli typically have a substantial cognitive component, especially for higher orders of mammals and birds (Kirsch et al. 2004), they are often the basis for motivated action, at least in a proximal sense (see Sections 3.5 and 3.7, below).

In fact, the processes of association and learning implicit to translating cues into conditioned stimuli are, at least in concept, the foundations of aversive conditioning (Busch [1971a]; see Section 3.6). If all goes according to plan, a bear seeing a person with a gun along a highway may experience the associated sights and sounds as diluted forms of past pain experiences, and be motivated to leave before a shot is fired. Or, more ambitiously, a conditioned bear may see, hear, or scent a person—or even a highway—and associate these more distal cues (i.e., CS) with pain…and be motivated to leave.

[10] Aydede (2018) defines **pain** as an unpleasant *sensory* and *emotional experience* associated with *potential or actual tissue damage*, all rooted in "its own proprietary sensory specialization about noxious stimuli." By contrast, **pleasure** is a somewhat more ambiguous experience that results from an amalgam of sensory-affective-motivational mechanisms tagging it as "pleasant." Pleasure is manifest in "liking" and "wanting," with the former primarily affective in nature and the latter largely cognitive and motivational (also see Berridge & Robinson 2016).

Having made these distinctions, a final observation is warranted, best made by quoting Overmier & Archer (1989): "…the S-R [stimulus-response] theories have at last been abandoned in favor of approaches to learning that emphasize cognitions rather than responses, and outcomes rather than strict performance…" The implication of this is that, if cognition is a central process, then clear conceptual demarcations between cues and stimuli, whether conditioned or unconditioned, are implausible. Information acquisition and processing is too complex for reduction to simplistic notions such as these. Nonetheless, the terms are useful shorthand as well as important for accessing the compendious research on behavior modification.

3.3 Processes versus Behavioral States

Several authors have previously emphasized the importance of differentiating between the observed *behavioral responses* of wildlife to people and the *instantaneous or historical processes* that inform those responses (Herrero et al. 2005, Bedjer et al. 2009). The former are subject to direct human observation—often in real-time—whereas the latter entail typically complex neurologic, cognitive, hormonal, and emotional phenomena hidden behind the veil of an animal's subjectivities and somatic sensitizations. These almost always have a longitudinal component as well. An animal's lifetime of experiences invariably configures how it is conditioned to respond to specific cues and stimuli set in a specific context—and rarely do human observers have much insight into what those experiences might be.

More concretely, a person might observe a bear eating human foods, or remaining unresponsive to his or her approach, and then describe what they saw as being a consequence of "food-conditioning" or "habituation," implying that the observed behavior was habitual—the consequence of learned associations. These learning and conditioning processes may or may not have occurred for the bear, but the verdict could shape how it was treated by wildlife managers and the affected public—with substantial implications for the bear's well-being and survival. Or, more immediately, an approaching human might assume that an unresponsive bear is emotionally or cognitively unaffected, when, in fact, the animal is experiencing anxiety or even fear—leading to miscalculations triggering unanticipated aggression by the bear.

3.4. Observable Behavioral Responses

At its most basic and observable, bears respond to encounters with people by either **staying**, **departing**, or **approaching**, with the latter two further differentiated by **speed** of withdrawal or advance (Figure 1). More subtle bear behaviors signal additional information without requiring that an observer speculate too much about motivations or emotions (Figure 1). If staying, a bear can exhibit no obvious reaction, or turn and directly look at the involved human, or, even more overtly, stand while doing so. If approaching, the bear can run at high speed with head down and ears back, which can reasonably be construed as an attack, or advance rapidly, but with head up, slapping the ground with its front feet, and popping its jaws—reasonably understood as a bluff charge (Stringham 2011). Withdrawal can be at a run, signaling flight, or at a studied walk, but with obvious attention being paid to the involved person.

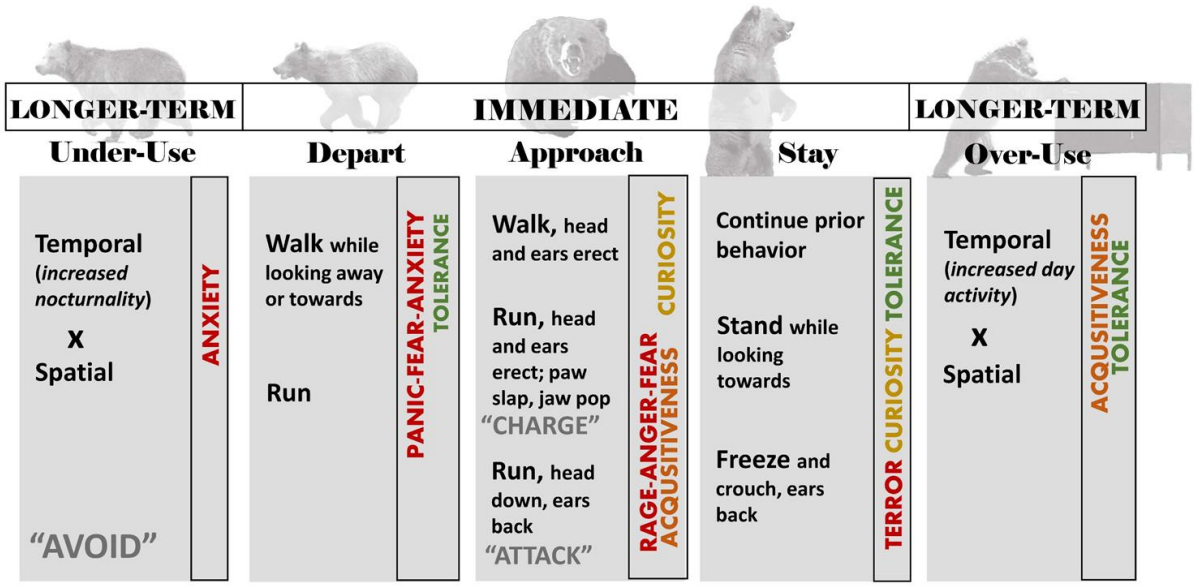


Figure 1. This figure provides a conceptual overview of observable responses by bears to encounters with people, differentiating immediate responses from those that are longer-term. Longer-term responses are differentiated by whether they manifest as underuse versus over-use of human environs, both of which can have temporal and spatial dimensions. The range of emotions underlying observed behaviors are shown in shades of green to red. I also show some of the interpretive descriptors that people commonly apply to these behaviors (i.e., avoid, charge, and attack).

Several researchers have attempted to standardize terminology and metrics for objectively describing all of this. Jordan & Burghardt (1986) and later Mattson (2019) describe anything that is overtly evident in terms of "reactivity," with bears being more or less "reactive." Herrero et al (2005) proposed the notion of **overt reaction distance** (**ORD**), treating the distance at which a bear overtly responds to a human as an index of reactivity. Taylor & Knight (2003) and Stankowich & Blumstein (2005) went so far as to suggest that **flight distance** alone—the distance at which an animal initiates "flight"—is a sufficient index. ORD and flight initiation distance have the virtue of being observable and quantifiable, but are limited by being only a measure of distance. Many of the additional behavioral signals offered by an animal (such as a bear) are ignored. Use of flight distance is furthermore disadvantaged by suggesting that rapid departure is the only response available to an animal, rather than attack, bluff charge, or curious approach.

3.5. Reactions and Responses—Emotional, Somatic, and Cognitive

There is unequivocal evidence that bears are cognitively motivated, with both cognition and motivation rooted in emotions and somatic experiences (see Section 3.7, below). Peering beneath the veil, certain types of approaches—attacks or bluff charges—can be interpreted as aggression or agonism, rooted in **fear**, **anger**, or even **rage** ("defensive aggression" [Blanchard & Blanchard 1984]; Figures 1 and 2), with the intent of driving off or intimidating a threat. Departures can be construed

not only as expressions of fear, but also **anxiety**[11] (Schakner & Blumstein 2013)—or merely continuations of normal activity bespeaking **tolerance**[12] (Herrero et al. 2005, Bedjer et al. 2009). Rapid flight bespeaks **panic** (Schakner & Blumstein 2013, Perusini & Fanselow 2015), potentially triggered by a discomfiting physical experience, and with the intent of escape. A bear staying in place could be experiencing an emotionally neutral state of tolerance, or, as plausibly, be experiencing fear and anxiety—but without any overt expression. In extremis, a stationary bear could simply be frozen by **terror** and a lost sense of agency (Seligman 1971, Moscarello & Hartley 2017).

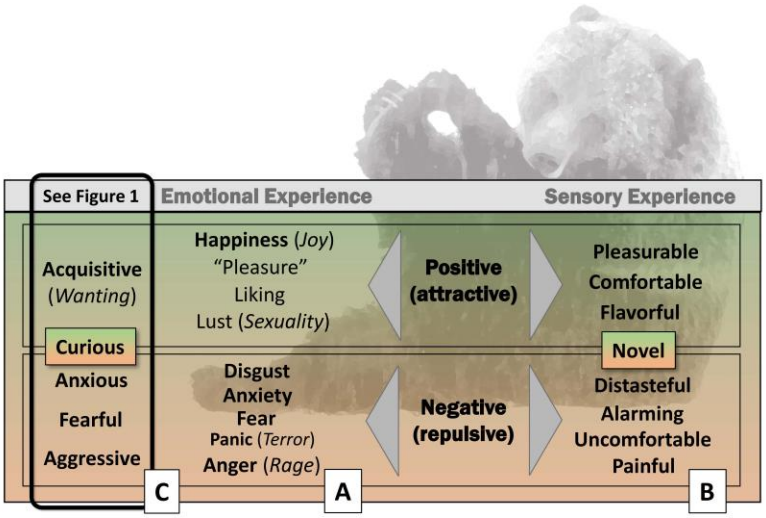


Figure 2. This figure shows some of the (A) sensory and (B) emotional experiences that have been ascribed to animals, ordinated top to bottom from those that are more "positive" (i.e., tending to be attractive or positively reinforcing) from those that are more "negative" (i.e., repulsive, repellent, or negatively reinforcing). A novel sensory experience in somewhere in between. Farthest left (C) I show motivations that roughly correlate with or arise from the emotional and sensory experiences in the same horizontal array and that are also highlighted in Figure 1.

All of the terms highlighted above are well-established in research related to behavior modification. However, laboratory scientists seem to have a blind spot when it comes to motivations rooted in **acquisitiveness** or **curiosity**. This is especially relevant for bears, because charges and attacks can plausibly be motivated as much by a desire to appropriate resources such as food or mating opportunities as by fear, anger, or rage (i.e., "irritable aggression," Moyer [1976]). Approaches can, moreover, simply be expressions of curiosity, as can standing erect. All of this is relevant to appropriately interpreting behaviors exhibited in response to unplanned encounters or to managers attempting to haze a bear.

Aggression, agonism, and avoidance, rooted in fear, anxiety, and pain, typically function in aggregate as **aversive (or negative)** motivations, whereas acquisitiveness rooted in pleasure—but prospectively involving aggression as well—usually function as **appetitive (or positive)** motivations (Overmier & Archer 1989).

[11] Faneslow (2018) defines **anxiety**, **fear**, and **panic** as states existing along a gradient corresponding to different perceived levels of threat. Grillon (2008) defines **fear** as an emergency reaction to an imminent threat, and **anxiety** as a "sustained state of heightened vigilance and apprehension."

[12] Tolerance is the evident willingness of animal to abide the nearness or other impingement of a potential or actual stimulus—in this case a human.

3.6. Longitudinal Processes

Much of the behavior that a person observes during an encounter with a bear—together with the unobservable cognitive, affective, and neurologic phenomena shaping the bear's response (Section 3.5)—is the result of past experiences that conditioned the animal to respond in certain ways to situations typified by certain ensembles of stimuli and cues. Sih et al. (2004a, 2004b) coined the term "behavioral syndromes" to describe this amalgam of exhibited behaviors and configuring associations, motivations, and conditioned responses.

The cumulative effects of past experiences are intrinsically longitudinal—in other words, historical. The entailed processes include sensitization, desensitization, conditioning, and learning. More specific to the terms applied to bears, food-conditioning, aversive conditioning, and habituation are commonly invoked to describe processes that reconfigure behaviors through repeated positive, negative, or neutral experiences (Gilbert 1989; Figure 2).

Conditioning refers to a process that leads to changes in sensitization and consequent reorientation of an animal to certain sets of cues and stimuli—under most circumstances entailing both autonomic and cognitive reconfigurations. Initial conceptions differentiated **classical (or Pavlovian) conditioning** from **operant (or instrumental) conditioning**, with the former involving *involuntary reactions* to stimuli not reinforced by consequences (e.g., Pavlov 1927), and the latter involving *associative learning* reinforced by a sequence of rewards and/or punishments (e.g., Skinner 1938). Under field conditions, rewards and punishments associated with different suites of stimuli and cues often operate simultaneously.

Responses that are involuntary (reflexive) versus under the control of the animal (motivated actions) are theoretically seen as a key distinction between classical and operant conditioning (Campese et al. 2015). However, this more-or-less black and white demarcation has been in recent decades largely replaced by a more nuanced and holistic conception of animal responses to suites of stimuli and cues. Responses clearly involve the whole-body system, organized around the triggering of a central emotional state that leads, in turn, to observed somatic, cognitive, and behavioral phenomena (Overmeier & Archer 1989, Anderson & Adolphs 2014).

Even though there is no longer a defensible basis for maintaining clear demarcations between the involuntary and voluntary, at least for more complex organisms reacting to externally delivered stimuli (Kirsch et al. 2004), it remains useful to think of the conditioning processes of greatest relevance to modifying the behavior of bears as operant, goal-oriented, or instrumental (Figure 3). **Associative learning** informed by changes in **sensitization**[13] is central (Bedjer et al. 2009).

Often conditioning is invoked in an affirmative sense—as *amplifying* both aversive and appetitive behaviors through associative learning. But the opposite process of *waning* behavioral responses is of equal importance, especially in the context of human-bear relations. Most often this waning of response is referred to as **habituation**, that is, a reduction in overt responses to stimuli under circumstances where there is a cumulative history of "neither adverse or beneficial consequences"

[13] Schakner & Blumstein (2013) reference Plappert et al (1999) to define sensitization as "non-associative learning exemplified by a heightened sensory responsiveness after exposure to aversive stimuli." This definition is handicapped by maintaining the pretense of a distinction between autonomic (or involuntary) and voluntary phenomena during conditioning processes, and by furthermore ignoring appetitive stimuli as well as desensitization as the necessary corollary of sensitization.

(Bedjer et al. 2009)[14]. The result of such a process is the transformation of a formerly fearful bear into one that is highly tolerant of people (Gilbert 1999, Herrero et al. 2005).

Reference to a former state of fear or intolerance is important because a bear could be tolerant simply because of personality (Section 5.2) or experiences as a neonate, without having gone through a more overt conditioning process that tempered its responses to humans. It could also be that, absent aversive learning, bears are innately tolerant of people (Stringham & Rogers 2017).

Parenthetically, habituation falls under the umbrella concept of **behavioral extinction**[15], which is, like habitation, typified by the waning of a learned behavioral response when a set of cues or conditioned stimuli is no longer reinforced by unconditioned aversive or appetitive stimuli (see Section 3.2 above; Skinner [1965], Schakner & Blumstein [2013]). More concretely, behavioral extinction can be used to describe a conditioning process experienced by a bear that becomes less reactive to the sight and sound of people (cues or conditioned stimuli), absent reinforcement by either painful human-associated experiences or the pleasurable consumption of anthropogenic foods (unconditioned stimuli). Behavioral extinction is rooted in **desensitization** as well as being tantamount to **fear extinction** (Milad & Quirk 2012, Blumstein 2016).

While apt for describing habituation, "extinction" is encumbered by being explicitly linked to conditioning experiments undertaken in laboratories (e.g., Skinner 1965, Lattal & Lattal 2012). As a response variable, extinction is of explicit interest to laboratory researchers because it refers to the tempo at which conditioned behaviors wane when conditioned stimuli (CS) are no longer experimentally reinforced by unconditioned stimuli (US)[16]. When used in this way, "extinction" has an arcane and circumscribed meaning.

Nonetheless, the term "extinction" is potentially more useful than "habituation" for describing the waning of behavioral responses by bears to certain situations simply because "habituation" is burdened by specific reference to humans and by a history of unhelpful usages (Whittaker & Knight 1998). In fact, extinction processes—for example, waning behavioral responses after implementation of an aversive conditioning program—are a central issue when it comes to judging the efficacies and contingencies of success for such efforts.

3.7. Cognition & Affect

All mammals, including bears, undoubtedly orient to the world through linked emotional and higher-order cognitive processes (see, for example, Damasio [1999] in reference to humans). Surprisingly—perhaps astonishingly—this general proposition was resisted up until only a few decades ago, despite the fact that Darwin (1871) posited in his earliest works that animals had cognitive-emotional lives akin to those of humans, and despite early evidence that animals could "reason" (e.g., from researchers such as Thorndike [1911], Köhler [1925], and Van Lawick-Goodall [1968]). Perhaps

[14] See also Rankin et al. (2009) for a more formalized and somewhat ponderous definition of habituation.
[15] Under laboratory conditions, *behavioral* extinction is differentiated from *procedural* extinction. The former refers to the waning of a behavioral response when CS are no longer reinforced by US, whereas the latter refers to a programmatic reduction in administration of US-CS couplings as part of an experiment (Lattal & Lattal 2012).
[16] Brush (1971b) features "retention of **aversively motivated behavior**," which can be viewed as the inverse of behavioral extinction, especially as applied to experiments undertaken in laboratory settings.

reasonably enough, resistance among those who studied animal behavior—especially in laboratory settings—was informed by the basic reality that cognition and emotion in non-human animals could not be studied on the basis of direct verbal inquiry, unlike with most people. However, a compelling body of evidence has emerged over time detailing not only well-developed cognitive and emotional lives among non-human animals, but also neurologic functions and pathways shared with humans (Berridge 2003). Papers by Bekoff (2000) and Dawkins (2000), both in the same year, synopsized compelling arguments that, to my mind, lay the question to rest.

There is broad agreement among researchers that human emotions are generated by complex processes spread across the limbic and paralimbic brain regions (Lindquist et al. 2016), and that emotions can furthermore be characterized according to whether they are **positive** or **negative** (i.e., by **valence**) as well as by whether they precipitate an impulse to **approach** (i.e., attract) or **avoid** (Ekman 2016; see Figure 5 as well). Emotions can be further characterized by **intensity** and **persistence** (Anderson & Adolphs 2014).

These dimensions of emotion are directly relevant to understanding the internal milieu of animals on the receiving end of aversive training (see Section 3.8 below). Panic and fear are negative emotions, with panic the more intense and shorter-lasting of the two (e.g., Schakner & Blumstein 2013). Anxiety is longer-lasting, typically less intense, and linked to avoidance of environmental features associated with unpleasant experiences (Grillon 2008). Of additional relevance, anger and rage are possible responses of an animal to painful or threatening human-associated experiences, with both being negative, and the latter being the more intense and short-lasting (Panskepp 2011, Ekman 2016; Figure 2)[17].

Emotions are additionally at center stage because they generate **salience** and **motivation** (Bekoff 2000). These two intangible phenomena determine whether and how an animal, human or non-human, will respond to specific stimuli and cues as well as act upon cognitions emerging in real time—or even whether certain memories and mental models will be triggered and mobilized (Damasio 1999). It is thus important for managers to recognize that, if inculcation of avoidance is the goal, then there is an imperative to avoid triggering anger and rage; foster an internal emotional transition on the part of a focal animal from panic and fear to anxiety; and trigger desired cognitive associations.

Emotion is, in fact, the figurative limbic fuel for motivated cognition, regardless of whether an animal is reacting in real-time (of relevance to an unfolding interaction with people) or anticipating and even planning for future action (of relevance to goal-directed or habitual avoidance [Campese et al. 2015, Cain 2019]). At its most basic, **cognition** can be thought of simply as centralized information processing, a capacity possessed by virtually all animals (Shettleworth 2000). **Higher-order cognition** is characterized by a capacity to abstractly represent stimuli and experiences (i.e., engage in **representation**; Shettleworth [2000], Kirsch et al. [2004]). The most sophisticated forms of cognition entail **causal reasonin**g (i.e., discernment of contingencies and cause and effect), the related ability to **solve problems**, and a capacity to **symbolize** and **form concepts**—to "think" (Davey 1981). There is

[17] A number of emotions other than the ones referenced above have also been ascribed to mammalian species, including joy, happiness, grief, embarrassment, despair, lust, separation anxiety, and anticipation (e.g., Moussaieff Masson & McCarthy 1996, Bekoff 2000, Panskepp 2011).

credible evidence that several non-primate mammal species, including bears (see Section 5.1), have all of these capabilities (Bolles 1972, Davey 1981, Schloegl & Fischer 2017, Goumas et al. 2020).

Adaptive goal-directed behavior is self-evidently rooted in sophisticated cognition, which is, in turn, deeply entangled with sophisticated memory processes and a highly-developed capacity to **discern**, **discriminate**, **categorize**, and **generalize** (Goumas et al. 2020). Fine-tuned adaptive reactions, responses, and planned behaviors depend on being able to categorize relevant packages of stimuli according to risk or benefit; store those discrete or gradated packages in **perceptual** and **declarative memory**; accurately and efficiently retrieve those memories as appropriate and needed; and, moreover, relate discrete packages and categories to each other based on relevant associative criteria (e.g., "generalize")—that is, according to some logic of cause and effect (Bolles 1972, Davey 1981, Harnad 1987, Eichembaum 2017, Podlesnik et al. 2017, Goumas et al. 2020). As important, **procedural memory** (the repository of reinforced or habitual response habits) and **emotional memory** (the repository of conditioned preferences and aversions) need to be highly functional if unrewarding behaviors and the need to relearn previously learned behaviors are to be avoided.

All of this is acutely relevant to designing, executing, and evaluating undertakings that aspire to modify animal behaviors under field conditions—notably efforts to aversively condition free-ranging wildlife (see Section 3.8 immediately below). Clearly, training that is undertaken with the goal of teaching animals to *avoid* not just the people directly associated with painful or uncomfortable experiences, but potentially *all people* or even *the infrastructure that people use* (see Section 3.9), is hugely ambitious given that achieving these goals requires that focal animals form representations, categories, causal mental models, and habitual behaviors that are not only encoded in declarative, perceptual, procedural, and emotional memory, but also based on the kinds of discriminations and generalizations that managers hope to craft through their conditioning program (see Figure 5). Whether such programs end up being successful or not, it seems relevant for those undertaking them to at least recognize what they are asking of themselves and the involved animal.

3.8. Training and Conditioning as Human Interventions

In addition to describing a *de facto* sensitization and learning process experienced by animals such as bears, conditioning can also be a component of goal-oriented human endeavors aimed at modifying animal behaviors[18]. In this context, conditioning refers to processes of associative learning that people aspire to initiate and sustain through the deployment of stimuli, often in association with specific cues (see Section 3.2). A prefatory modifier such as "aversive" or "appetitive" is applied to conditioning efforts, tailored to communicate the intended outcome and employed regimen. Rewards are emphasized in positive or appetitive conditioning whereas punishments are emphasized in negative or aversive conditioning (Davey 1981). All of the entrained processes involve some degree of operant conditioning (Figure 3; Section 3.6).

[18] More correctly, human undertakings designed to modify animal behavior should be called "training," in the sense of bespeaking a set of procedures and tools deployed to entrain some kind of conditioning process (e.g., Overmier & Archer 1989). Even so, wildlife managers commonly substitute "conditioning" for "training" when referring to the package of tools, protocols, and desired outcomes employed to modify the behaviors of wild animals (e.g., Gillen et al. [1992]; see Section 7), which is the convention I use here.

Of the conditioning processes, those that are aversive or negative are of particular relevance to bear managers because the associated tools are often seen as useful for dealing with bears chronically attracted to human foods or exhibiting unacceptable tolerance of humans (see Sections 5 and 7). Extinction conditioning (i.e., "habituation") is rarely a goal in management situations, whereas positive (or appetitive) conditioning is generally considered to be undesirable given that it characteristically involves attraction to human-associated foods (i.e., food-conditioning, although diversionary feeding is sometimes used as a tactic to prevent or alleviate conflicts [Rogers 2011, Kubasiewicz et al. 2016, Garshelis et al. 2017]).

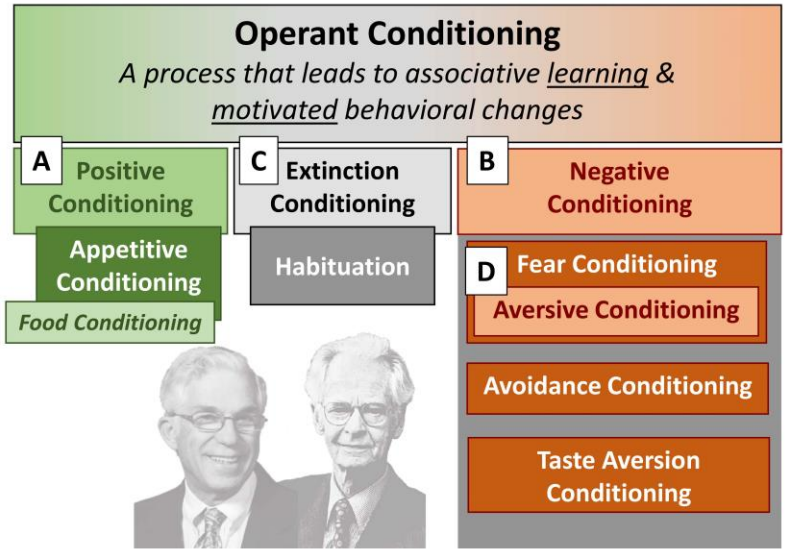


Figure 3. This figure conceptualizes different forms of conditioning under the overarching rubric of "operant conditioning," with (A) positive or appetitive conditioning farther left, (B) negative conditioning farthest right, and (C) extinction conditioning in the middle. In wildlife management, appetitive conditioning is commonly known as "food conditioning" and extinction conditioning as "habituation," usually with reference to people. Fear, avoidance, and taste aversion conditioning are all forms of negative conditioning. The terms "aversive conditioning" and "fear conditioning" are often used interchangeably (D).

Negative conditioning can be decomposed into different types, including **fear conditioning**, **avoidance conditioning**, and **taste aversion conditioning**[19] (Figure 3). Fear conditioning is more commonly known as aversive conditioning, whereas avoidance conditioning is sometimes known as discriminative avoidance (Overmier & Archer 1989). Fear conditioning entails the classical pairing of cues with unconditioned stimuli with the intent of fostering the translation of cues into conditioned stimuli (McAllister & McAllister [1971]; Section 3.2), and applies to most efforts that aspire to train bears to avoid humans and human facilities (where humans and human facilities function as "cues" or "conditioned stimuli" [Section 3.2]; Schakner & Blumstein [2013])—although avoidance conditioning has also been used to describe efforts designed to teach animals to actively avoid situations that they associate with pain and discomfort (Campese et al. 2015). As should be obvious from this thumbnail description, fear conditioning, avoidance conditioning, and aversive conditioning conceptually intergrade and, even more confusingly, are

[19] Taste aversion (or -aversive) conditioning, which is not my focus here, has in some instances been construed as synonymous with aversive conditioning (Dorrance & Gilbert 1977, Dorrance & Roy 1978), despite being a distinctive process involving distinctive methods and tools. Foods are contaminated with noxious substances such as thiabendazole, with the intent of sensitizing bears to the problematic after-effects of these substances to the point where they avoid any foods with the associated scent—or even all human foods that they come to associate with the experiences of illness or discomfort (Ternent & Garshelis 1999, Homstol 2011).

defined in basically the same ways even by disciplinary specialists.More concretely, negative conditioning in animals is invariably coupled with painful, discomforting, or distressing experiences (Davey 1981) and, because of this, negative stimuli are typically a focus of attention for managers undertaking programs to aversively train (or condition) wild animals such as bears (Figure 4; see Section 7). In this context, the deliberate instigation of negative experiences by humans can accurately be called a "**treatment**"[20]—in other words, the purposeful and goal-oriented administration of negative stimuli (in the case of aversive conditioning) with the intent of achieving a desired outcome (e.g., Podlesnik et al. 2017).

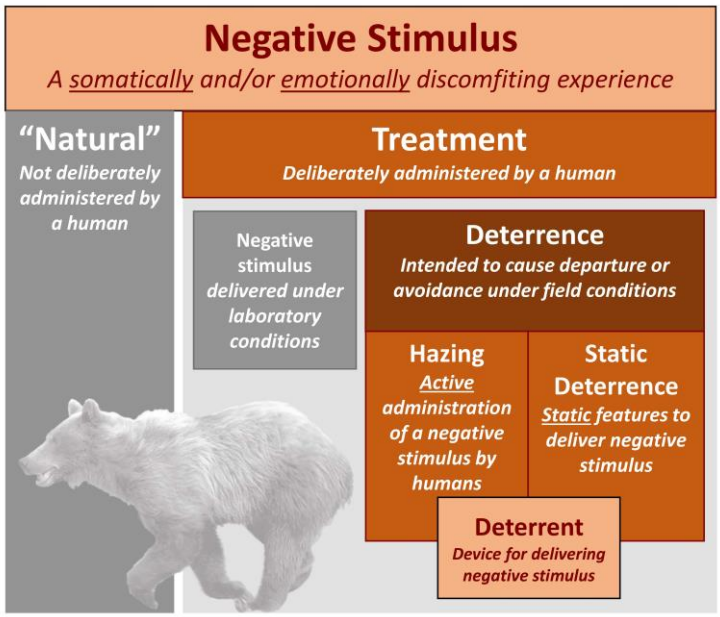


Figure 4. This figure is a hierarchical schematic relating negative stimuli—the somatic and emotional experiences integral to negative or aversive conditioning processes—to the intentional efforts of wildlife managers as well as the physical manifestations of those efforts. Managers employ a "treatment" to deter an animal either as an immediate or longer-term response to humans or human facilities. "Hazing" involves real-time actions by people, as distinct from "static deterrence," which typically involves a fixed mechanical device such as electric fencing. Most hazing or static deterrence entails the use of "deterrents"—devices such as firearms, capsaicin spray, fencing, and bear-proof garbage or food containers.

Under field conditions, negative stimuli are almost invariably used by managers to deter a bear from behaving in certain ways at certain times, whether through initiating a short-term response or by contributing to a learning process that yields longer-term outcomes (Figure 4; see Section 3.8). More actively, deterrence can be achieved by **hazing**. More passively, it can be achieved by deploying infrastructure that repels or deters an animal—i.e., **through static deterrence**. The key distinction is between situations where people interact with an animal in real time to deter it, or whether a stationary physical device is deployed and functioning absent the presence of any human.

Barring situations where a human is yelling or physically chasing an animal (e.g., Kloppers et al. 2005), deterrence and aversive conditioning rely on deploying a device—a **deterrent**[21]—designed to deliver a negative stimulus (Schakner & Blumstein 2013). Without being exhaustive, deterrents commonly used to haze bears include rubber projectiles, explosives ("cracker shells"), dogs, marbles, rocks, and pepper spray (see Section 7.1). Passive deterrents include electric fencing, bright lights, horns, and, less often, fladry (e.g., Davies & Rockwell 1986, Breck et al. 2006, Miller et al. 2016, Ohrens et al. 2019, Khorozyan & Waltert 2019, Backs et al. 2020). Trapping and handling bears falls in a conceptual middle

[20] In *Merriam-Webster*: "…subjection of something to the action of an agent or process"; in experimental design: "…something that researchers administer to experimental units."
[21] Also sometimes called "repellents" (e.g., Miller 1987; see footnote 7).

ground given that it employs static devices such as traps, as well as procedures such as immobilization, physical manipulation, and release that more actively involve a human.

Given these considerations, I find it useful to distinguish hazing and static deterrence from each other and from the larger category of just simply "deterrence"—as well as deterrents (physical devices) from all of the above (Figure 4).

3.9. Outcomes, Goals, and Learning

In theory, different training or conditioning regimes are implemented by people with different goals or desired outcomes in mind for the target animals, with procedures designed and devices deployed to meet those ends (Section 3.8). With free-ranging bears, managers are sometimes focused on simply deterring them from specific hazardous or otherwise problematic situations. However, the more common goal—whether tacit or explicit—is to teach bears to avoid people, human facilities, or human-associated foods (but see Section 7.1).

Perhaps self-evidently, there are several intermediate linkages between the delivered stimuli—as well as the program for delivering those stimuli—and the desired outcome, including immediate responses of the target animal, and, most importantly, the learning process that the animal experiences. Figure 5 highlights the multiple and contingent pathways connecting treatments to a longer-term outcome. Shorter-term, an animal such as a bear can depart, stay or attack (Section 3.4). Attack is plausibly associated with a learning process that leads to future aggression towards the specific people or categories of people posing a demonstrable threat, or even elevated aggression towards all humans—a patently undesirable outcome. This pathway is rarely given credence by bear managers, despite being a possibility highlighted by researchers such as Gillin et al. (1992). Another pathway leads to the kinds of fine-grained un-generalized learning by an animal that leads it to differentiate those who deliver pain from all others, either as individuals or stereotypic categories. This plausibly leads to avoidance only of these individuals, or avoidance of the environments that an animal associates with such people—another undesired longer-term outcome. Finally, there is the desired pathway that leads an animal to generalize its unpleasant experiences with specific people under specific circumstances to all humans, or even to the infrastructure used by humans, with the animal then presumably avoiding all such things in the future.

The point here is that the pathways connecting what people do to animals under auspices of a purposeful conditioning effort and what the animals learn and how they subsequently behave are more contingent and potentially varied than is often credited. As demonstrated by much of the conditioning work I've witnessed in person, the blithe assumption of most wildlife managers seems to be that punishment axiomatically leads to the lessons and reformed behavior that they desire. The fallacies of this assumption are often further complicated by the failure of many managers to recognize the multiple factors they can't control that powerfully configure the outcomes of conditioning efforts (Section 4; see also my concluding comments in Section 8).

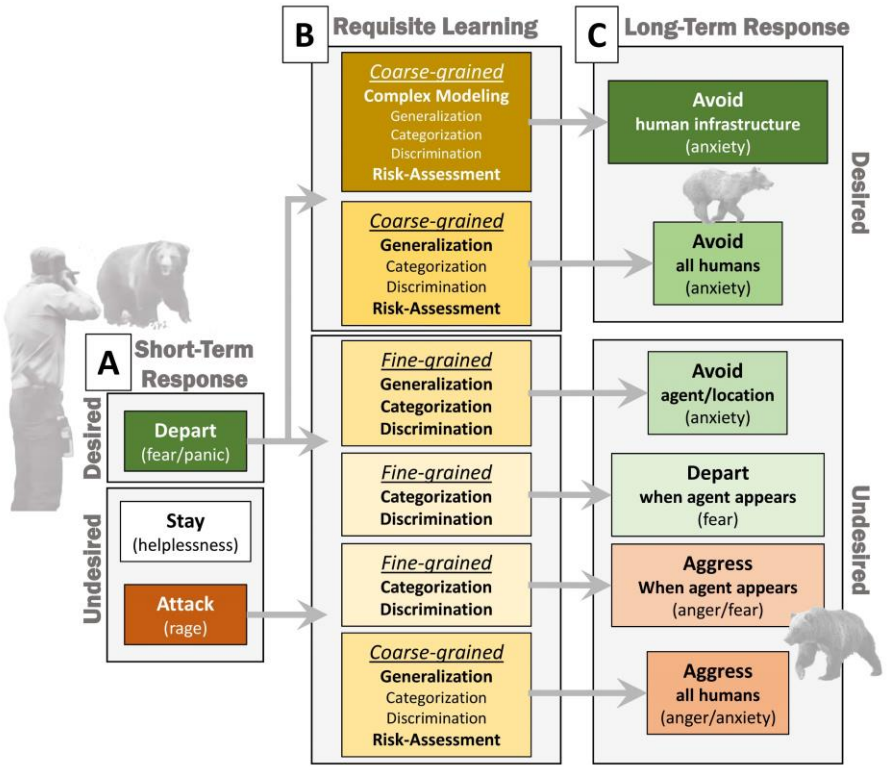
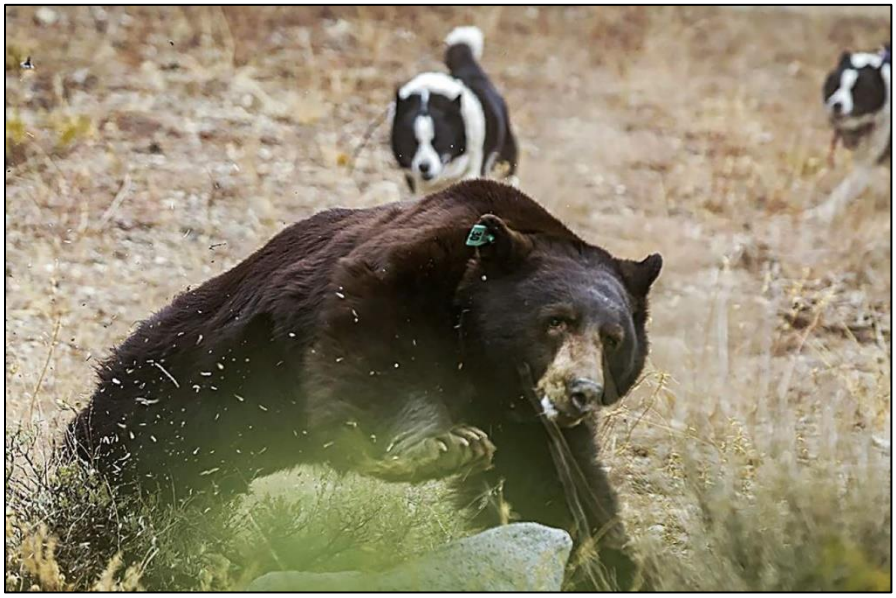


Figure 5. This conceptual diagram relates (A) short-terms responses of bears to encounters with humans to (C) longer-term responses or conditioned behaviors linked by (B) the characteristic learning processes entailed by longer-term outcomes. Short- and long-term responses are categorized by those that managers would generally consider to be desirable (in shades of green), in contrast by those that would generally be considered undesirable (shades of orange). Responses are further characterized by the motivating emotions of involved bears. Learning for each linkage is characterized by entailed cognitive functions such as generalization, discrimination, categorization, modeling of cause-and-effect, and risk-assessment, and also whether these functions lead a bear to cognitive "map" the world at a fine- or coarse grain.

4. Contingencies of Conditioning



Karelian bear dogs being used to haze a black bear near Lake Tahoe, Nevada

by John Humphrey

There are a number of potent factors that configure the outcomes of efforts undertaken by managers to modify behaviors of wildlife under field conditions, some of which apply to laboratories as well. A few of these factors are at least partially under the control of managers, whereas most are not, which does not debar the point that all to some extent determine the outcomes of hazing efforts. In this section I review some of the more important factors that introduce contingency and complexity into conditioning processes, including the treatment regime itself, features of the figurative arena (i.e., context), history, animal personalities, self-assessments of agency and stress and trauma. But first, human hazing needs to be placed in an evolutionary perspective.

4.1. Hazing as a Form of Predation

Despite a tendency to locate ourselves outside and above the sphere of natural phenomena, we humans are basically animals interacting with other animals—human or otherwise. As important, non-human animals almost certainly have not evolved to view humans as rarified beings. Even so, there is ample evidence that non-human animals can and do differentiate humans from other entities as an outcome of normal cognitive processes devoted to discrimination and categorization (see 3.7). We are obviously viewed variously as threats, a source of rewards, potential prey, or basically irrelevant—much like any other animal. But there is no reason to think we are viewed as veritable gods.

All of this is relevant to understanding how wildlife respond to different forms and intensities of hazing under field conditions (Section 3.8; Figure 5). Several decades ago, Ydenberg & Dill (1986) developed the basic propositions of Passana (1957) into a simple economic model of trade-offs informing how animals react to the threat of predation, of which hazing by humans is but one form

(Frid & Dill 2002)[22]. Under-reacting to a dire threat invites pain or death. But over-reacting entails costs in the form of energy expenditure, lost foraging opportunities, and even opportunities to mate. Animals thus almost certainly engage in a cost-benefit analysis, either undertaken in real time or stored in procedural memory, resulting in calibrated responses to threats such as hazing (Goumas et al. 2020). In other words, the threat posed by hazing is only one consideration in the balance with others, such as lost foraging or mating opportunities. If the loss of substantial resources or opportunities is at stake, then wild animals are likely be less reactive to hazing.

But there is an additional wrinkle to all of this. Wild animals—including bears—are potentially subject to the figurative or literal threats posed by multiple predators. Among carnivores, these other predators often include conspecifics (Polis 1981, Polis et al. 1984, Palomares & Caro 1999). Moreover, different species of predators also typically have different characteristic distributions relative to each other and to human facilities (for more, see Section 5.6).

The implications of all this have been most explicitly addressed in studies of elk faced not only by threats from humans, but also simultaneously by the threat of wolf (*Canis lupus*) predation (Kloppers et al. [2005], Proffitt et al. [2008]). In both of these referenced studies, literal or figurative[23] human predators were concentrated near roads and townsites, whereas wolves were concentrated in the backcountry. Not surprisingly, elk seemed to balance their exposure to these two predators so as to minimize the most severe perceived risks while retaining access to important resources—much like one would expect for any animal—including bears.

4.2. The Nature of Conditioning Regimes

Of all the factors determining the outcomes of hazing, humans clearly have the greatest control over the particulars of when, how, and where punishments are delivered. There are several self-evidently important facets of delivery, including how soon punishment follows undesired behaviors (**immediacy**); the extent to which specific punishments are clearly associated with specific behaviors (**contingency**); the extent to which undesired behaviors consistently elicit punishment (**consistency**); the absolute frequency of punishments (**time-specific frequency**); the severity of punishment (**magnitude**); and the duration of the hazing program (**duration**; e.g., Davey [1981], Miltenberger [2016]).

The means of addressing each issue during implementation of a hazing program may seem intuitively obvious and, in most cases, intuition would indeed yield productive results. However, in some instances, intuition would be a poor guide. There is, moreover, the question of goals[24]. Appropriate treatments could differ substantially depending on the desired outcome(s) as well as relevant

[22] Of additional relevance, Perusini & Fanselow (2005) document connections between distinct neural circuits and anxiety, fear, and panic, with these different adaptive emotions triggered by the imminence of predatory threat—described in terms of what they call the **predatory imminence theory**.

[23] In the Kloppers et al. (2005) study, researchers hazed habituated elk concentrated near residential areas by yelling at and chasing focal animals; i.e., by behaving like virtual predators.

[24] As I point out in Section 3.9, goals can be vagarious as well as under-specified. McCullough (1982), for example, offers the goal of "stalemate" through "reinforcement of mutual fear and respect." It is unclear to what extent the last part of this statement was meant to apply to people as well as bears and, if so, whether people should be subject to hazing as part of a larger aversive conditioning program.

contexts. Is the goal simply to drive an animal away from a problematic situation for a short period of time? Or is it to teach an animal to avoid a specific locale or set of circumstances for longer periods? Or is the goal to somehow condition an animal to avoid a broader spectrum of environments—also for longer periods of times? To what extent are the welfare and well-being of the target animal a consideration (see Section 4.8)?[25]

B.F. Skinner preparing to administer an electric shock—a "negative stimulus"—to a rat in a Skinner Box.

Setting aside the contingencies introduced by goals, some relations between punishment and immediate or longer-term responses by target animals are comparatively robust. *All else equal*, punishments that more immediately follow undesired behaviors tend to be more aversive, primarily because the animal is better able to associate its experienced pain or discomfort with its prior behavior (Fowler 1971, Miltenberger 2016). Likewise, *all else equal*, punishments that are exclusively delivered in juxtapose with an undesired behavior will also facilitate behavior-specific associative learning by an animal, resulting in an increased aversion to the targeted behavior (Davey 1981, Miltenberger 2016).

Of equal intuitive sense, more intense episodes of punishment that cause more intense experiences of pain or discomfort tend to yield greater fear conditioning (Section 3.6)—as well as more overt escape and shorter-term avoidance behaviors (Fowler 1971, McAllister & McAllister 1971, Davey 1981, Miltenberger 2016). At the extremes, a single episode of severe punishment can cause longer-term avoidance ("one-trial learning"; Davey [1981]) or, conversely, merely exacerbate "learned helplessness" (see below; Seligman [1971])—*depending on the personality and history of the involved animal, as well as other aspects of context* (see below).

Less intuitively, relentless infliction of pain—as part of a relentless hazing program—will likely inhibit rather than facilitate aversive conditioning, as well as longer-term retention of learned behaviors (see Section 4.7). As it turns out, ample research involving various animal species has shown that *intermediate frequencies* of hazing, training, or reinforcement accelerate learning processes for animals and result in longer-term retention of avoidance behaviors (e.g., North & Stimmel 1960, Angermeier & Hürten 1977, Demant et al. 2011, Found et al. 2018). In other words, as long as the inflicted punishments are consistently associated with—as well as delivered immediately after—

[25] In Section 8 I address the possibility that the particulars of hazing programs are meant largely to be a demonstration of punitive capacity and control—or even retribution—by managers; or simply a reflexive application of a particular set of tools that a manager is trained to use. If either are the primary motivation or consideration, then the implemented hazing program could look quite different from one designed to meet goals more pragmatically focused on modifying animal behaviors to alleviate conflict situations.

exhibition of undesired behaviors, an intermediate spacing of treatments will likely yield better results compared to the assiduous infliction of punishment after every display of the targeted behavior.

Another significant contingency over which managers may or may not have control is the provision of escape options to targeted animals. As might be expected, animals that are provided with an opportunity to escape the discomfort and pain being inflicted by a hazing operation will more readily learn avoidance behaviors (Bolles 1971, Seligman 1971). Without access to escape, learning processes are likely to be impeded by the experienced stress (Sandi & Pinelo-Nava 2007, Bentz et al. 2012) and by a diminished sense of agency (Moscarello & Hartley [2017]; Sections 4.6 and 4.7, below), all of which can lead to "learned helplessness" and an animal that is, paradoxically, unresponsive to future punishments (Seligman 1971). Importantly, an animal's assessment of escape options may differ substantially from assessments made by managers, especially if an animal is in a conflict situation because it has been driven there by fear of other non-human predators or a lack of foraging options elsewhere (Sections 4.1 and 4.3).

All of this having been said, learned aversion and associated avoidance behaviors usually wane following hazing (i.e., conditioning) endeavors—even those typified by the infliction of acute pain (Davey 1981, Vervliet et al. 2013). Of course, at a minimum, this generalization is contingent on numerous factors intrinsic to the focal animal, including its history with humans, its personality and intelligence, and the context within which it operates (Sections 4.3 4.4, and 4.5, below). That having been said, if managers hope to teach an animal to habitually avoid potential conflict situations (as per Cain [2019]), then, by implication, the aspects of an endeavor that they do have control over must be well-thought-out, well-planned, well-executed, and appropriately goal-oriented—as well as attentive to context.

4.3. Contingencies of Context

I use the term "**context**" here in reference to all of the factors external to an animal that inform its short- and longer-term cognitive and behavioral responses to aversive conditioning efforts. In this sense, context has an immediate sensory component that triggers memories and fuels learning, as well as a longitudinal or historical component that encapsulates how *past* cue- and stimulus-laden experiences shaped learned associations, habitual behaviors, and procedural memories (Overmier & Archer 1989).

Perhaps self-evidently, the immediate contexts of hazing efforts are saturated with stimuli and cues of varying valence, salience, similarity, and intensity for an animal—in addition to the stimuli and cues directly associated with involved humans. Visual, auditory, olfactory, and tactile stimuli that are emitted by immediate physical contexts have an objective and measurable component (e.g., the velocity of a rubber projectile, or the decibels of cracker shell explosions). However, everything else is subjectively experienced by an animal, entailing its' full of array of abilities to detect, discriminate, categorize, and generalize sensory experiences unfolding in real time. More importantly, though, the external contexts and internal processes of animals by-and-large seamlessly meld to configure what an animal experiences, learns, and retains during a hazing effort.

More to the point, hazing and other human efforts to modify behaviors of animals such as bears occur in context of numerous, potentially conflicting, and often uncontrollable stimuli and cues manifesting in real time.

Unlike in laboratory experiments (see Section 3.1), the tacit goal of most efforts to aversively condition wildlife is to have the targeted animals somehow associate their experienced pain and discomfort (unconditioned stimuli) with various human-related cues imbedded in the **operational context**—but under circumstances where those doing the hazing have little or no control over the full panoply of cues and stimuli actually being experienced by the involved animal. By implication, many of the cues of relevance to the involved animal may be of little relevance to those undertaking a hazing effort. For example, although hazing almost invariably aspires to elevate relatively abstract features such as highways, houses, vehicles, or upright hominids to the status of paramount cues, the targeted animals may, in fact, be registering and associating other stimuli or cues during a hazing experience that have little to do directly with "humans" writ large.

Laboratory research has clearly shown that retrieval of learned behaviors depends not only on exposure to stimuli and cues propagated by humans in association with inflicted pain or discomfort (e.g., the presence of people or vehicles), but also on context, with efficiency and accuracy of retrieval being a function of how closely an unfolding situation matches the conditions under which the animal was trained (e.g., the season and attendant habitat conditions) (e.g., Medin 1975, Overmier & Archer 1989, Bouton 1994, Bouton et al. 1999, Podlesnik et al. 2017). Of relevance, context both *contains* and *predicts* cues and stimuli for an animal (Nadel & Willner 1980).

Context-dependent retrieval processes are entangled with an animal's internal processes of generalization and discrimination (Medin 1975, Struyf et al. 2015, Asok et al. 2019). Managers hope that aversively conditioned animals will be highly tuned to the human-associated cues and stimuli that they deem to be important. But animals ultimately dictate whether this happens or not as a function of both their internalized learning processes as well as the full spectrum of what they attend to in a conditioning environment. As an outcome, "…behaviors learned in one context may be absent, or altered, in another" (Podlesnik et al. 2017).

There are various tensions or conflicting dynamics that determine not only the extent but also the ways in which animals discriminate, generalize, and then store their experiences of specific contexts, leading to the phenomenon of "**tuning**." Mangers who haze animals often tacitly hope that the unpleasant experiences they propagate will lead to "**context generalization**" (or "**trans-situationality**" [Anderson & Adolphs 2014]) by a targeted animal, meaning that the animal generalizes what it experienced in one context to a large number of other contexts with different constellations of stimuli (Nadel & Willner 1980).

But the opposite may occur as well. An animal may discriminate the particulars of a context within which it experienced an unpleasant experience to the point where it then retrieves the attendant memories and conditioned behaviors only in closely matching situations (Podlesnik et al. 2017, Section 4.5). Even though managers may dislike such an outcome, it could be highly adaptive for the involved animal if the entailed behavioral syndromes minimize its overall costs when reckoned against a full spectrum of risks and benefits, including access to foraging opportunities and avoidance of non-human predators (Sih et al. [2004a, 2004b]; see Section 4.1).

This last point highlights an important dimension of "context." Most contexts likely contain conflicted cues leading to dueling processes of sensitization and desensitization reinforcing reactivity to different aspects of that particular context—a phenomenon analogous to what Groves & Thompson (1970) theorized to be the dual processes of habituation. Put another way, an animal likely experiences different cues and stimuli in any given situation that signal different meanings about a context—some attractive and some aversive. This, in turn, could trigger several different and potentially conflicted behavioral responses. More concretely, a roadside environment may attract a bear because of high-quality food resources and the security it offers from other bears (Sections 5.3 and 5.6, below), while at the same time repelling them because of the disturbances created by nearby humans. Managers potentially confront all of this complexity when they use hazing to induce an animal to avoid human environs.

4.4. The Role of History

Animals self-evidently enter into the multifarious situations of their lives with a history of experiences, learning, conditioning, and habits, either attenuated or truncated by the length of time they've lived. All else equal, young naïve animals will likely react differently to a specific context compared to an older more experienced one, especially if the older animal is manifesting lessons that allowed it to survive previous risky or otherwise challenging situations.

This age-related rule of thumb alone explains some of the contingencies of successful hazing operations as well as the abilities of certain animals to live and survive near people. More specifically for bears, it is widely recognized that young naïve bears are more likely to respond well to hazing compared to older bears with more entrenched habits (e.g., Gilbert [1989]; see Section 7, below). Likewise, older bears that have managed to survive human-impacted environs tend to be more cany (e.g., more nocturnal) compared to compatriots who died at a younger age, presumably because of differential learning (Lamb et al. 2020) as well as good fortune.

More abstractly, history is often used to refer to the totality of an animal's experience up to a given point in time (e.g., Overmier & Archer 1989, Bejder et al. 2009, Goumas et al. 2020). However, history only matters in an unfolding situation to the extent that these past experiences were preserved by an animal in the form of memories, habits, or more visceral conditioning. "History," as a codified manifestation of past experiences, is thus highly selective and substantially pared down, as well as subject to the distortions inevitably introduced by the somatic, emotional, and cognitive processes required for storage and retrieval[26]. As important, even the rarified components of history that do get somehow stored are subject to attrition ("forgetting"), distortion, and increasing ambiguity over time, not only as declarative cognitive representations[27], but also as behaviors exhibited in response to certain constellations of stimuli (Davey 1981, Bouton 1994, Kraemer & Golding 1997, Bouton et al. 1999).

[26] See the various chapters in Honig & James (1971) and Spear & Miller (1981), as well as Roitblat (1982) and Harnad (1987).

[27] Human investigators hardly ever have the opportunity to access an animal's symbolic and declarative representations of its history and memories—to the extent they exist (Shettleworth 2000, Schloegl & Fischer 2017).

All of this is relevant to managers undertaking aversive conditioning efforts with wild free-ranging animals for two main reasons. First, managers only rarely know the history of an animal they are attempting to deter or haze. More certainly, they virtually never have insight into how, whether, or to what an extent the animal has preserved its history in terms of memories, emotions, or somatic sensitizations. And, second, passage of time and the related effects of cumulative experiential history likely leads to distortion, loss, or even amplification of the conditioned behaviors that managers labored so hard to instill. An animal may increasingly fail to match conditioned conflict-avoidance behaviors with conflict-engendering contexts; or increasingly fail to exhibit conflict avoiding behaviors altogether; or increasingly react to human-associated stimuli in extreme ways that create yet other sets of problems for people (e.g., by being aggressive).

History, like so many factors, is an aspect of aversive conditioning efforts that has substantial guaranteed effects on the nature and durability of outcomes, and yet over which managers have comparatively little control.

4.5. The Role of Personality & Cognition

The personalities and cognitive abilities of target animals are yet additional factors outside the control of people involved in aversive conditioning efforts—perhaps more so than any other. However, both have plausible or demonstrable effects on outcomes (see below and Section 5.2).

That having been said, the conceptualizations and related definitions of "personality" and even "intelligence" are varied and rooted in controversy (e.g., Cloninger 2009). Many of the conceptions applied to humans are configured by the fact that investigators can make linguistic or written inquiries of people using a shared symbolic language. This is obviously not an option with non-human animals. As a result, the definition of personality in animals has settled on observable behaviors, specifically: "…behavioural regularities that are relatively consistent across time and context" (Gosling & Harley 2009).

The emphasis is thus on regularities that are implicitly predictive of animal behaviors, even as contexts change. Much of these regularities are presumably a result of early learning and development (Gosling & Harley 2009, Sih 2011). Even so, there is a compelling body of evidence showing, not only that personality is heritable among humans[28], but also among non-human animals as varied as sticklebacks (*Gasterosteus aculeatus*), squids (*Euprymna tasmanica*), great tits (*Parus major*), yellow-bellied marmots (*Marmota flaviventris*), chipmunks (*Tamias striatus*), bighorn sheep (*Ovis canadensis*), chimpanzees (*Pan troglodytes*) and, obviously, domestic dogs[29]. Behavioral traits (i.e., personalities) are thus potentially transmitted genetically among animals such as bears, much as evolutionary theory would predict (Dingemanse & Réale 2005, Van Oers et al. 2005).

[28] A recent review and meta-analysis by Vukasovic & Bratko (2015) showed that between 30 and 50% of variation in measurable personality traits among humans could be explained genetically, i.e., by inheritance, with differences in values depending on the specific trait or specific schematic.

[29] Studies documenting personality traits in these species include Dingemanse et al. (2002, 2009), Petelle et al. (2015), Réale et al (2007), Sinn et al. (2006), St.-Hilaire et al. (2017), Strandberg et al. (2005), and Weiss et al. (2002).

Researchers have used various schemes to describe animal personalities, with much of this variation driven by limitations on what a human observer can observe and plausibly interpret for different animal taxa. However, some traits are repeatedly featured (Figure 6), with a gradient from **bold** to **shy** being most common, although other gradients such as **aggressive** to **docile**, **dominating** to **sociable**, and **explorative/curious** to **habitual** are often invoked[30]. These spectra of traits can be organized according to super-ordinate gradients of **Assertive** to **Retiring** and **Socially Sensitive** to **Environmentally Sensitive** (Figure 6), with the latter gradient differentiating animals that are more attentive to social interactions from those that are more attentive to risks and opportunities engendered by the biophysical environment as such.

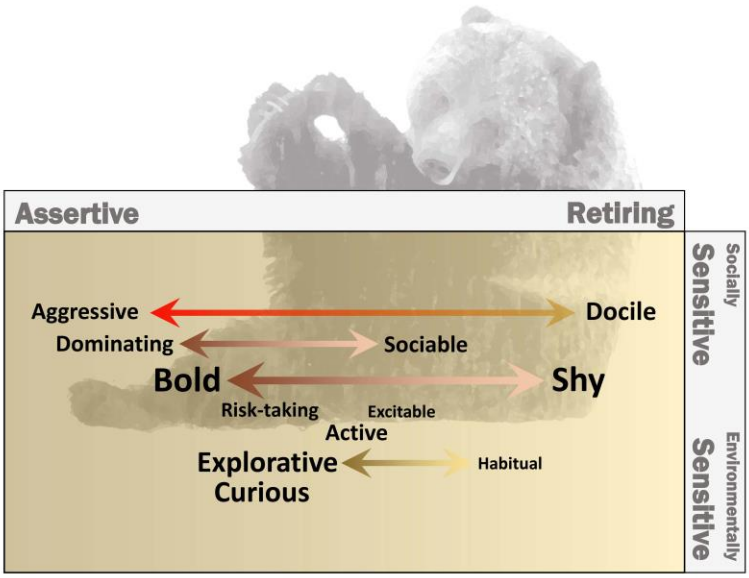


Figure 6. This schematic shows a number of personality traits that have been commonly ascribed to non-human animals, with those most commonly invoked by researchers shown in larger fonts. Traits are arrayed along two dimensions, horizontally ranging from those associated with more assertive (left) versus more retiring (right) behaviors, and, vertically, from those associated with greater social sensitivity (top) to greater attunement or sensitivity to the biophysical environment (bottom). An explorative or curious bear would be behaviorally more assertive, but in ways that were more closely attuned to the biophysical environment. An aggressive or dominating bear would also be more assertive, but in ways more closely linked to social interactions.

Of relevance to human-animal conflicts and related aversive conditioning efforts, Goumas et al. (2020) make the obvious point that the personalities of involved animals are predictive of both the likelihood of conflicts and the subsequent prospects for non-lethal resolution. More specifically, Barrett et al. (2019) suggest that **boldness**, **innovativeness**, and attraction to novelty (**neophilia**) typify animals that come into conflict with humans. More nuanced yet, Found & St. Clair (2018) found that bold elk who were highly tolerant of humans exhibited a complex response to aversive conditioning efforts. These bold (i.e., assertive) animals were more likely to depart when hazed, but also more likely to quickly return to human-impacted environs.

Importantly, Barrett et al. (2019) and Goumas et al. (2020) highlight some conflict-engendering traits that correlate with "intelligence"[31]—specifically, highly functional memory systems coupled with

[30] Freeman & Gosling (2010), Gosling & Harley (2009), Réale et al (2007), and Van Oers & Naguib (2013) provide useful reviews of trait-based research on animal personalities.

[31] "Intelligence" is often seen as a problematic construct. Even so, there is broad agreement that intelligence correlates with the ability to create mental constructs of cause and effect and locate "self" relative to others (i.e., mental maps)—all leading to an enhanced ability to accurately predict the contingent occurrence of opportunities and risks in explicit spatial and temporal contexts (Davey 1981, Shettleworth 2000, Schloegl & Fischer 2017).

enhanced abilities to learn from novel situations, manifest in behavioral flexibility and facility at social learning. These traits plausibly indicate a greater ability to recognize the costs and benefits of novel opportunities—including those associated with anthropogenic foods or security from non-human predators (see Section 4.1)—and adjust behaviors accordingly. Greater intelligence could thus more often bring animals into conflict with humans, lead them to more readily respond to hazing efforts, but do so in ways that are inconveniently discriminating, at least from the perspective of humans attempting to permanently displace an animal from human environs.

This characterization of intelligence highlights the important roles played by discrimination and generalization in the orientation of animals to humans and human-associated features—more specifically in how animals categorize experiences and construct mental maps. Most systematic hazing efforts seems to be undertaken with the tacit goal of teaching targeted animals to not only avoid all humans, but also all human infrastructure (Figure 3). Achievement of this goal requires that an animal construct a mental map in which distressing situations are generalized to the abstract notional category of "human," and moreover, additional abstract categories equivalent to our linguistic conceptions of "house," "highway," or "campground." However, a particularly intelligent and motivated animal might discriminate and categorize *specific types* of humans involved in inflicting pain or discomfort—even to the level of individuals—along with associated spatial, temporal, and other contextual cues (Goumas et al. [2020]; see Section 4.3). This kind of discriminative acuity and related narrow generalization gradient would work against the broader kinds of generalization that managers might hope to engender (e.g., Struyf et al. 2015), and lead a targeted animal to merely avoid certain contexts and types of people.

Photo by Ann Smith
A tolerant bear, called Felicia by her fans, stretching while her cubs play in full view of people along a highway in Wyoming.

Managers obviously have little control over the personality and intelligence of animals they interact with. Even so, these factors almost certainly play important roles in configuring the particulars of management situations, including the likelihood that hazing will achieve desired outcomes, especially when in the balance with human-associated attractants such as food and security from non-human predators. Perhaps perversely, the kinds of personality traits that increase odds of an animal coming into conflict with humans are likely to be the same traits that complicate non-lethal resolutions.

4.6. Self-Assessments of Agency

An animal's assessment of its own agency—i.e., perceived control over actions and consequences (Moore 2016)—occurs at the intersections of personality, intelligence, stress, and context. Of these dimensions, humans have some degree of control over stress (see Section 4.7) and context (see Section 4.3), with important implications for whether and how animals involved in conflict situations will respond to management interventions.

Human and non-human animals are usually motivated to act if there is some prospect of realizing a benefit—either escaping discomfort or obtaining a reward. This basic notion is a tenet of behavioral conditioning and the entailed motivated behaviors (see Sections 3.2 and 3.6). By implication, if an animal is in a situation where it is chronically deprived of any *perceived* control over its exposure to pain or pleasure (see Sections 3.2 and 3.5), then it can lapse into "learned helplessness" (Davey 1981, Overmier & Archer 1989). This foreseeably happens when people relentlessly or unpredictably inflict pain on an animal under circumstances where it doesn't perceive any options for escape (Seligman et al. 1971).

An important distinction here is that animals derive a sense of agency or control based on *their own perceptions and self-assessments* (Moscarello & Hartley 2017). These self-assessments are not necessarily a perfect match to the perceptions of people involved in conditioning efforts—as when humans attempt to haze animals away from human-impacted environments. Perhaps not unreasonably, wildlife managers often seem to over-estimate the literal or figurative space available to an animal for escape from conflict situations or, at the very least, fail to recognize the constraints that an animal may be experiencing. The upshot can be the kind of situation I describe in Section 2.2, where an animal is immobilized by a no-win situation, with threats on all sides and limited access to food. As a consequence, the animal may show little overt response to the pain and discomfort being meted out during hazing efforts while at the same time experiencing acute distress (see Section 3.4)—the antithesis of a desired outcome.

4.7. The Role of Stress

Acute stress and emotional exhaustion are key somatic-affective ingredients of immobilizing fear and learned helplessness (Seligman et al. 1971)—clearly undesirable outcomes for an aversive conditioning effort. On the other hand, stress is also a primary instigator of action (Fink 2016), including motivated fear reduction—a key ingredient of any conditioning program leading to learned avoidance of humans and human facilities (Overmier & Archer [1989], Campese et al. [2015], Cain [2019]; see Sections 3.6). Adding a further wrinkle, although stress can facilitate internalization of more instinctive reactions to conditioned stimuli (i.e., the presence of people in a certain context), at the same time too much stress can impair development of mental models that link pain to causal contexts (Sandi & Pinelo-Nava 2007), as well retrieval of fear-conditioned behaviors from emotional and procedural memory (Bentz et al. 2012)—yet some more potentially undesirable outcomes.

By implication, hazing should ideally be calibrated to induce the right kinds and levels of stress in targeted animals. With too much stress, learning and memory retrieval processes can be impaired. Under a worst-case scenario, an animal could be immobilized. But, with too little stress, an animal may not be sufficiently motivated. But this kind of calibration is guaranteed to be difficult, primarily

because humans have intrinsically limited insights into how a specific punishment—or series of punishments—will be experienced by a wild animal (for reasons outlined in Sections 4.3., 4.4, and 4.5), as well as other factors that may be impinging on or motivating it (for additional reasons described in Sections 4.3 and 4.4).

All of this amplifies the potential for vagarious unpredictable responses by animals to hazing efforts—whether short- or long-term, overtly behavioral, or obscurely emotional and cognitive (see Sections 3.4 and 3.5).

4.8. Potential for Trauma

I conclude Section 4 by highlighting a potential issue that more overtly intersects with ethical considerations: the potential for trauma and impaired well-being in wild animals subject to hazing and aversive conditioning.

Pain, discomfort, and distress are clearly powerful experiences for any animal—and for good reason. In the larger balance of its life, an animal will presumably respond adaptively to unpleasant experiences in ways that increase its well-being, whether judged as increased odds of survival, increased access to foraging and reproductive opportunities, or an enhanced emotional and cognitive milieu. It is virtually axiomatic that most animals will act most of the time in ways that appear to increase beneficial experiences—whether out of instinct or learning. But constellations of physical and biological factors invariably constrain and otherwise impinge upon an animal's self-enhancing behaviors, whether in the form of extreme climatic conditions, food shortages, disease, competition, or predation.

In this context, humans are unmatched as competitors and predators for most wildlife species. We are not only arch-competitors, but also often super-predators (Darimont et al. 2015). Only rarely do human aspirations, goals, and perspectives seemingly align in ways that either enhance or aspire to enhance the welfare of *individual* wild animals (as per Paquet & Darimont [2010], Sekar & Shiller [2020]), as opposed to managing them as interchangeable widgets—or aggregating the issue of welfare to the level of populations with comparative indifference to the plight of specific individuals (e.g., Hampton & Hyndman 2019).

The point here is that the question of whether hazed animals experience impaired well-being—or even trauma—is relevant to people only to the extent that they care about the welfare and well-being of individual animals.

Having introduced this contingency, research with dogs and other domesticated animals is relatively clear about the net results of aversive-based training methods—i.e., methods that inflict pain, discomfort, and distress as a means of modifying behaviors (Sections 3.8 and 4.2). These sorts of "negative" methods tend to compromise the welfare of targeted animals, jeopardize their physical and mental health, and even lead to increased aggressiveness, especially in contrast to more positive methods (e.g., Fernandes et al. 2017, Ziv et al. 2017).

More to the point of this report, sustained hazing of wild animals such as bears is very likely deleterious to the welfare and well-being of targeted individuals. Whether this is deemed acceptable—or even desirable—depends on the goals of involved managers, the sensibilities of the

engaged public, whether lethal options are being considered, and perhaps also on whether aggressive reactions by targeted animals are viewed as a risk (Figure 4). More certainly, approaches to conditioning based on positive methods, or even the goal of habituation, are not often on the table for managers attempting to alleviate a conflict situation driven as much by the behaviors and expectations of humans as by the behaviors of involved animals (e.g., Nyhus 2016).

5. Deterring & Conditioning Bears: Some Basics

399 with cubs
by Tom Mangelsen

In this report I use bears (family Ursidae) to provide concrete grounding for the general concepts and considerations outlined in Sections 3 and 4. Bears are often subject to hazing and aversive conditioning efforts, and are a taxon I know well both from my field research (see Section 2.2) and acquaintance with relevant scientific literature. Plus, bears are an intrinsically useful focus given that they are intelligent omnivores, much like us, and thus reasonable candidates for extrapolation of the ample research done on conditioning in humans. In what follows I populate some of the general considerations in Section 4 with details from research on bears—all of which are relevant to understanding their internal complexities, the context within which they typically operate, and the contingencies that determine outcomes of efforts to haze, deter, and condition these animals.

5.1 Bear Intelligence

By and large, bears are intelligent animals[32]—at least by all of the signifiers that researchers use to judge this intangible quality. For one, whether reckoned in absolute terms or relative to body mass, bears have on average the largest brains of any terrestrial carnivores (Gittleman 1986, Swanson et al.

[32] As I note in Section 4.5, intelligence is a notoriously tricky phenomenon to judge, especially when comparing species (Willemet 2013). At its most basic, intelligence can be assessed by how well individuals—or species—are able to upload and process information, contextualize it, store it, and then retrieve it in real time to aid planning, mapping, problem solving, and other orientation (Benson-Amram et al. 2016). In situations where there is no shared verbal language and where an animal orients to the world in fundamentally different ways—as with bears—researchers use various proxies to assess intelligence. Perhaps crudest is relative or absolute brain size. This follows from the simple fact that a big brain provides more space and related wet wiring for carrying out complex sensory functions and cognitive tasks. But relative brain size (or, alternatively, encephalization quotient) also provides important information about intelligence (Gould 1981, Steinhausen et al. 2016). Moreover, anatomy matters, especially the comparative volume of the frontal cortex and, of that, the neocortex. These areas of the brain are the most closely associated with spatial reasoning and conscious thought, including the deployment of abstractions.

2012), Benson-Amram et al. 2016). They also tend to have a comparatively large frontal cortex and, within that, a comparatively large neocortex as well (Willemet 2012, Swanson et al. 2012, Sienkiewicz et al. 2019).

But there is also research focused on bears that more directly assesses attributes commonly associated with intelligence. Without being exhaustive, bears are known to use tools, which puts them in the same league as chimps (Waroff et al. 2017, Stirling et al. 2021). They can also count (Vonk & Beran 2012). They have the ability to learn, develop, and deploy abstract categorizations similar to the abilities of primates, which suggests a relatively well-developed ability to formulate concepts (Vonk et al. 2012, Vonk & Galvan 2014, Vonk & Johnson-Ulrich 2014, Vonk & Jett 2018). However, they (or at least pandas [*Ailuropoda melanoleuca*]) don't recognize themselves in mirrors (Ma et al. 2015). Rather, they see their self-image as that of another conspecific, which differs from the ability of more social animals to identify themselves in similar mirror-based tests. Even so, bears such as pandas can discern emotions from expressions on human faces (Li et al. 2017). In general, bears are comparable in most facets of intelligence to primates, and this despite the fact that bears are primarily solitary—which, as a side note, is not the same as asocial (see Section 5.3).

All of this laboratory research is merely suggestive. Those who have closely observed bears offer less ambiguous and more nuanced assessments of intelligence[33]. Bears clearly have a highly developed ability to categorize relevant facets of the world, and then create, store, and retrieve detailed spatial and temporal maps that allow them to successfully avoid hazards and navigate to important resources—notably foods. Bears are also adept problem solvers, which correlates with a well-developed ability to adaptively respond to novel situations. As a corollary, they self-evidently monitor their surroundings, which allows them to exploit newly discovered resources and avoid newly-experienced threats. In short, bears have manifestly flexible behaviors, albeit constrained, like all animals, by internalized conditioning, past learning, early development, imminent threats, and inherited traits.

The implications for understanding and addressing human-bear conflicts are inescapable. Bears are highly attuned to opportunities that provide food and security, many of which can occur close to people. Bears are, moreover, unlikely to forget these benefits once they have experienced them (e.g., Herrero 1985). More positively, their facility at learning likely works to the advantage of managers trying to deter bears from problematic situations or teach longer-term avoidance of humans (see Sections 3.8 and 4.2). But, then, well-developed abilities to discriminate, categorize, and cognitively map situations potentially allows bears to engage in the kind of fine-grained navigation that works against generalizations that managers would presumably most often like to see (see Section 4.5). In short, a bear's intelligence can potentially be both an asset and a liability for humans working to modify behaviors—depending on context and the constraints that a bear may be experiencing.

[33] Krott (1964), Murie (1981), Herrero (1985), Treadwell (1997), Russell & Enns (2002), and Gilbert (2019) are some of the many close observers who have distilled experiences with bears into written impressions of their intelligence.

5.2 Bear Personalities

It should be no surprise that bears have personalities given how widespread this phenomenon is among animals of all sorts, especially when personality is understood as "…behavioural regularities that are relatively consistent across time and context" (Gosling & Harley 2009; Section 4.5). There is ample scientific evidence of bears exhibiting behavioral regularities that vary amongst individuals for reasons without any self-evident relationship to immediately adaptive uses of the environment (Fagen & Fagen 1996; Leclerc et al. 2016; Myers & Young 2018; Hertel et al. 2019, 2020)—which is tantamount to having a "personality."

Peter Krott with one of the two brown bear cubs he raised in the Alps during the 1950s.

But, again, as with reckonings of "intelligence," close observers of bears such as Krott (1964), Treadwell (1997), and Russell & Ennis (2002) offer more convincing as well as compelling accounts of personality in individual bears compared to insights provided by esoteric analyses of data. Bears clearly have nuances of personality that most humans would recognize, including traits such as boldness, curiosity, aggressiveness, irritableness, agreeableness, social facility, neuroticism, and more (Figure 6; Section 4.5).

As with intelligence, personality clearly has the potential to shape human-bear conflicts as well the outcomes of efforts by managers to deter, haze, and condition bears. As Barrett et al. (2019) suggest for mammals more broadly, bears that are bolder, more innovative, and attracted to novelty are probably more likely to raise the ire of humans by more often attempting to exploit human spaces and foods. Likewise, bolder and more neurotic bears are probably less likely to conform with the goals of hazing and conditioning efforts. Other facets of personality such as level of intelligence (see above) and social facility also prospectively have effects, but in ways that are less predictable—or at least more contingent.

5.3. Bear Social Life

As I note in Section 5.1, bears tend to be solitary, but not asocial. Sociality among bears manifests in many ways, organized around several different senses, most notably olfaction[34]—unlike for humans.

[34] The research on olfaction in carnivores is somewhat ambiguous regarding the comparative olfactory performance of bears. The relative volume of the olfactory bulb in the brain and olfactory turbinals in the sinuses are not exceptional for bears in comparison to other carnivores (Gittleman 1991, Green et al. 2012). On the other hand, features related to the amount of olfaction-related enervation (e.g., size of the cribriform plate and number of foramina within it) suggest comparatively enhanced olfaction (Bird et al. 2014) as does, simply, the total volume of sinuses in bears. Total volume of organs plausibly matters as much as volumes scaled to body mass when detecting and registering scents. Bears may or may not have an exceptional sense of smell compared to other carnivores, but undoubtedly far superior to that of humans.

Insofar as direct social learning is concerned, the most obvious configurative experiences occur while cubs are with their mothers and in the company of litter mates. Play and other intense social interactions are commonplace[35], and an obvious means by which young bears learn or otherwise hone social skills. Likewise, behaviors are self-evidently taught to cubs by mothers—including behaviors that humans might see as problematic (Morehouse et al. 2016).

Otherwise, there is ample evidence of bears socially interacting during close encounters, with behavioral outcomes that can be plausibly interpreted as either reducing future risks or enhancing future benefits from encountering conspecifics[36]. Most behavioral adjustments are in the nature of avoidance, although some can be construed as cooperative alliances (e.g., Stringham 2012). Almost invariably, adult males end up being avoided by all other sex- and age-classes of bears—for the good reason that these smaller-bodied bears were typically on the receiving end of aggression or some other agonistic displays during previous encounters with larger-bodied adult males (see Section 5.5 below).

More diffusely, there is also ample evidence from movements data that bears use space in ways that are socially attentive to conspecifics, sometimes manifest as attraction, especially during the breeding season, but more often as avoidance[37]. The mechanisms behind these broader-scale configurations are rarely directly known, but plausibly involve conditioned behaviors resulting from histories of close interactions with other bears. As an important adjunct, there is increasing evidence that bears can overcome their comparatively solitary habits by using olfaction to track the movements and activities of equally solitary conspecifics, often by orienting to trees that are communally rubbed by bears endowed with sex- as well as even individual-specific scent (Rosell et al. 2011, Clapham et al. 2012, Jojola et al. 2012, Sergiel et al. 2017)—all of which seems to be a crucial part of the strategy used by reproductive males to find reproductive females (Clapham et al. 2014, Morehouse et al. 2021).

The main point here of relevance to understanding human-bear relations is that bears are indeed social. Even more important, social relations with conspecifics are plausibly more potent determinants of why bears are active at particular times or in particular places than are the effects of humans and human-infrastructure. We are not always a paramount presence, at least when it comes to configuring bear behaviors.

5.4. Bear Energetics

One of the most important realities of a terrestrial bear's life, at least at higher latitudes, is the need to meet most of its energetic needs with food ingested during a relatively brief and frenzied period lasting little more than 3-½ months—a **hyperphagic season** that typically begins in mid-July and ends

[35] Krott (1964), Burghardt & Burghardt (1972), Henry & Herrero (1974), Pruitt (1976), and Clapham & Kitchin (2016) document play behaviors and other intense social interactions within family groups.

[36] Stonorov & Stokes (1972), Egbert & Stokes (1976), Herrero (1983), Olson & Gilbert (1994), and Craighead et al. (1995) are just a handful of the many studies based on direct observation that have documented interactions among bears. Most of these studies have occurred at garbage dumps or coastal salmon spawning streams for the simple reason that bear interactions are more frequent and more observable under such circumstances.

[37] Again, there is abundant research on use of space by bears showing that they pattern their movements attentive to conspecifics—especially adult males. Mattson (2019) provides a synopsis of this research in a paper describing how people on foot impact bears, all in context of bear-bear interactions.

by early November (Nelson et al. 1983, Mattson et al. 1991). This exigency arises not only from the fact that the high-quality foods of greatest benefit to bears are concentrated during this season, but also from the fact that bears subsequently spend any where from 3 to 6 months hibernating in a den. Ample adipose reserves are thus crucial (e.g., Hilderbrand et al. 2000; Harlow et al. 2002; Robbins et al. 2012a, 2012b). But deposition of adequate reserves is contingent on bears having access to foods that readily convert to body fat, notably foods with high concentrations of fat, but also simple carbohydrates and digestible proteins (Erlenbach et al. 2014). This contingency arises from the simple carnivoran digestive tract that bears were endowed with by evolution—a digestive tract ill-equipped to digest fibrous foods (see https://www.allgrizzly.org/the-gut-environment and https://www.allgrizzly.org/digestion).

As is the case with virtually all mammalian species, these energetic exigencies are substantially amplified for adult female bears simply because they are confronted with gestating offspring and then sustaining them by lactation after parturition (e.g., Oftedal et al. 1993, López-Alfaro et al. 2013). There are, moreover, the demands of providing for the security and food of cubs even after lactation has ended, some of which translate into additional energetic costs (Ben-David et al. 2004, Steyaert et al. 2013a).

The upshot of all this is that most bears are highly motivated to obtain high-quality foods during much of the time they are not hibernating. This is even more the case for females of reproductive age, and for all bears during the fall and late summer. Given that human foods and human-associated foods such as field crops and domesticated animals are typically high-quality bear foods (Bojarska & Selva 2013, Coogan & Raubenheimer 2016), it is thus not surprising that bears sometimes end up being attracted to human environs. More indirectly, if human environs offer the additional benefit of providing access to both natural and human-associated foods unhampered by concerns about security from adult males, then it is also not surprising that human environs would be especially attractive to adolescents as well as adult female bears (see Section 5.5 below).

When all of these dynamics are at play, the odds of successfully inducing a bear to depart from and permanently avoid human environs are predictably low.

5.5. Bear Reproduction & Infanticide

In common with other carnivores (see Palormares & Caro [1999]), bears sometimes kill and even eat conspecifics, including young bears in the care of their mothers—phenomena respectively known as **cannibalism** and **infanticide**. Adult males are far and away the most common perpetrators. Cubs and yearling are the most common victims[38].

This dynamic of adult males killing dependent offspring is conceivably amplified by some basic features of bear populations as well as by life histories (e.g., Steyaert et al. 2012). On average, reproductive females give birth once every two to three years, with the shorter interval common

[38] A sampler of the literature documenting perpetrators and victims of conspecific killings among bears includes Taylor et al. (1985), LeCount (1987), Mattson et al. (1992a), Olson (1993), Hessing & Aumiller (1994), Swenson et al. (2001), Amstrup et al. (2006), Garrison et al. (2010), Stirling & Ross (2011), Steyaert et al. (2012), and Ivanov et al. (2020). This topic is clearly ripe for a synthesis, although the patterns are relatively clear cut.

A female with cubs deterring a nearby boar.

among black bears (*Urus americanus*) and the longer prevalent among grizzlies and other brown bears. The upshot in the case of brown bears is that reproductive-aged females are available to breed roughly once every three years. Given that the ratio of adult males to adult females in unexploited bear populations is often near parity (e.g., Schwartz et al. 2006), this means that two to three males are competing for the opportunity to mate with every one female in a comparatively promiscuous free-for-all (e.g., Barber & Lindzey 1986, Schenk & Kovacs 1995, Bellemain et al. 2006). The competition to reproduce is thus particularly intense, especially among male brown bears (Craighead et al. 1995).

To some extent males can mitigate their reproductive crisis by killing the dependent offspring of a female. Given that ovulation in female bears can be potentially induced by the loss of cubs (Boone et al. 2004, Curry et al. 2014 Stewart 2016), it is conceivably beneficial for a male to kill cubs assuming they are not his from a previous mating, and assuming that the female does indeed ovulate and then become receptive to his advances (e.g., Bunnell & Tait 1981, Larivière & Ferguson 2003, Himelright et al. 2014). There is increasing evidence for the existence of this somewhat speculate sequence, consistent with well-documented increases in infanticide under conditions were there is an influx of non-resident male bears (Bellemain et al. 2006; Gosselin et al. 2015, 2017; Leclerc et al. 2017).

The bottom line is that there are perhaps good reasons for adult males to kill cubs. But there are even more compelling reasons for females with dependent offspring to avoid adult males as much as possible. If females can use humans as veritable shields against adult males (see below) and in the process have less competitive access to foods, then they will almost certainly not readily comply with manager's efforts to haze them away from human environs.

5.6. Navigating People—Human Shields and Threats

Humans can in some contexts be a benign and even safety-engendering presence for bears while, in other contexts, be experienced as an acute threat. This push-pull—repulsion-attraction—dynamic can be expressed at an aggregate population level, as well as experienced by individual bears (see Figure 7). Unfortunately, for most bears the threat posed by humans is often not perceived or otherwise experienced up until the moment they are shot—or trapped and then killed by managers. Hazing is thus an opportunity with tolerant bears for managers to amplify the perceived threat posed by humans short of taking lethal action.

The phenomenon of reproductive-aged female and adolescent bears using human environs as a shield—a "**human shield**"—is relatively well documented, both at an individual and population level (e.g., Elfström et al. [2014], Steyaert et al. [2016], plus the review in Mattson [2019]). The latter is expressed by differential concentrations of these vulnerable bears near human facilities, in contrast to

Charlie Russell with one of the orphan brown bear cubs he raised in Kamchatka, Russia. Charlie often served as a protector—a human shield—from predatory males for his cubs as well as cubs left for him to babysit by female bears.

differential concentrations of adult males farther away (Mattson et al. 1987, McLellan & Shackleton 1988, Mattson et al. 1992b, Rode et al. 2006, Steyaert et al. 2013b). This difference in relative distributions can plausibly be understood as a consequence not only higher comparative mortality rates among males when near people (e.g., Boulanger & Stenhouse 2018) but also adult males having greater prerogative to occupy habitats free of human impacts—which would allow them to meet their energetic and other needs without going through what is probably an initially stressful process of habituating to the presence of humans.

Adolescents and reproductive-aged females are thus often likely to be in a crucible insofar as opportunities and threats are concerned. One way out of this plight, at least at an experiential level, is through either being initially highly tolerant of people, or going through a habituation process that leads to the same outcome (Sections 3.4 and 3.6). The potential pay-off is less exposure to adult males together with access to under-utilized foods.

Subjecting tolerant bears that have settled near humans to the pain and other discomforts of hazing predictably leads to mounting stress, and even the possibility of trauma (Sections 4.7 and 4.8). These outcomes may be ethically objectionable to some people or, more pragmatically, simply impair the learning needed to foster avoidance conditioning. The point here is that bears live near people for sometimes multiple reasons that can figuratively conspire to form a compelling *raison d'etre*. Unlike some representations in the media (e.g., https://county10.com/hazing-seems-successful-on-habituated-roadside-repeat-offender/), bears that are seen by managers as posing a threat to people are not "repeat offenders" engaged in criminal activity.

6. A Conceptual Framework

399 running from people after being hazed away from a moose carcass during one of her early encounters with humans.

Before reaching the penultimate section in which I review the research that has been done specifically with bears (Section 7), there is potential utility in assembling the information covered in Sections 4 and 5 into a conceptual framework that relates the effects of various general and specific factors to desired or even undesired outcomes of efforts to deter, haze, and condition bears. This utility arises not only from the simple fact that it is often difficult for humans to hold multiple factors and effects simultaneously in short-term memory and related cognitive buffers (Mattson & Clark 2014), but also from the need for a coherent framework by which to interpret and judge the available research (Section 7). A comparatively replete conceptual framework is also potentially useful for gaining insight into situations that spawn conflicts involving bears and, from those insights, develop interventions that are likely to yield productive outcomes.

6.1. The Attraction-Repulsion Dynamic

Building on what I describe in Section 5.6, perhaps the most fundamental dynamic affecting bears involved in conflict situations with people is the push and pull—the attraction and repulsion—of features nearer and farther away from people; in the euphemistic front- and back-country (Figure 7). These can be decomposed into features operating in real time or imbedded in a bear's cognitive representations that betoken threats and opportunities, most commonly high-quality foods (both natural and anthropogenic) and threats perceived to arise from humans and conspecifics. Over time, these features manifest as either rewards (positive reinforcements) or punishments (negative reinforcements; Section 3.2).

Importantly, these salient features of a bear's cognitive and physical environments can combine in ways that are either synergistic or conflicted to the extent that they cancel each other out, at least as manifest in overt behaviors and the use of human environs by bears. Situations where humans are palpably threatening, conspecifics do not pose a risk, and where there are more high-quality foods available in the back- compared to the front-country will result in a situation where bears involved in conflict situations with people will likely respond readily to hazing. By contrast, situations where conspecifics pose an acute threat, and where available foods are concentrated near people, will likely

be typified by intransigence (or at least undesirable fine-tuned behavioral adjustments) on the part of bears trapped in this plight.

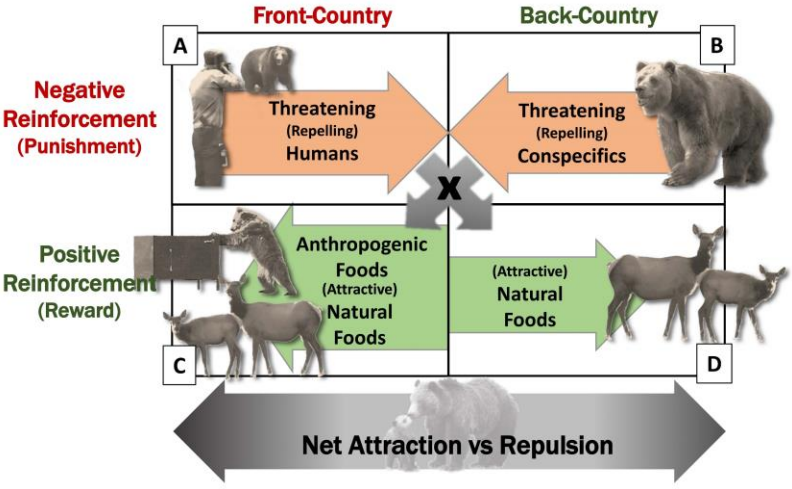


Figure 7. This figure conceptualizes the spatial configuration (front- versus back-country) of basic reinforcement regimes (negative versus positive) that, in turn, shape the motivated responses of bears to human environs—manifest in either a net attraction or net repulsion. Threatening humans can synergize with concentrated foods in the back-country to encourage avoidance of humans. Conversely, threatening conspecifics can synergize with attractive foods in the front-country to yield the opposite.

6.2. Configurative Considerations

Aside from these generalized dynamics, there are a number of more concrete factors that plausibly have substantial effects on the outcomes of hazing and conditioning efforts. These factors can be lumped into those that are characteristic of the foods and habitats used by bears near people (Figure 8a), characteristics of the involved bear itself (Figure 8b), the nature of the hazing or conditioning regime (i.e., reinforcements; Figure 8c), and other features of context, notably densities of adult conspecifics (Figure 8d). This list is not exhaustive, although attentive to factors likely to play a major role. The nature of this role is denoted in Figure 8 by the color of arrows coalescing on the abstract notion of a "successful" outcome (e.g., long-term avoidance of humans and human facilities by the targeted bear). Red denotes a factor that is likely to complicate or even confound success, whereas green denotes a factor that is likely to be conducive.

Insofar as foods are concerned, if attractive anthropogenic or natural foods are present near people, then odds of success will be diminished, in contrast to if such foods are absent. Furthermore, if attractive foods are widely dispersed in the vicinity of human features such as highways, as is often the case with natural foods, then success will be less likely simply because of the increased logistical demands of detecting and treating a bear within a larger arena—this in contrast to if foods are concentrated, as is often the case when they are anthropogenic and located at campsites and residences.

Insofar as the bear itself is concerned, a younger naïve bear with little experience of humans or anthropogenic foods will likely respond more readily to hazing (see Sections 4.4 and 4.5). By contrast,

a bear that has become habituated to humans or conditioned to eating anthropogenic foods will likely be less responsive simply because of the need to overcome habitual conditioned behaviors (see Section 3.6). Likewise, "bold" bears will be more problematic (see Section 4.5), as will females accompanied by dependent young given their energetic needs and security concerns vis-à-vis adult conspecifics (Section 5.5). An important proviso is that the comparative density of other adult bears in the backcountry could change all of this (Sections 5.3 and 5.6).

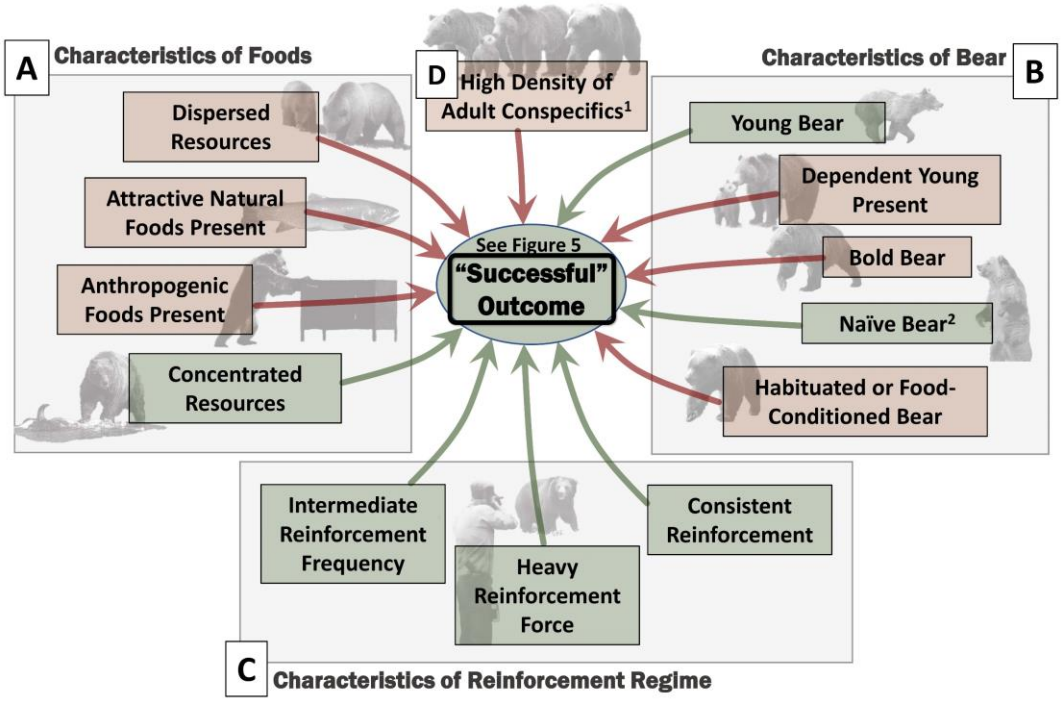


Figure 8. This figure shows the array of factors likely to have major effects on the outcome of aversive conditioning efforts targeting bears. These factors are differentiated by whether they are (A) associated with the quality and distribution of foods; (B) associated with the involved bear itself; (C) associated with the reinforcement or conditioning regime; or (D) associated with other features of context, notably the densities and distributions of adult conspecifics. Factors likely to work against a successful outcome are shown in shades of red, whereas those likely to promote success are shown in shades of green (but note the contingency of "success" on how goals are specified [Figure 5]). [1]The effect of adult conspecifics is contingent on comparative distributions in the front- and back-country. [2]"Naïve" is in reference to experience with humans and human-associated foods.

Finally, features of the hazing or conditioning regime are important. Although there are goal-dependent nuances, negative reinforcements that are consistently associated with undesired behaviors and not delivered unrelentingly will more likely yield desired results (Sections 3.8 and 4.2). Insofar as reinforcement severity is concerned, the effects are a bit more contingent. By-and-large, infliction of more severe punishments will more likely cause a bear to immediately depart a situation, but may not facilitate learning that leads to longer term avoidance (Section 4.7). If the goal is short term deterrence, then greater severity is probably more desirable but, if not, then more temperate treatments would likely be more productive (Section 4.2).

6.3. Some Concrete Examples

These effects and contingencies can be expressed in terms of situations that are easier versus more difficult for managers to deal with, especially if they hope to inculcate longer-term avoidance of humans and human facilities by targeted bears. Figure 9 shows an array of typical situations that might confront a manager, expressed in terms of bear traits and configurations of foods and conspecifics (Figure 9a); diagnostics characterizing the focal bear and its context (Figure 9b); and then, simply, how this all plots relative to the "easier-more difficult" gradient (Figure 9c).

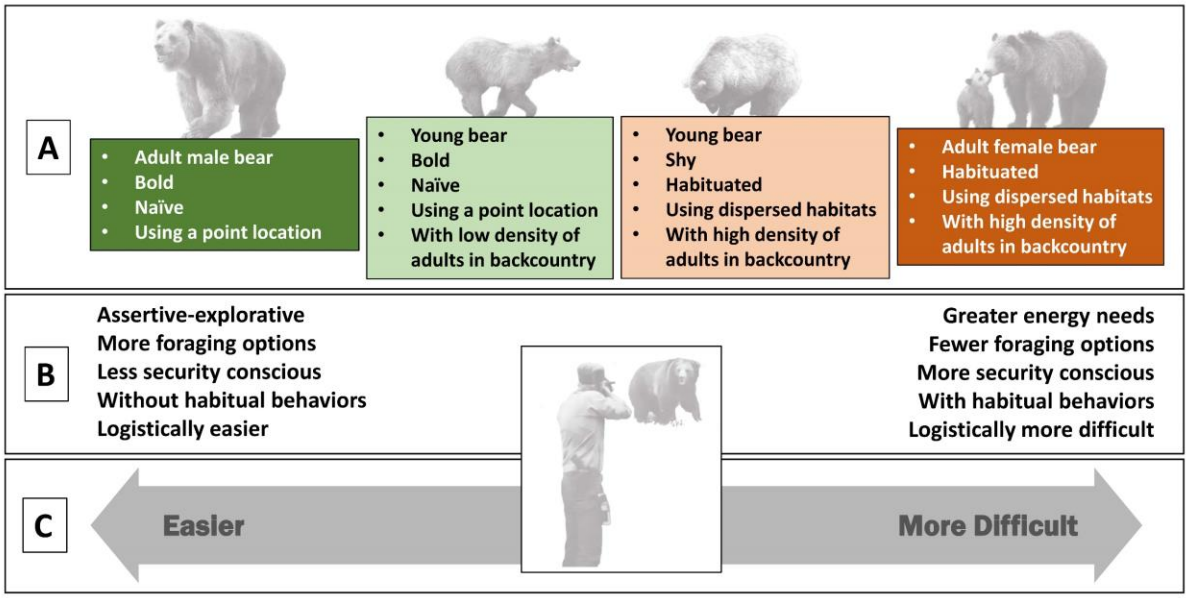


Figure 9. This diagram translates (B) a number of conceptual considerations into (A) more concrete examples of situations where successfully conditioning a bear to avoid people and human facilities is likely to be (C) easier (farthest left) versus more difficult (farthest right). Successful conditioning is likely to be easier with intolerant and assertive bears that are less concerned about security from conspecifics, with more foraging options, and involved in a conflict at a specific location—exemplified by a naïve but bold adult male bear that encountered trouble at a single campground or human residence. Conditioning is likely to be more difficult with a human-tolerant bear that prioritizes security from conspecifics, has fewer foraging options, and is interacting with people at multiple locations. Habituated adult females accompanied by cubs that are hemmed in by high densities of other adults in the back-country and using dispersed human-influenced habitats are an exemplar of a "difficult" bear.

Perhaps surprisingly, naïve but bold adult male bears are plausibly one of the easiest to successfully haze, especially when the point of contention has a fixed location. Bold bears are more likely to react to hazing, especially if they are naïve about people (Section 4.5). Moreover, adult males predictably have more perceived options and self-assessed agency compared to other bears (Section 5.3). A situation almost exactly like this was captured on video in 2021 by a tourist visiting Yellowstone Park. An adult male who was clearly unfamiliar with humans was pursuing an adult female in estrus while near a road. After reacting aggressively towards nearby people—plausibly out of frustration and anxiety—the male was easily hazed away from the road by a Park Service ranger who hit him with a rubber bullet and then followed up with cracker shells (https://cowboystatedaily.com/2021/06/11/yellowstone-bear-biologist-seriously-stay-away-from-bears-they-can-kill-you/).

Conversely, some of the most intractable situations predictably involve adult females that have habituated to the presence of humans and use dispersed roadside habitats as a means avoiding high densities of potentially threatening conspecifics in the back-country (Section 5.6). This type of bear typically has heightened energetic demands, is beset by concerns about the security of offspring, has learned to be tolerant of humans, found food resources near people, and is mobile enough to complicate the logistics of a hazing effort. Such a bear may respond temporarily to hazing efforts, but is unlikely to avoid a niche that she uses because of habitual behaviors entrained by potent formative experiences. Longer-term responses are more likely to be in the form of fine-tuned adjustments to humans and human environs (e.g., by increased nocturnal behavior) rather than generalized avoidance (see Sections 4.5 and 5.1).

Precisely this sort of situation played out during the years 2000-2020 along roadsides in an area north of Jackson Hole, Wyoming. An exceptionally fecund female grizzly bear known as "399"[39] established a home range that was highly localized along roads and highways. She may have started out tolerant, but, if not, she clearly became highly tolerant through a process of habituation (see Sections 3.4 and 3.6). She produced multiple female offspring, all of whom undoubtedly internalized her tolerance of humans (Section 5.3). Of these females, two subsequently established home ranges near people and, in turn, produced cubs. At the same time, another unrelated female bear (called "Felicia" by local fans) adopted a similar roadside niche.

The resulting onslaught of people intent on watching and photographing these bears resulted in chaotic situations along highways that were unsafe for both the bears and the involved people. As a result, wildlife managers implemented a hazing program during 2020 that intensified during 2021. At the date of this report, final results are not yet obvious. However, given all of the factors at play (e.g., as in Figures 8 and 9), early claims of "success" (https://www.wyomingpublicmedia.org/natural-resources-energy/2021-06-30/14-day-hazing-for-grizzly-family-initially-successful-felicia-will-stay-put) are unlikely to translate into long-term generalized avoidance of humans by any of the female bears subjected to the hazing program. As a corollary, this conditioning effort provides examples of some of the problems outlined in Section 7, including underspecified goals.

6.4. Putting It All Together

Figure 10 is my attempt to put much of what I describe in previous portions of this Section as well as in Sections 3 through 5 into an integrative conceptual graphic. The basic elements roughly correspond to those described by Goumas et al. (2020), but are shown here in greater detail, and in ways that directly relate to the overall content of this report. In service of this last purpose, I explicitly reference other Figures that provide additional graphical illustration of the factors and effects highlighted in Figure 10.

Longer-term responses of bears to hazing efforts are typically the focus of managers attempting to non-lethally resolve problematic situations (Section 3.9). Longer-term responses by bears are thus

[39] Her name is simply the number given her by grizzly bear researchers when she was first trapped and radio-collared, and corresponds to when this first happened in temporal sequence relative to all other grizzly bears trapped in the Yellowstone region.

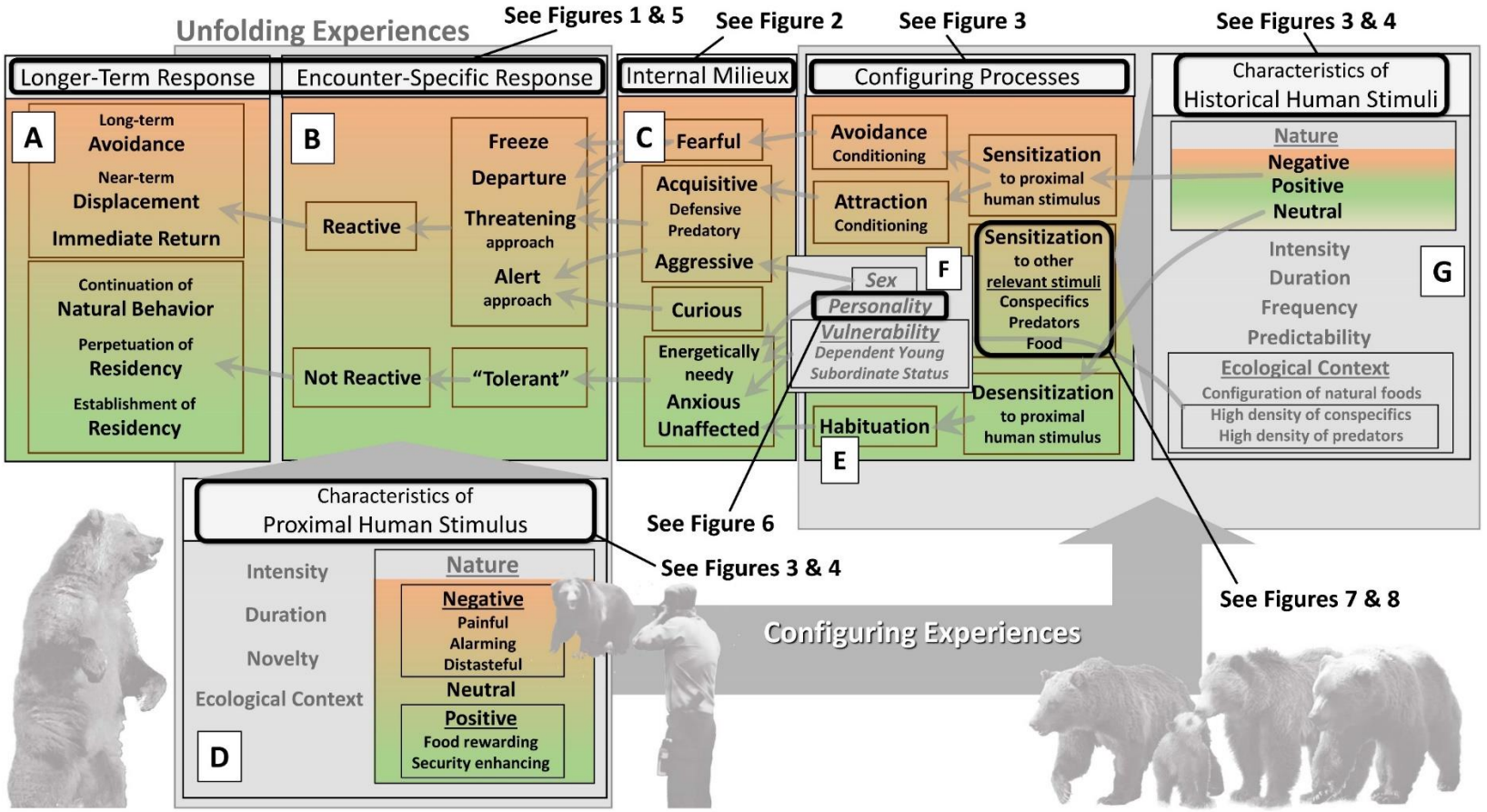


Figure 10. This conceptual model organizes over-arching domains of factors that relate (farthest left) to responses by bears to encounters with humans, both (B) during a specific encounter as well as (A) longer-term—the latter as a result of cumulative experiences; resulting from (C) the internal emotional and motivational milieux that a bear brings to an encounter; resulting from (E) prior configurative processes such as conditioning, sensitization, or desensitization, all mediated to some extent by the sex, personality, and self-perceived vulnerability of the involved bear; with configurations specific to humans shaped by (G, farthest right) the nature of human stimuli historically experienced by the bear, conditioned on specific contexts. The manifold of unfolding experiences (left) is typified not only by the bear's encounter-specific response, but also by (D) the nature of proximal stimuli delivered by involved people, with each specific experience then becoming part of the historical configurative totality. Each of these domains is elaborated in the referenced Figures 1-8.

placed farthest left in Figure 9 (Figure 10a), representing the culminating outcome of a number of configuring factors and effects (see Figure 5, Sections 3.4-3.8). Long-term responses are a logical derivative of short-term reactions by bears to encounters with humans (Figure 10b), which can be broadly categorized as either "reactive" or "not reactive," with the latter a natural expression of tolerance (see Figure 1, Section 3.4). These short-term responses are axiomatically configured by the internal milieux of the involved bear (see Figure 2, Section 3.5), the nature of stimuli delivered by or associated with involved people (see Figures 3 & 4, Sections 3.8 and 4.2), as well as the proximal context (Section 4.3). Encounter-specific responses by bears together with proximal human stimuli are part of an "unfolding experience."

The internal milieux of bears (Figure 10c, Section 3.5) is a repository of cognitive and emotional codifications that forms a bridge between an unfolding experience and historical—or "longitudinal"—configurative experiences and related conditioning processes. Relevant processes include sensitization—e.g., avoidance-engendering and appetitive conditioning—as well as desensitization, the latter leading to habituation (Figure 10e; see Figure 3, Section 3.6). Sex, age, personality, and presence of dependent young are intrinsic to the bear itself, but, aside from sex, also a function of developmental experiences and the simple passage of time (Figure 10f; Sections 4.4, 4.5, 5.2, 5.3, and 5.5). Of relevance to human-bear relations, historical human stimuli—whether positive, negative, or neutral—are important catalysts of conditioning processes that configure future responses by a bear to humans (Figure 10g; Section 3.6). And, finally, human stimuli unfolding in real-time (Figure 10d) become part of this historical legacy.

The point here is not to belabor topics covered elsewhere in this report, but rather to emphasize that all of these factors are potentially relevant for people wanting to usefully understand (i) why a bear behaves as it does in human environs; (ii) why a bear responds as it does to encounters with people—including people involved in hazing efforts; (iii) prospects for effectively deterring a bear from a problematic situation; and (iv) factors relevant to designing and implementing an effective intervention. The factors illustrated in Figure 10 thus constitute a holistic framework for contextualizing and evaluating research focused on deterring, hazing, and conditioning bears. As such, anyone attempting to interpret and apply this body of work would hopefully find that most, if not all, of these contextualizing factors were at some level addressed by the involved researchers, either as limitations to the scope of inference, or more explicitly in research design and implementation.

7. Deterring & Conditioning Bears: Field Research

Ranger hazing a naïve adult male grizzly bear pursuing a tolerant adult female in estrus near a highway in Yellowstone National Park

From video taken by a park tourist

In this penultimate Section I review and try to make sense of published investigations that focused on the efficacies of not only specific deterrents (see Section 4.2), but also various approaches to hazing, deterring, and aversively conditioning bears. The preponderance of these investigations took place under field conditions involving focal bears that were almost invariably free-ranging (see Section 3.1). As a corollary, investigators typically knew little about the histories, intelligence, personalities, or even contexts of the involved animals (see Sections 3.7, 4.3-4.6, and 5.1-5.3 for the importance of these factors).

My searches of peer-reviewed journals, gray literature, and graduate theses turned up 18 published studies reporting results that were based on the systematic collection of data—including one review paper (Khorozyan & Waltert 2020). Eleven of these studies involved black bears, seven involved grizzly or brown bears, and two involved polar bears. Fifteen were undertaken in North America, including four in the east, six in intermountain regions, three in coastal areas, and three in the far north. Some of the studies were reported in multiple publications, including progress reports, with each typically offering additional relevant details (e.g., Hunt et al. 1987; Gillin et al. 1992, 1994). The body of work I cover here almost certainly does not exhaust what might be lurking in the gray literature, but it does represent the outcome of due diligence on my part.

In reviewing this literature, I attempted to determine for each study whether food-related attractants were natural or anthropogenic, and dispersed or concentrated (Sections 4.2, 6.2, and 6.3). I also attempted to determine the sex, age, and reproductive status of focal bears, as well as uncover any assessments made by investigators regarding whether these bears were food-conditioned, intrinsically tolerant, or even tolerant as the outcome of habituation (see Sections 3.4, 3.6, 5.3, and 5.5). Insofar as

research design and treatments are concerned, I attempted to determine numbers of bears treated, the deterrents used, the related nature of hazing efforts (e.g., frequency, scheduling, and duration), and the standards by which "success" was determined (e.g., the nature and duration of responses by focal bears; see Sections 3.8, 3.9, 4.1, and 4.2). Finally, I attempted to determine rates of success—at least as defined by the standards specified in each study—as well as synopsize any determinations made by investigators regarding the contingencies and overall prospects for successful hazing and conditioning efforts.

7.1. Problems & Limitations

None of the studies that I reviewed fully specified the relevant context (as per Figure 10, Section 6.4), which considerably complicated any interpretations regarding scope of inference and potential extrapolability of results. Most of the published material was quite limited in this regard. More specifically, there was uniformly little information about overall bear densities, distributions of natural foods, and the comparative distributions of sex-age classes (see Sections 5.3-5.6 for why this all matters), although this last bit of information could to some extent be inferred from the composition of bears that were hazed or otherwise treated in human environs.

These commonplace limitations were typically exacerbated by vagueness regarding goals as well as standards for judging success (see Section 3.9), and even more often by lack of any justification for adoption of a given evaluative framework. In some studies, it was difficult to determine the exact nature of the hazing or conditioning regime, including the per-bear frequency of efforts, as well as the spacing and consistency of these efforts (see Sections 3.8 and 4.2 for why all of this matters). For a few studies, it was hard to even determine overall numbers of treated bears.

There were yet more complications that further limited the potential extrapolation of results from this compilation of investigations, notably the tremendous variation in deployed deterrents, hazing or conditioning regimes, standards for judging a satisfactory response, as well as timeframes considered by investigators to be relevant. When all of this variability was accounted for, including evident differences in context, each study potentially collapsed to a singularity with highly uncertain applicability to specific management situations or even conceptual position relative to other reported research (as per Figure 8-10).

The upshot of all this is that the available published studies are not easily interpreted, judged, or extrapolated. As a consequence, the conclusions I offer in the remainder of this section are the result of a considerable number of subjective judgements as well as ample subjective interpretation.

7.2. Overview of Results

The plots in Figure 11 provide a graphical summary of variation in effort, deterrents, and standards reported for the studies I reviewed. Both the numbers of treated bears and per-bear incidents or treatments varied enormously, from between 5 and >100 individual bears and 1 and approximately 80 treatments per animal (Figure 10a). The median for each was 10 and 2.4. This variation alone complicated extrapolating and interrelating these studies, especially when compounded by relatively

uncorrelated differences in deployed deterrents, types of treated bears, types of attractants, and overall (largely unspecified) context.

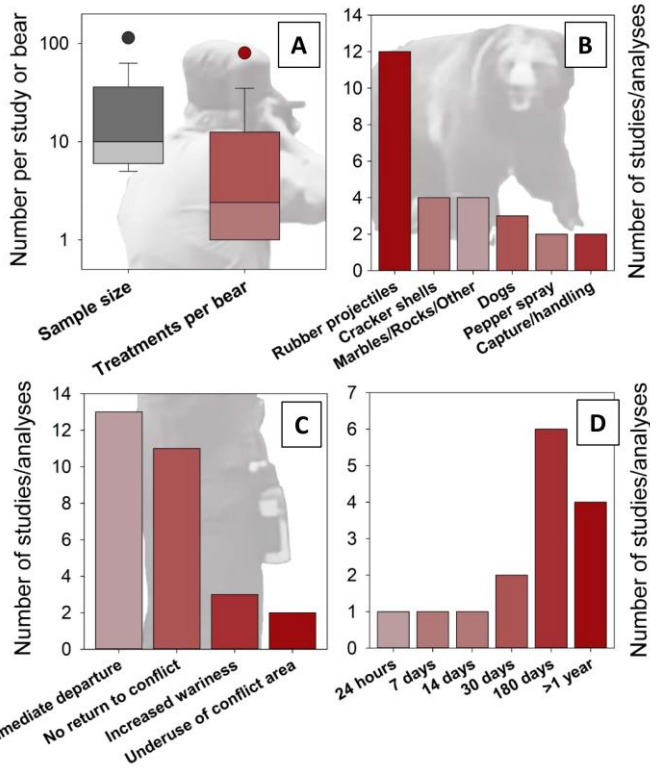


Figure 11. These graphs summarize key parameters of published research that focused on the contigencies of hazing or aversively conditioning bears, including (A) a box-and-whisker plot summarizing total numbers of individual treated bears per study as well as average number of treatments per bear; (B) the number of studies that used different types of deterrents or other treatments to condition or haze bears; (C) the number of studies that invoked or simply reported different types of responses by bears as a standard for judging "success" of hazing or conditioning operations; and (D) the number of studies that used various response durations as either a standard for judging "success" or merely as a metric relevant for reporting results.

The methods used for hazing were equally varied (Figure 11b), especially when permuted by variation in combinations of deployed deterrents. Even so, rubber projectiles (e.g., bullets, batons, buckshot, or beanbags) were used most often, sometimes in combination with cracker shells. Considerable mixing of tools occurred during a few studies, both within as well as among hazing incidents—in one study including the use of rubber projectiles, pepper spray, thrown rocks, and chases (Mazur 2010); and in another, the use again of rubber projectiles and pepper spray, but in combination with cracker shells and dogs (Beckmann et al. 2004). Another study relied solely upon the adverse experiences of being trapped, immobilized, and handled (Clark et al. 2002). Honeyman (2008) merely invoked using "bear shepherding" techniques, which is presumably tantamount to primary reliance on Karelian Bear Dogs for hazing operations[40]. Here, again, this variation debars ready isolation of effects attributable to any particular combination of tools or treatments, let alone the effects of a single deterrent or technique.

Investigators described an equally wide range of responses by targeted bears, often with lack of clarity regarding whether these responses had been established *a priori* as standards for judging

[40] In all of the written materials that I've been able to uncover, whether printed or online, I have not been able to determine the exact methods used in Bear Shepherding. The website of the Wind River Bear Institute makes reference to an "all-inclusive approach," without any greater specification. Other content of this website as well as descriptions on the Western Wildlife Outreach website, in Masterson (2016), and elsewhere leave the distinct impression that bear shepherding is tantamount to hazing bears with Karelian Bear Dogs, often in combination with a trapping and handling operation. However, this last proviso doesn't seem to apply to the efforts described by Honeyman (2008).

achievement of a goal, or were merely a *post hoc* characterization. A favorable response was most often either described in terms of immediate departure after a hazing incident or the absence of subsequent "conflict" at locations where a treatment had occurred (Figure 11c). Only rarely were responses judged in terms of increased apparent wariness during subsequent encounters with people or subsequent comparative underuse of human environs. Insofar as response duration was concerned, a favorable outcome was most often described as having occurred if a treated bear did not become involved in a conflict for the remainder of the non-denning season (Figure 11d). Even so, favorable responses were nearly as often described as lasting between one and 30 days, usually without clarification regarding whether this duration was deemed adequate or not.

I found that determining the combined sex, age-, and reproductive class of treated bears was often impossible. In most studies males were differentiated from females, but without jointly specifying the age-class or reproductive condition of targeted animals. In most instances, the treated animals seemed to be targets of opportunity, with the apparent exception of studies by Gillin et al. (1994) and Rauer et al. (2003), which presumably prioritized targeting adult females. However, in aggregate, most focal bears in most studies were males, and most of them were apparently adolescents.

Of additional relevance, all but one of the reported studies involved situations where anthropogenic foods had attracted a bear to a conflict site. Of these, all but one clearly entailed point sources. Parenthetically, but importantly, there was rarely any mention of whether human-related attractants had been removed as part of a conflict-resolution effort and, if so, to what extent these sanitation efforts had affected subsequent bear behaviors, especially in contrast to hazing efforts.

The upshot is that the results of these hazing and conditioning studies probably apply largely to young male bears attracted to anthropogenic foods located at a residence, townsite, or campground. By the same token, these results are less likely to apply to bears using dispersed natural foods, or to other sex- and age-classes including females with dependent young. Although this parsing is based largely on reading the tea leaves offered by various studies, it is arguably the most defensible specification of scope of inference for the aggregated investigations focused on hazing and aversively conditioning bears.

With all of this variation in relevant parameters and configurative factors—as well as lack of specificity regarding context—I found it difficult to assemble any kind of meaningful statistical summary that aggregated the results of various studies. However, if one reckons success as being the rapid departure of a targeted bear followed by avoidance of the hazing site for the next 1-24 hours, then nearly all hazed bears will likely comply. On average, where this sort of response was recorded, it occurred 71% of the time, albeit with a range of 50-90%.

In the face of all this ambiguity, perhaps the most useful means of summarizing research on longer-term or broader-scale efficacies of aversively conditioning bears is to look at how the involved researchers chose to summarize their own work. Authors of eight of the reviewed publications concluded that aversive conditioning had limited if not very little utility as a means of inducing longer-term or more generalized avoidance of human environs by bears, especially if anthropogenic attractants remained available (Gillin et al. 1994, McCarthy & Seavoy 1994, Rauer et al. 2003, Weaver 2004, Leigh 2007, Mazur 2010, Homstol 2011, Comeau 2013). On a related note, Khorozyan & Waltert (2020) concluded that the deterrents they reviewed "…varied widely in effectiveness."

At a somewhat more nuanced level, Stokes (1970), Gilbert (1989), Gillin et al. (1992), Clark et al. (2002), and Mazur (2010) either surmised or concluded perhaps the obvious (Section 6.3; Figure 9)—that younger bears without much exposure to food rewards from humans (or, in general, so-called "wild" bears) were perhaps one of the easiest types of bears to haze with prospects of longer-lasting aversive effects. By contrast, Clark et al. (2002) concluded that females with young were the most difficult candidates (Section 6.3; Figure 9). Gillin et al. (1992) also went on to recommend against attempting to haze or aversively condition bears that appeared to be inherently aggressive (see Figures 2, 5, & 6; Sections 3.5 and 4.5; Gilbert [1989]), or that seemed to be sick or injured.

7.3. A Notable Exception

The one striking exception to these general expressions of skepticism, reticence, or at least ambivalence can be found in Honeyman (2008). He unequivocally concluded that aversive conditioning "…is an effective management tool to reduce [*sic*] human conflicts with grizzly bears." In addition to its main conclusion, this study is an outlier in several other notable regards. It was the only to apparently target bears using natural foods dispersed along and around human features. It apparently employed the largest average number of treatments per bear by far (around 80). It was also the only of those reported that used largely unspecified treatments other than as implied by "bear shepherding."

Photo by Jay Honeyman
Karelian bear dogs such as were used for "bear shepherding" in Peter Lougheed Provincial Park.

However, like all of the other studies, the context was largely undescribed, which introduced an additional handicap when determining the relevance and extrapolability of this study. Also, like most of the other studies, it described the primary metric for desired outcomes in relatively vague terms, notably as increased "wariness" during encounters with humans—although, more concretely, the author made reference to a substantial decline in conflict situations.

Of importance to interpreting Honeyman's results, the larger encompassing area is typified by some of the lowest grizzly bear densities in Alberta (Boulanger et al. 2018), which are, overall, some of the lowest in North America outside of arctic areas (Mowat et al. 2013: Supporting information). The grizzly bear population in Alberta is also in the process of recovering from a long history of unsustainable exploitation (Festa-Bianchet & Kansas 2010). It is thus quite likely that the comparative ease with which grizzly bears were conditioned to avoid humans was partially a function of low bear densities (see Section 5.3, 5.5, and 5.6). If densities in this area were, moreover, below carrying capacity, the upshot would be greater functional access for all affected bears to resources outside of human environs (i.e., "escape" options; Sections 4.2 and 4.6).

As I note above, another complicating aspect of this potentially important study is the opaque description of methods. If "bear shepherding"—the invoked method—equates primarily to reliance on the use of Karelian Bear Dogs for hazing operations (see footnote 38) then supporting evidence becomes a prominent issue. Unfortunately, I could find no systematically collected and contextualized evidence for the efficacy of these dogs in hazing operations. Primary support was instead in the nature of uncontextualized anecdote[41].

VerCauteren et al. (2013) best describe the problem: "The efficacy of Karelian Bear Dogs in reducing human–wildlife conflict has not been rigorously evaluated and reported in the scientific literature, although both ASRD [*Alberta Ministry of Environment & Sustainable Resource Development*] and WDFW [*Washington Department of Fish & Wildlife*] appear convinced that they provide real value for managing problem wildlife." As it turns out, the latter agency apparently often uses Karelian Bear Dogs as part of multi-faceted "hard releases" for black bears captured at conflict locations (Masterson 2016). Hard releases are characterized not only by the use of Bear Dogs but also by trapping and handling and use of rubber projectiles and cracker shells (https://www.youtube.com/watch?v=deOfEkuJGVQ). This also typifies hazing operations involving Bear Dogs conducted by the Nevada Department of Wildlife (http://www.ndow.org/Nevada_Wildlife/Bear_Awareness/Karelian_Bear_Dogs/).

It is thus difficult to determine from available anecdote what effect Karelian Bear Dogs have had in isolation, the contextual determinants of those effects, and how, more broadly, efficacy was judged. This clearly has implications for interpreting the results of Honeyman (2008), especially when determining what tools might work well, in what combinations, and under what circumstances (as per Figure 10).

7.4. Implications & Applications

What can be made of these investigations directly involving bears? Unfortunately, not much, given how virtually all of these studies were implemented, described, and otherwise reported. Importantly, this conclusion does not apply to research done under both captive and field conditions investigating the effectiveness of various deterrents for non-lethally repelling a bear during close encounters. The conclusions from this latter body of work are robust[42] in part simply because close encounters, although sometimes influenced by a number of factors, are relatively straight-forward phenomena compared to the complexities attending most efforts to aversively condition or haze bears under field conditions (see Sections 3-5).

[41] Unfortunately, much of this anecdote comes across as promotional rather than edifying, with the esthetic appeal of Karelian Bear Dogs typically placed front and center. For example, Washington Department of Fish & Wildlife depends on the appeal of its dogs to generate the public donations needed to support operations with these animals (https://wdfw.wa.gov/about/enforcement/KBD). As has been noted a number of times by others (e.g., https://beardogs.org/kbds/), Karelian Bear Dogs are moreover probably one of the most challenging tools to deploy for hazing purposes given the training demands placed on both dogs and handlers.

[42] For example, there is good evidence supporting the efficacy of pepper spray in situations where a person is not carrying a firearm suited to firing non-lethal projectiles (Section 2.2; Hunt [1984]; Rogers [1984]; Herrero & Higgins [1998]; Smith et al. [2008, 2012]; Smith & Herrero [2018]), or rubber projectiles if a person is carrying and trained to use the requisite shotgun (Stenhouse et al. 1983, 1984).

Of relevance to this last point, the main generalizable conclusion that *can* be drawn from investigations of aversive conditioning comports with the well-documented effects of deterrents during close encounters. Assuming that the delivered stimuli are sufficiently discomfiting, a bear will likely depart from a conflict situation and not return for 24 hours or so after being hazed (see Section 4.2). Other than this, aversive conditioning efforts will probably not inculcate generalized avoidance of humans or human infrastructure—with the possible exception of inexperienced young bears early in the process of exposure to human attractants.

One other more speculative conclusion can be drawn from the Honeyman (2008) analysis. Odds of successful conditioning probably increase if hazing is frequent, sustained, and moderately intense (see Section 4.2), as well as undertaken in an environment with comparatively low densities of conspecifics (see Sections 5.3, 5.5, and 5.6). Another significant contingency suggested by the conditions of this particular study highlights to potential importance of securing anthropogenic foods if aversive conditioning efforts are to succeed. Honeyman (2008) makes clear that the provincial park in which the work he analyzed took place was relatively free of human-related foods, unlike most areas outside of protected areas where managers do not have paramount authority.

7.5. A Way Forward

My main conclusion from reviewing this bear-specific research is that accumulating a truly useful body of intersubjective knowledge about how to successfully condition bears under field conditions will depend on researchers designing their investigations and then reporting their results in ways that are fully contextualized. In the absence of controlled laboratory conditions (see Section 3.1), the only way to generate valid inferences with the potential for extrapolation is by explicitly locating field efforts and field conditions within a replete conceptual map containing all important potential intervening effects, as per Section 6.4 and Figure 10[43].

As the famous statistician Sir Ronald Fisher quipped "…make your models complex for non-randomized studies"—which is to say, for just about every study done outside of a laboratory. Radford Neal (1994) elaborated on this basic point when he wrote: "…deliberately limiting the complexity of the model is not fruitful when the problem is evidently complex. Instead, if a simple model is found that outperforms some particular complex model, the appropriate response is to define a different complex model that captures whatever aspect of the problem led to the simple model performing well." In other words, evidence-based inferences about the effects of an individual factor—or effect—require that managers and field researchers embrace rather than ignore complexity, and that the necessarily singular conditions of a given field study be insightfully mapped onto the universe of conceptually relevant situations.

This perhaps arcane consideration is crucially important if managers hope to employ research rather than anecdote or immediate personal experience as a professed basis for deterring, hazing, and aversively conditioning bears. An even greater imperative for the same is created by the fact that increasingly engaged members of the public are more often demanding that scientific evidence rather than expert assertion be offered as justification for how bears are managed, especially when the

[43] See, for example, the numerous insightful comments by Lasswell & Kaplan (1950) and Lasswell (1971) about the hazards of under-contextualizing "self-in-situation."

welfare of individually-targeted bears that are well-known and much-loved is at stake, as is not uncommon for tolerant bears using human environs (Spencer et al. 2007, Baruch-Mordo et al. 2014, Mangelsen & Wilkinson 2015).

Given these exigencies and the uncertainty of directly relevant research (Section 7.2), perhaps the best means of defensibly marshalling evidence and information for diagnosing conflict situations and designing interventions is one that is perhaps intuitive but conceivably dissonant with the professed dogma (but not practice[44]) of wildlife management. The wealth of background information regarding contingencies of conditioning processes (Sections 3 and 4) as well as bears themselves (Section 5) provides a basis for specifying conceptual models (Section 6) that offer prospectively robust explanations for conflicts involving bears (e.g., Figures 8 and 10) as well as predictions for the outcomes of various interventions (e.g., figure 9; Bauer & Johnson-Laird 1993). Results of vagarious field research can be mapped onto these conceptual models to either refine or adjust explanations and related intervention designs—analogous to planning and decision-making informed by Bayesian theory (Newton et al. 2007, Ma 2019).

Taken as a whole, this sort of approach can maximally leverage generalized as well as specific knowledge and mitigate against the limitations of under-specified and incomplete field research. It also embraces rather than ignores the endemic complexity of efforts to condition bears[45].

[44] See, for example, Artelle et al. (2014, 2018) and Treves et al. (2021).

[45] Parenthetically, the approach described above is probably not much different from the approach tacitly taken by most wildlife managers, but with some important differences. As with all humans, the largely undisclosed mental models constructed by managers as a means of representing "how the world works" is necessarily bounded by the limits of experience and imagination (Johnson-Laird 1983, Byrne 2005, Evans 2008, Moon et al. 2019). Experience is, in turn, bounded for individuals by limited geography and time spans. While our mental models may be useful guides to action under most circumstances—within certain spatial and temporal bounds—they are at the same time guaranteed to have limited efficacy under novel conditions. More importantly, subjective mental models are intrinsically difficult to communicate, which complicates building an intersubjective body of knowledge (Agazzi 1985, Jones et al. 2011, Moon et al. 2019).

8. Concluding Thoughts

People watching a tolerant female grizzly bear along a highway in Grand Teton National Park

by Tom Mangelsen

The synthesis of concepts, theory, laboratory research, research with humans, field research with other animals, and field research with bears presented in this report provides a robust basis for judging the prospects for aversively conditioning bears as well as the contingencies of achieving a successful outcome. Bears will likely exhibit generalized avoidance of humans and human infrastructure—especially for periods of years—only in a small subset of the circumstances typifying conflicts between humans and bears, and then only if hazing efforts are well-designed. When subject to conflicting stimuli and cues, bears will more likely be motivated to discriminate the specific conditions typifying hazing efforts, and make fine-tuned behavioral adjustments accordingly. More promisingly, hazing will likely work as a tool to displace bears from a conflict situation long enough for human-related factors to be addressed.

8.1. Focus on Humans Instead

The reference immediately above to human-related factors raises a critically important point. In contrast to the minimal or at least highly contingent support for efficacies of aversive conditioning, there is an enormous amount of support from on-the-ground efforts for the relatively non-contingent effectiveness of managing people to prevent and resolve conflict between humans and bears. Researchers and managers have documented substantial declines in conflicts as well as incidents posing a threat to human safety after implementing efforts to control people watching bears along roadsides[46] or on foot watching bears at salmon spawning streams[47]—an approach used to good effect by managers seeking to harmonize human safety and opportunities to view tolerant bears (Knight 2009, Herrero et al. 2005, Gunther et al. 2018). The temporary or permanent closure of areas

[46] Gunther et al. (2015, 2018) offer probably the best description of how roadside interventions by managers have helped to reduce conflict, specific to the conditions of Yellowstone and Grand Teton National Parks.
[47] Aumiller & Matt (1994) and DeBruyn et al. (2004) describe measures taken to increase human safety while facilitating viewing opportunities at McNeil River Falls and Brooks River Camp, respectively.

with a high potential for human-bear encounters is an extreme version of this strategy—but one that has produced sometimes dramatically positive results (Gunther 1994, Gniadek & Kendall 1998, Coleman et al. 2013).

Perhaps even more definitively, reducing the availability of human-associated attractants such as garbage, other human foods, remains of animals killed by hunters, and domesticated animals almost invariably resolves existing conflicts and prevents the emergence of chronically problematic situations associated with human infrastructure[48]. Conversely, many of the incidents leading to human death or injury from a front-country mauling can be traced to situations where attractants were available to the involved bear[49].

Despite demonstrable efficacy, interventions focused on humans can be confounded by limits on the dispositions and exercise of management authority. Managers theoretically hold paramount local authority in jurisdictions such as strictly protected areas. National parks and wildlife preserves are prime examples. Under such circumstances it is far easier to impose restrictions on people and their behaviors compared to elsewhere. In places such as the United States, where the freedom to act with impunity is often viewed as sacrosanct[50], opportunities for those with ostensible authority to control human behaviors are often quite limited. This is especially the case on private property. But even in areas or countries where government officials have greater ostensible scope of authority, this scope can often be constrained by opaque social and political forces—or limited simply by insufficient resources for implementation and enforcement of policies[51].

Interventions for reducing conflicts with bears that focus on people are thus frequently beset by numerous real or perceived constraints that are frequently mediated by human-human or at least "government"-human conflict. Under such circumstances, wildlife managers confronted with managing people often revert to focusing on animals instead, even when changes in human behaviors would likely yield greater benefits—as with most situations that catalyze conflict between bears and people. However, problems of both a practical and political nature can arise when hazing or conditioning efforts appear to be acts of desperation, displacement, or political expediency.

8.2. A Parable

The observation immediately above brings me back to the incident I describe in the Introduction of this report (Section 1). For over 15 years, between roughly 2004 and 2019, managers in Wyoming's Yellowstone and Grand Teton National Parks had been choosing to prioritize management of humans

[48] Follmann (1989), Gunther (1994), Schirokauer & Boyd (1998), Gunther et al. (2004), Creel (2007), Madison (2008), Wilson et al. (2014), Masterson (2016), Johnson et al. (2018) and others present results showing that removing or securing human-associated attractants can effectively resolve as well as prevent human-bear conflicts.

[49] Herrero (1985), Herrero & Higgins (1999, 2003), Herrero et al. (2011) review factors associated with bear-caused human injuries and deaths.

[50] See Trakman & Gatien (1999) for an insightful critique about the nexus of libertarian and communitarian conceptions of rights and responsibilities—and the balance between the two.

[51] Laswell (1971, 1976) helpfully defines the concept power in a democratic society as being a widely shared expectation about who has both the authority and the means—i.e., controlling authority—to impose severe value deprivations. Power without shared expectation about either authority or control is inherently fragile.

rather than bears when people were crowding roadsides to watch nearby tolerant grizzly bears. Salaried employees as well as trained volunteers were deployed by the Park Service in related crowd control efforts. This human-focused approach had been judged a success (Gunther et al. 2018), although not readily extrapolated to a rapidly evolving situation towards the end of this period that involved a highly tolerant female bear using habitats along a high-speed highway in nearby non-park jurisdictions of the Jackson Hole, Wyoming, area.

Photo by Tom Mangelsen

Bear 399 walking down a road in Grand Teton National Park with three cubs-of-the-year.

Many of the tolerant grizzly bears that attracted crowds of viewers were of lineages that could be traced back to a handful of matriarchs (e.g., Mangelsen & Wilkinson 2015). Regardless of whether these matriarchs were initially tolerant or underwent a process of habituation, they passed on the habit of tolerance and associated exploitation of human-influenced habitats to their progeny. This all took place against the backdrop of a bear population that was rapidly approaching carrying capacity (Van Manen et al. 2016), with adult males disproportionately concentrated in the back-country (Mattson et al. 1987, 1992a; Reinhart & Mattson 1990). The result was a classic worst-case scenario insofar as prospects for aversive conditioning are concerned, especially when reproductive females—of which there were several—were prospective targets (see Sections 5.3-5.6, 6.2, 6.3, and Figures 8 and 9).

At the same time that managers were focused on controlling crowds of bear watchers, numbers of visitors to the Yellowstone region grew by roughly 33%, with numbers during 2021 alone nearly 40% higher than the year before (https://irma.nps.gov/STATS/Reports/Park/YELL). Chaotic mob scenes emerged along highways as people gathered to watch tolerant bears—at the same time that interagency cooperation and the personnel devoted to managing these mobs failed to appreciably increase[52]. The situation was especially problematic along a through-highway (US Highway 26) with a

[52] https://www.grizzlytimes.org/single-post/playing-russian-roulette-with-grizzly-matron-399-and-the-bears-of-yellowstone-part-1-this-is-the; https://www.grizzlytimes.org/single-post/playing-russian-roulette-with-grizzly-matron-399-and-the-bears-of-yellowstone-part-2

65-mph speed limit where mounting numbers of people were stopping to watch a tolerant adult female bear, causing hazards for both the bear and passing traffic[53].

The problems caused by insufficient resources and inadequate planning by wildlife managers were compounded by politically-imposed constraints on options to manage other human elements of the conflict landscape. The state of Wyoming had failed to pass—much less enforce—laws that prohibited the feeding of wildlife[54]. Similarly, the U.S. Fish & Wildlife Service and local jurisdiction of Teton County failed to adequately enforce its laws prohibiting the feeding of wildlife on private property[55], which exacerbated problems arising from availability of garbage and other human foods. Both inadequacies arguably arose from the sanctification of private property rights. Nor did local wildlife or wildlands managers have the authority to limit visitation to public lands or substantively limit speed limits on highways outside of Grand Teton National Park where tolerant bears were active.

Wildlife managers responded to this increasingly out-of-control situation with people by more aggressively targeting tolerant bears with hazing operations[56]. Some of these hazing operations were described as being part of an aversive conditioning program. The grizzly bear female with two cubs-of-the-year that had used non-park areas along Highway 26 was targeted by a 2-week program of aggressive hazing, which followed an initial period of more *ad hoc* efforts by local wildlife managers[57]. The long-term results of these aversive conditioning efforts remained unclear despite the fact that officials involved in the hazing represented short-term displacement of targeted bears as "success"[58].

Unfortunately, these efforts by wildlife managers during 2020-2021 to aversively condition highly tolerant grizzly bears using human environs in Yellowstone National Park and the Jackson Hole area of Wyoming are, more than anything else, a cautionary parable. These undertakings had all the hallmarks of acontextuality, reflexive use of certain tools, exasperation with an increasingly chaotic management situation, and even desperation—and were, moreover, an exemplar of the messy and unpredictable situations that wildlife managers increasingly face at the intersection of complex human and bear social and ecological systems. The arenas of operation certainly bore little resemblance to a laboratory (see Section 3.1) or, for that matter, the circumstances typifying most research on hazing and aversively conditioning bears (see Section 7.2).

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[53] https://www.fws.gov/mountain-prairie/pressrel/2021/06112021-USFWS-and-Partners-Conducting-Grizzly-Hazing-Operations-Togwotee-Pass-Public-Asked-to-Avoid-Area.php; https://www.grizzlytimes.org/single-post/2019/06/26/felicia-s-fate-the-trials-of-a-grizzly-bear-mom

[54] https://wgfd.wyo.gov/regulations

[55] https://www.tetoncountywy.gov/657/Wildlife-Feeding-Violations; https://www.jhnewsandguide.com/news/environmental/homeowner-feeds-teton-park-grizzlies-for-years-feds-decline-charges/article_c3e0b597-1816-5d07-b042-bb866a87e216.html; https://www.wyomingpublicmedia.org/natural-resources-energy/2021-03-19/teton-county-takes-up-illegal-wildlife-feeding-after-feds-drop-case

[56] https://www.ktvq.com/news/after-3-bear-encounters-yellowstone-is-urging-folks-to-be-more-bear-aware; https://www.youtube.com/watch?v=0dCcNgHzSl4

[57] https://www.fws.gov/mountain-prairie/pressrel/2021/06112021-USFWS-and-Partners-Conducting-Grizzly-Hazing-Operations-Togwotee-Pass-Public-Asked-to-Avoid-Area.php

[58] https://www.wyomingpublicmedia.org/natural-resources-energy/2021-06-30/14-day-hazing-for-grizzly-family-initially-successful-felicia-will-stay-put

8.3. Displacement, Misuse, and the Urge to Punish

More to the point of this report, hazing operations in the Yellowstone region during 2020-2021 could be reasonably construed as manifesting anxieties displaced by wildlife managers faced with limited perceived options, of which perhaps the politically, socially, and emotionally easiest was to punish bears implicated in intractable management situations. The impulse to punish certainly comports with the punitive nature of wildlife management institutions organized around precepts of domination and even violence[59]. However, this kind of dynamic is unlikely to yield long-lasting non-lethal solutions to conflict situations, especially if improved management of people and human attractants is not vigorously pursued during intervals of respite provided by successful hazing. The hard work of people management could easily be derailed by seductive claims of short-term success, as typified hazing operations in the Yellowstone region during 2021[60].

Although the development and application of non-lethal methods for resolving human-bear conflicts is critically important to aligning management with increasing public demands for humane treatment of wild animals, this imperative ideally should not be construed as license for misguided or imprudent uses of these tools. Over time, misuse or misapplication of management practices has the potential to further erode public trust in wildlife managers, with undesirable consequences for the involved people and animals[61]. In the case of bears, ill-advised use of hazing as part of ill-thought-out aversive conditioning efforts runs the risk of being seen by the engaged public as little more than gratuitous infliction of pain.

Aversive conditioning with the goal of instilling long-term generalized avoidance of humans and human infrastructure is guaranteed to have a small place in the overall agenda of promoting human-bear coexistence and non-lethally resolving human conflicts with bears. Hazing has perhaps a larger role to play, but only with the intent of meeting circumscribed short-term objectives. Discerning these roles will continue to be a challenge for bear managers, but if coexistence between humans and bears is indeed the over-arching goal, hazing and aversive conditioning will invariably be a minor feature of management necessarily focused on engaging with and managing people.

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[59] There are numerous publications that document the domination-oriented and hunter-centered cultures of wildlife management agencies in the United States. Not surprisingly, a primary purpose featured in mission statements of these agencies is provision of surplus animals for hunters to kill, typically for sport and "satisfaction" (Metcalf et al. 2020). Some relevant publications documenting this cultural bias include Nie (2004), Brown et al. (2006), Mattson & Chambers (2009), Mattson & Clark (2009, 2010), Jacobs et al. (2014), Manfredo et al. (2017), and Gamborg et al. (2019)—plus many others.

[60] https://www.wyomingpublicmedia.org/natural-resources-energy/2021-06-30/14-day-hazing-for-grizzly-family-initially-successful-felicia-will-stay-put

[61] Various authors, including Cvetkovich & Winter (2003), Jacobson et al. (2010), Decker et al. (2016, 2019), and Manfredo et al. (2017) have highlighted the importance procedural fairness and alignment with broader public values as key to maintaining stakeholder trust in wildlife managers—but set against the crisis of declining trust caused by failures of wildlife managers to fulfill these basic obligations. Interestingly, academic authors such as Rudolph & Riley (2014), Schroeder & Fulton (2017) and Riley et al. (2020) fuel the trust crisis by featuring hunters and anglers as primary stakeholders—indeed clients—of relevance to trust relations with wildlife managers. Parenthetically, these authors receive their research funding from wildlife management agencies.

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Teaching Bears

Complexities and Contingencies of Deterrence and Aversive Conditioning

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