12 The Twin Challenges of Preventing Real and Perceived Threats to Human Interests

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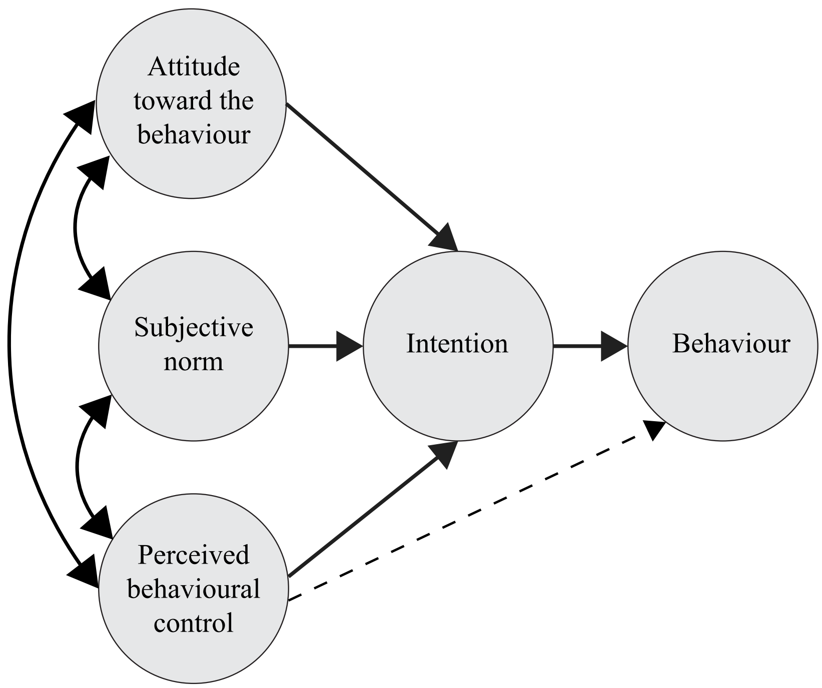
Humans and other species have historically competed over resources and space, resulting many times in interspecies conflict. For example, humans have hunted or domesticated wild herbivores for protein, which are also consumed by predators. This has led people to retaliatory killing of carnivores, posing a major threat to their populations (Woodroffe & Ginsberg 1998; Chapron et al. 2014). Although societies have developed mitigation strategies to reduce such conflicts, the rise of social conflicts between people who value carnivores and those who do not has sometimes affected the use of mitigation strategies, whether lethal or non-lethal (Treves & Karanth 2003; Treves et al. 2006; Redpath et al. 2013; Treves & Bruskotter 2014; Woodroffe & Redpath 2015). Differences in interests between people can lead to imposed solutions that benefit some people over others, due to power relations or prevailing attitudes (Redpath et al. 2013; Treves et al. 2015). Because of this imbalanced decision making ability, a proposed method may not be implemented as planned (Fishbein & Yzer 2003) or dismantled later (Karanth & Madhusudan 2002), even when functionally effective.

Non-implementation highlights hidden cognitive mechanisms that have been described by social psychologists' theories (e.g. Ajzen's Theory of Planned Behaviour (hereafter TPB); see Text Box 12.1), in which a complex mix of social norms, emotions and external conditions can influence people's decisions and actions (Fishbein & Yzer 2003; Wieckzorek Hudenko 2012; Schlüter et al. 2017; Amit & Jacobson 2017). The cognitive dimensions of human behaviour interact with both individual appraisals of effectiveness - which does not necessarily correlate with functional effectiveness - and uncertainty about effectiveness to alter implementation. We use the term effective (*powerful in effect; producing a notable effect*, www.oed.com) and effectiveness because these allow us to address both the potential of individual actors to achieve coexistence and the efficacy of technical devices to attain that goal. We do not use the term efficacy as it is more limited (*not used as an attribute of personal agents* www.oed.com) and avoid efficient because of its potential for confusion with feasible (*capable of being done, accomplished or carried out; possible, practicable*). We also focus on evidence for effectiveness of an intervention from actual experimental trials under working conditions (not under laboratory conditions), not idealized claims of effectiveness that have not yet been realized through real-world testing.

Text Box 12.1. *Theory of Planned Behavior* (adapted from Ajzen 1991)

This theoretical framework describes how intentions to perform certain behaviours are predicted by cognitive variables such as attitudes toward the behaviour (i.e. evaluation of the behaviour in question), subjective norms (i.e. social pressure to perform the behaviour), and perceived behavioural control (i.e. self-efficacy or perceived capacity to perform the behaviour).



Scientific research has shown that numerous methods of intervention can promote coexistence of people and carnivores (Inskip & Zimmermann 2009; Treves et al. 2009; McManus et al. 2015). However, few have been scientifically evaluated along multiple criteria of effectiveness, cost-efficiency, environmental consequences, social acceptability (Shivik et al. 2003; Breitenmoser et al. 2005; Inskip & Zimmermann 2009; Treves et al. 2009; Zarco-González & Monroy-Vilchis; 2014; McManus et al. 2015) and adequacy of implementation. Here, we lay out an integrative framework for understanding the implementation of interventions for coexistence and conflict, which includes both the effect in preventing future damages (functional effectiveness, 'FE' hereafter) and the individual human perceptions of effectiveness of an intervention (perceived effectiveness, 'PE' hereafter). In some cases, conflicting perceptions of effectiveness and functional effectiveness can lead to negative outcomes for wildlife or property owners, where the goals of conservation and coexistence with wild animals may be jeopardized. We expose the cause-and-effect logic underlying decisions to intervene or not, where both explicit and hidden mechanisms are considered. By understanding better how FE and PE relate, we believe the field can avoid a sterile debate claiming that *people are irrational* on the one hand or that *technical experts have no common sense* on the other hand. Avoiding such misunderstandings may improve intervention design and implementation, conservation and coexistence efforts, policy, conflict resolution, and scientific analysis of human wildlife-coexistence and conflict (HWCC).

12.1 The theory behind FE and PE

Functional effectiveness (FE) in our context of HWCC measures *whether the intervention reduces future attacks by wildlife* (Treves et al. 2016). Because empirical measurement of wildlife damage and its attribution to wildlife is a technical skill with a measurable rate of errors (e.g. Plumer et al. 2018), FE differs markedly from human opinion of the effectiveness of an intervention, to which we return below. Nevertheless, FE is difficult to evaluate rigorously. Biomedical sciences have pioneered in experiments yielding strong inference about the FE of interventions. For instance, randomized control trials (*gold-standard* hereafter; see Text Box 12.2), are the most robust methods to estimate the effectiveness of an intervention (Grimshaw et al. 2000; Mukherjee 2010). Avoiding biases at several stages and reducing the effect of confounding variables are indispensable advantages of this method. For instance, there has been four recent reviews on the FE of methods to reduce carnivore predation on livestock, which revealed diverse interpretations and standards of evidence (Miller et al. 2016; Treves et al. 2016;

Eklund et al. 2017; van Eeden et al. 2018). One of the main results of all four reviews was the high variability in the effectiveness of interventions. Moreover, all four reviews concurred that strong inference was scarce because of a lack of experimental controls. Because there has been little consensus until now on standards of evidence for FE, at least one of the above reviews used measures of PE (did the livestock owner report satisfaction or perceive reduction in losses of livestock?). In the next section, we define PE so future research will maintain a clear separation between FE and PE.

Text Box 12.2 *Definition of gold, silver and platinum-standard experiments (see Treves et al. 2016)*

Gold-standard
Random assignment of treatments and controls, without detectable biases in sampling, treatment, measurement, or reporting. It produces the strongest inference and evidence of effectiveness of an intervention. Examples of this were reported in Treves et al. (2016).

Silver-standard
Non-random assignment of treatments. Includes quasi-experimental designs with haphazard assignment of treatments, such as case-control or Before-After Control-Impact (hereafter BACI) designs. Produces weaker inference because of potential pre-existing differences between treatment and control replicates, and because of confounding temporal effects coincident with the treatments.

Platinum standard
A gold-standard experiment in which 'blinding' prevents intervenors from influencing measurers and vice versa, and other recommendations from Ioannidis (2005) are put in place by researchers, such as registered reports in which the methods are peer-reviewed before the experiment begins.

Because strong inference depends on careful experiments that oppose hypotheses (Platt 1964), Treves et al. (2016) emphasized that only a handful of studies in North America and Europe had ever produced strong inference about interventions to prevent predation on livestock. Although their goal was to review studies that fulfilled the *gold-standard* criteria, only two tests of non-lethal method met that standard between 1973 and 2016 and zero for lethal methods of intervention. Therefore, they had to relax the criteria to include silver-standard studies (a total 10 studies under this criteria) (see Text Box 12.2 for definition). Furthermore, a 2018 re-evaluation of one of the tests of lethal methods led to its removal from the list of functionally effective methods (Santiago-Ávila et al. 2018a), given concerns related to their identification of study subjects (potential sampling bias) and the construction of their dependent variable (potential measurement bias). In summary, we highlight the importance of implementing rigorous and robust designs that measure functional effectiveness with strong inference. This will prevent implementation of ineffective interventions that would lead to wasted resources and harm to animals (wild and domestic) and, therefore, not promote coexistence. We also conclude that after more than 40 years of studies with weak inference or flawed designs, societies seeking evidence-based policy on wildlife control may find little certainty. That can lead to choices of interventions based solely on PE.

By contrast with FE, PE is a cognitive state. Perceived effectiveness (PE) in the context of HWCC measures *individual perceived reduction in damages of an intervention*. For example, most readers would accept that two individuals could perceive the same effect differently from each other and, neither PE may be identical to the scientific measurement of a functional effect. The logical inference in both cases is that PE relies on subjective cues that can be accurate or not. Human brains and senses are not scientific tools for unbiased measurement. For instance, several studies have demonstrated the influence that factors like experience, context, cognition, and perceptual biases (e.g. preconceived ideas about something) have on filtering individual observations (Starr 1969; Kellert 1985; Slovic 1987; Finucane et al. 2000; Wieczoreck Hudenko 2012). In this section, we attempt to explain more precisely the conditions under which FE and

PE do and do not overlap, and the role that overlap plays in fostering or hindering coexistence with others, especially nonhuman others.

12.1.1 PE components and development of framework

Differences of perception between two persons relates both to physical constraints on perceptual abilities (e.g. sensory and motor constraints) and to psychological factors that influence appraisals (Starr 1969; Slovic 1987). The field of psychology has a long history of investigating appraisals and two major conclusions have emerged. Human brains make rapid appraisals on the order of milliseconds, using more ancient regions of the brain such as the amygdala (Whalen et al. 1998; Morris et al. 1999). Rapid appraisals (e.g. emotions - fear of snakes) often have high survival value and are difficult to modulate by the slower, cortical regions of the brain (Öhman & Mineka 2001; Barrett 2006; Lindquist et al. 2012). Fast appraisals captured by the amygdala may even go unnoticed by the perceiver, who simply may not be aware of the stimulus (i.e. unconscious pathway) (Esteves & Öhman 1993; Whalen et al. 1998). Human brains also make slower appraisals on the order of tenths of seconds, using more recently evolved regions of the brain such as the frontal cortex (Ajzen 1991; Treves & Pizzagalli 2002; Kahnemann 2003). For instance, when humans face obstacles or threats, their preferred solutions reflect both the rapid-affective (as simple as like or dislike) and slower-cognitive responses (should I like or dislike this?), which may integrate numerous criteria that reflect both the characteristics of the obstacle or threat, and the perceiver's own attributes including experiences and perceived social norms (e.g. how others perceive the situation and what they expect from the subject) (Kahnemann 2003; Wieczorek Hudenko 2012). The way the different appraisals replace each other or integrate is not yet well understood generally and largely unknown for HWCC. In summary, there is a mixed route of decision making relevant to behaviour based on a rapid, automatic pathway (e.g. affective) combined with a slower, reasoned one (e.g. conscious) (Kahnemann 2003).

Building on the above research into cognition and behaviour, investigators of HWC decision-making suggest that both cognitive (rational) and affective (emotional) components are relevant and important in understanding human behaviour. This is significant given that emotions (e.g. fear) will most likely predominate during these interactions and, therefore, would influence human behaviour (Johansson & Karlsson 2011; Wieczorek Hudenko 2012; Frank et al. 2015; Sponarski et al. 2015). Thus, in our treatment of PE, we restrict ourselves to referring simplistically and similarly to a mixture of affect (rapid responses) and cognition (slower responses) rather than the exclusive use of one or the other.

Observers or non-evaluators may disagree with scientific measurement of FE and will, therefore, behave differently from evaluators. For instance, confirmation bias can be understood loosely as a tendency to ignore information that conflicts with pre-existing beliefs, and to focus on information that conforms to a person's beliefs (Dunwoody 2007; Wieczorek Hudenko 2012). Related but sometimes acting separately, humans may change their perceptions, and behaviours that follow from those perceptions, if the bearer of the new message is familiar and trusted *versus* unfamiliar or untrusted (Dunwoody 2007; Powell et al. 2007). For instance, trust and familiarity have been addressed through research on social norms. Addressing HWCC explicitly, Heberlein (2012) described norms as behavioural regularities and as being closely related to one's role in a social group. Social norms can trump attitudes when it comes to shaping behaviours and expectations (Kinzig et al. 2013). Further, norms of acceptable behaviour and those enforced by social pressure can govern over alternate rules or motivations (e.g. laws or mechanistic explanations for behaviour such as income needs), as in the case of illegal behaviours (Jones et al. 2008; Marchini & Macdonald 2012). For example, social norms strongly influenced the intention to kill jaguars in Brazil more so than retaliation due to livestock predation. People's intention to kill carnivores was driven by the thought that peers kill carnivores more than wealth of the respondent (Marchini & Macdonald 2012). Furthermore, the decision to act may depend on the individual's perceived behavioural control over that action or the phenomenon being perceived (Ajzen 1991; Fishbein & Yzer 2003; Amit & Jacobson 2017). Discriminating the two cognitive mechanisms (social norms or behavioural control) may be very difficult because of the hidden nature of cognitive processing that precedes action or inaction. Finally, perceptions might change following an intervention event or before, during and after an intervention took place. For example, a farmer may ask himself questions like: (1) *Will this intervention reduce damages or threats*? (before implementation), (2): *Is this reducing damages*? (during), (3) *Do I like the outcome*?, *Were there any unexpected consequences*? (immediately after), and; (4) *Would I try it again*? (longer after; see PE in Fig. 12.1). Some authors (Ajzen 1991; Fishbein & Yzer 2003) predict that events may produce changes in intentions or in perceptions of behavioural control, with the effect that the original measures of these variables no longer permit accurate prediction of behaviour.

Here, we build and expand on the TPB (Ajzen 1991) as well as more recent work on behaviour change in the literature on human-environment interactions (Fishbein & Yzer 2003; Wieczorek Hudenko 2012; Amit & Jacobson 2017; Schlüter et al. 2017;) to offer a schematic figure both to illustrate the complexity of human cognition as it relates to PE, and as a heuristic tool for partitioning the process of PE into more manageable components for analysis, as discussed previously (Figure 12.1). For instance, Amit & Jacobson (2017) described an expanded model adapted from Ajzen's TPB (1991) applied to human-carnivore conflict mitigation strategies. This expanded model included additional factors such as emotions and situational variables (i.e. livestock mortality rates by carnivores, income from livestock production and size of the property) that may influence farmers' decision-making behaviour related to the adoption of an intervention or not. Here we simplify intervention choice or implementation down to the most important causal variables so that we can integrate FE and PE. Integration of both will help us to identify and understand the circumstances when they do or do not align and, therefore, focus on where and how we should put our efforts on interventions aimed at coexistence.

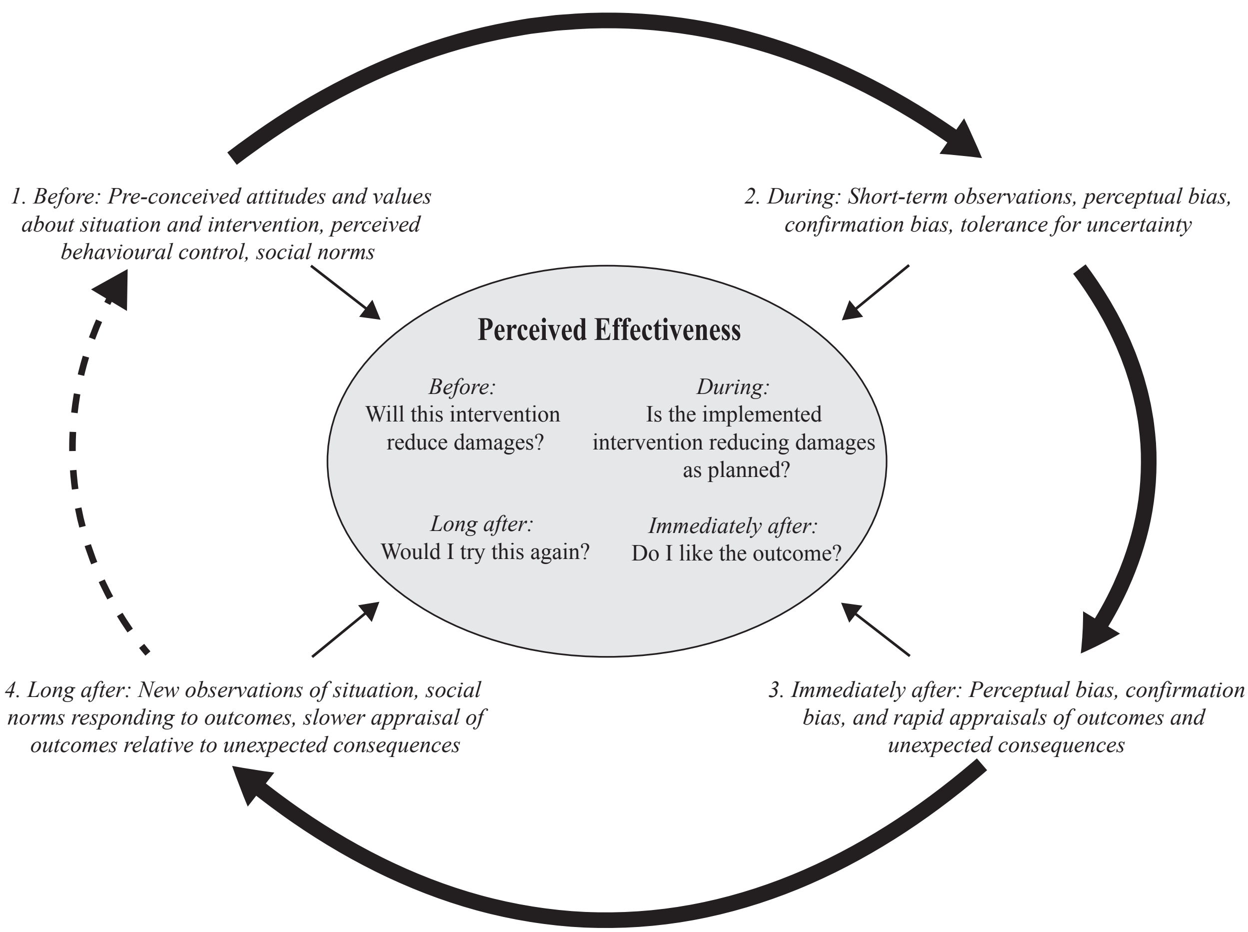


Figure 12.1 Perceived effectiveness framework adapted from social-psychological decision-making theories. In this adapted framework, human cognition variables are laid out

chronologically from the upper left running clockwise from pre-implementation of an intervention to long-term post-implementation. The dashed arrow indicates the possibility of re-starting the process adaptively if the implementers are not satisfied.

12.1.2 Integrative Framework: Theory of Relationship between Functional and Perceived Effectiveness

So far, we have described the theory behind FE and PE independently. Now, we want to integrate the two concepts to propose a hypothesis. Our hypothesis is that, a scientifically-proven functionally effective intervention (high FE) is more likely to be adopted if $PE \geq FE$, than if $PE < FE$. Alternatively, an ineffective intervention (FE low) is more likely to be adopted if $PE > FE$, than if PE is low (Figure 12.2).

Figure 12.2. Hypothesis that integrates concepts of perceived and functional effectiveness

FE \ **PE**	*Low*	*High*
Low	Least likely to be adopted	More likely to be adopted
High	Less likely to be adopted	Most likely to be adopted

This hypothesis highlights two cases of important conservation and coexistence concern. We predict that (1), non-adoption of a functionally effective intervention, (high FE and low PE, lower left in Figure 12.2) leads to political conflicts between researchers and stakeholders in addition to adoption of another intervention method, which might in turn lead to (2), the adoption of an ineffective intervention (low FE and high PE, upper right in Figure 12.2). We predict outcome (2) leads to wasted resources and harm to animals without improving coexistence. In both cases, our goal is to predict the factors that are influencing the decisions and suggest outcomes for coexistence.

Here, we propose three cognitive processes that may influence PE and the decision to implement an intervention: (1) uncertainty about FE, (2) ecological and social side-effects and outside interest groups influences (e.g. social norms), and (3) ability to implement (e.g. feasability, behavioural control[1]). These cognitive processes do not act separately, presenting levels of overlap and correlation between them (Ajzen 1991; Fishbein & Yzer 2003; Amit & Jacobson 2017). Nevertheless, all of the cognitive processes underlying PE might contribute to the decision to act (implement an intervention), which we defined as an area where all three processes overlap in Figure 12.3. Because two of the three cognitive processes have nothing to do with FE (social norms and perceived behavioural control), we predict in many instances FE ≠ PE. We predict that FE is more likely to equal PE and that appropriate action would follow when a trusted messenger demonstrates the intervention or testifies to its usefulness (Dunwoody 2007) (reducing uncertainty), when unintended side-effects are minimized or eliminated, and when resource or technical aid is provided to improve perceived control over the intervention.

[1] the degree to which an individual perceives the behaviour under their volitional control

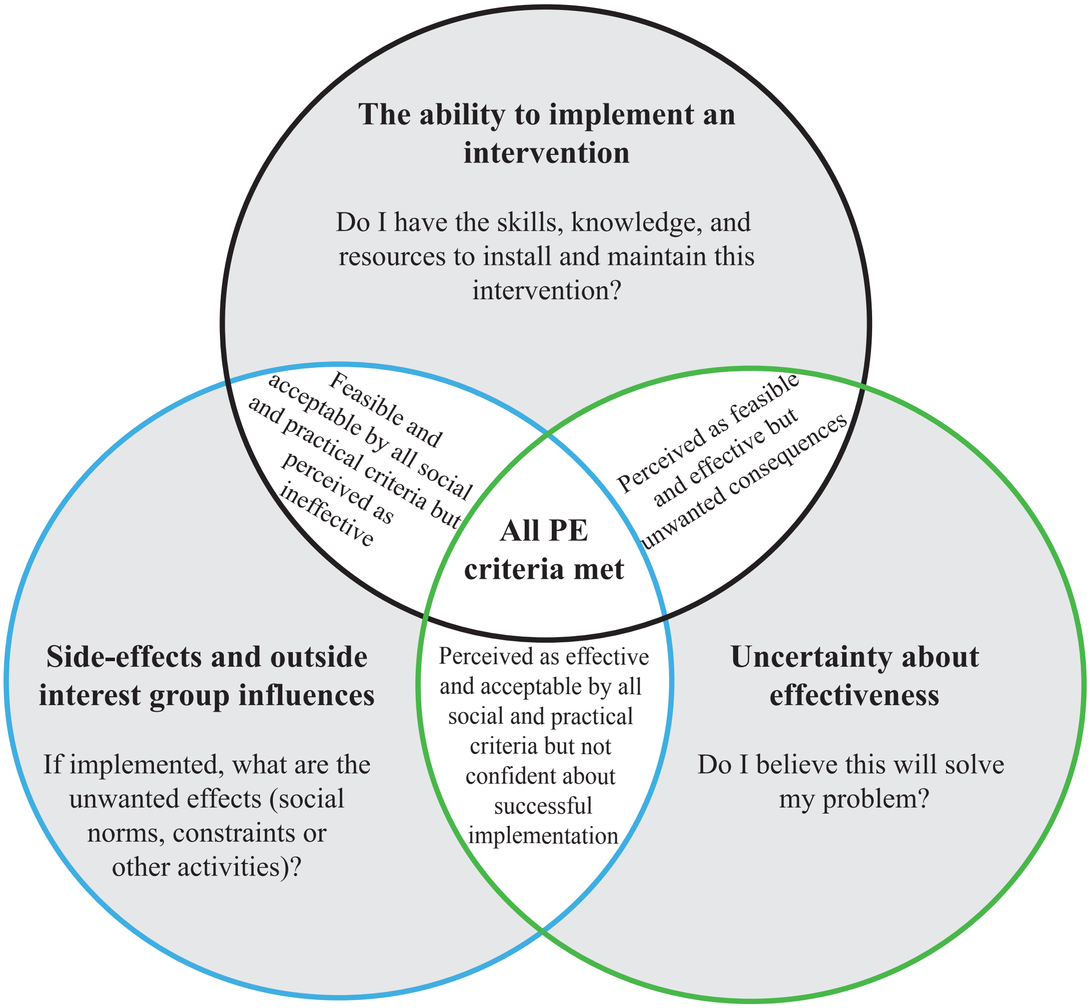


Figure 12.3. Integrative framework for effectiveness of interventions regarding human-wildlife conflicts. Decision-making variables span different groups and levels, indicated by overlapping circles. The overlapped area indicates the co-occurrence of PE variables. Examples of questions are provided for each variable (circle) which might influence decision-making. The bottom right circle relating to uncertainty is meant to predict that FE (scientific evidence) is still filtered through a cognitive process relating to uncertainty if the FE applies to the subject in question.

A framework should guide the testing of a hypothesis, if the predictions are articulated properly and measured appropriately. Our integrative framework helps to explain why an implementer may decline or dismantle an intervention that shows evidence of FE, because FE does not address side-effects, social norms, or feasibility. Likewise, our framework helps to explain why technical experts often disapprove of the actual methods in use by lay persons. For instance, the implementation was feasible and accepted by social norms but the technical expert may see a design flaw that precludes FE. Our framework would improve future coexistence if it exposes mismatches between PE and FE so that intervention designers and implementers can include persuasive interventions if needed.

Below we explore some cases in which PE ≠ FE yet FE is high. Our first example addresses a non-lethal intervention in which social norms are favourable and uncertainty is low but individuals seem to rate the feasibility (perceived control) as low. A proven intervention such as Livestock Guarding Dogs (LGDs hereafter) can reduce livestock losses in a variety of situations (Gehring et al. 2010; Treves et al. 2016), but many livestock owner's express concerns about their ability to raise, maintain, and train such dogs or share the belief that these dogs do not work on large, open pastures despite evidence of the contrary (Espuno et al. 2004). If we are correct that other components of PE are moderate to highly conducive to adoption but a perceived lack of behavioural control or ability to implement an LGD is widespread (issues and asisstance with proper training and caring for guarding dogs), then adoption might be promoted by training and demonstration projects with owners.

Other methods of intervention seem to be perceived as feasible (high perceived behavioural control) yet are not adopted widely. For example, in Sweden subsidized fencing to protect livestock has not led to a widespread installation by farmers (Frank & Eklund 2017), although individuals accepted the help initially and this intervention has substantial evidence of FE (Karlsson & Sjöström 2011; Ängsteg et al. 2014). According to our hypotheses and its predictive framework, some component of PE must be low or missing. We predict that a social norm exists against the subsidized fencing or that after installation farmers are discovering side-effects or infeasible aspects.

It is tempting for scholars to assume that when PE ≠ FE, the lay person needs more information (the information-deficit hypothesis). Our framework suggests instead that other important cognitive processes may be blocking adoption and maintenance of the implemented method. Uncertainty and novelty of methods can dampen adoption. For example, differences between sites where FE experiments take place and the actual site of implementation could elevate uncertainty. Small differences in livestock husbandry, carnivore species, or landscapes can raise doubts about FE in even the most willing adopter. Even after implementation, a person might abandon the method if outcomes are not as promised. Slower appraisals that arise from unexpected outcomes, as well as dynamic social norms might lead to dismantling or defection of implementers. Moreover, the farmer may oppose the general view of effectiveness due to disagreement over conservation goals and might, therefore, dismiss and contest research (Redpath et al. 2013; Woodroffe & Redpath 2015). Therefore, the presentation of information and its acceptance by various audiences is best understood by studying the communication process and participants, more than by the content of the communication.

It is widely believed that owners of domestic animals should be engaged actively in decision-making to help build trust and meet PE criteria. For example, participant engagement approaches have been described as helpful when promoting adoption of interventions (Treves et al. 2006, 2009; Reed et al. 2008; Woodroffe & Redpath 2015). Nevertheless, it does not necessarily follow that participants must be engaged in groups to decide on each other's interventions. That might amplify social norm imposition (peer pressure) that could drive PE further from FE. The ideal scenario for coexistence in HWCC is for both people and wildlife to be protected with FE interventions that meet PE criteria. The ideal scenario would be researchers measuring the cognitive components of PE before attempting an intervention. What we are proposing here has not yet been fully tested but promising projects are underway (see Text Box 12.3 below).

12.2 Case Studies on Perceived Effectiveness of Methods to Reduce Damages to Livestock

We reviewed various case studies regarding PE of interventions with the goal of comparing them with the proposed integrative framework, and then give guidance on how to design a study to measure these components. We selected 3 studies where we addressed at least one of the cognitive processes or components described in our integrative framework (see Text Box 12.3).

[Start Text Box 12.3]

Case study 1: Integrating proposed framework to improve coexistence between pumas and people in Chile

Research began by measuring attitudes among Aymara indigenous people in northern Chile towards pumas and perceptions of methods to protect livestock. These baseline data revealed low perceived behavioural control (owners felt they needed help to implement any intervention), that non-lethal methods were viewed as an option by respondents (i.e. permissive social norms) (Ohrens et al. 2016). Furthermore, researchers had very weak evidence about FE of any method for the predator, the livestock, or the region. Subsequently, authors offered help to intervenors (owners) by attempting a participatory intervention planning workshop (see methods in Treves et al. 2009) to select a non-lethal method of their preference. This participatory process (i.e. local engagement) might have helped to overcome PE about what would be effective and what would not, given equal uncertainty among methods. Besides, researchers attempted to improve participants' perceptions of behavioural control. Only one of 12 participants in the experiment abandoned the project midway, the remaining 11 accepted the placebo control in a cross-over (reverse-treatment) design, and after the end of the experiment all 11 requested to keep the light deterrent device they had tested. Although this example attempted to integrate several criteria of PE, it did not measure social norms explicitly and does not yet demonstrate long-term adoption.

Case study 2: Lethal interventions against jaguars in Brazil

The second study, done in Amazonia and Pantanal, Brazil (Marchini & Macdonald 2012), measured social norms regarding lethal control of jaguars. To gather specific variables that could help to predict behaviour and intentions to use lethal methods, the authors followed the TPB (Ajzen 1991) and separated social norms into several components (e.g. descriptive norm, social identity) to measure cognitive aspects of coexistence or illegal killing of jaguars. The authors concluded that peer group pressures and other social norms (cultural beliefs about men and jaguars) were important predictors of the intention to kill jaguars, independently from wealth or economic losses, which did not predict that intention well. Apparently, respondents believed that killing jaguars would save cattle despite lack of evidence of FE (low uncertainty about the method), and that belief was amplified by social norms. Nevertheless, farmers who expressed an intention to kill jaguars reported substantial variation in their ability to do so (Marchini & Macdonald 2012). In sum, implementation (illegally killing a jaguar) was predicted strongly by behavioural control and the expected positive social benefits of doing so. In such a situation, measuring FE or intervening to raise uncertainty about the effectiveness of killing jaguars to protect cattle may be irrelevant. Conservationists aiming at coexistence should address the social norm affecting those individuals who intended to kill jaguars or report the ability of those individuals to act on their beliefs.

Case study 3: Perceived effectiveness of interventions in South Africa

We combined two studies that similarly presented measurements on uncertainty of effectiveness, and retention of interventions over time. The first study, from McManus et al. (2015), applied a pseudo-control design to measure the effect of lethal interventions compared to subsequent non-lethal ones. The authors found that livestock losses and related costs declined after implementing a variety of different non-lethal methods. Therefore, FE of non-lethal was concluded to be higher than FE of lethal methods. Follow-up interviews revealed that 6 of the 11 farmers continued the effective non-lethal methods 12 months after the team stopped measuring livestock losses. However, after 36 months only 4 of 11 farmers continued the effective non-lethal interventions. The reasons that 7 farmers abandoned the non-lethal methods included unexpected outcomes (dog that may have killed livestock was shot by neighbour), ability to implement (farmer found easier to implement lethal method) and uncertainty of effectiveness (lethal method perceived more effective). We infer that FE was not sufficient to assure long-term adoption of a non-lethal method. Several components of PE resurfaced over time and a lower FE method supplanted the method with higher FE (McManus et al. 2015).

The second study conducted by Rust et al. (2013) applied a quasi-experimental design (before-and-after), without controls, to measure attitudes of farmers to the performance of LGDs in protecting livestock from cheetahs as well as costs associated with their implementation. Researchers documented that LGDs were perceived as cost-effective in reducing livestock predation by carnivores. Mean perceived annual predation for the total participating farms (n=70) were reduced by 33 to 100% after LGD placement. The authors reported that from a total of 97 LGDs, 22% (n=21 dogs) were removed from farms. Reasons for dog removal were mostly reported to be related to farmer's perception of dog's behaviour and capacity (uncertainty of effectiveness) followed by a few cases that were related to owner's capacity to implement dog training or husbandry properly (ability to implement). Again, an FE method in the short-term proved to have longer-term problems in a minority of cases or at least the PE of the method diminished over time.

[End Text Box 12.3]

Our three examples have highlighted incongruities between PE and FE but do not serve to test our hypothesis rigorously. We lack a study of FE combined with measures of PE at the same site that are both focused on the same intervention, regardless of how many subjects benefited from the intervention (i.e. a continuous measure of FE). With a sufficient sample of respondents, such a study could test our hypothesis by correlating PE to each PE component and to individual experiences of FE across subjects.

Alternately, we would need a study across many sites that compares aggregated PE measures for each site to the binary variable of FE (i.e. was it effective at that site or not?). Under those conditions, the intervention does not need to be the same across sites because site-specific PE and FE are being compared to each other (within-subject correlation). Such a study would provide a more general test of our hypothesis, but would lack the specificity to reveal clearly which component of PE was responsible for any observed mismatch because different biophysical, socio-political, and intervention designs would cloud the interpretation of results. Regardless, either type of study would help to advance research on preventing HWCC. We expect coexistence would be promoted as a result.

12.3 Guidelines to Measure Perceived Effectiveness of Interventions

For this purpose, we present guidelines and steps in designing and conducting research regarding our PE criteria. We will focus on the intent of coexistence interventions, and how they affect PE, and each of its components. For example, we need to: (1) use the integrative framework to target and focus on components that have not been addressed in former studies conducted in the same locations (e.g. define research questions), (2) select robust designs to reduce all sorts of biases (e.g. design of studies), (3) develop methods to target research questions (e.g. questionnaires, appropriate framing and design of questionnaires) (see Marchini & Macdonald 2012; St. John et al. 2014), and (4) consider temporality within study design (e.g. before, during, after and follow-up measurements) (see McManus et al. 2015) (see summary in Table 12.1).

12.3.1 Study Design for PE

We propose the randomly apply questionnaires to farmers within a study area, a common method in social sciences, to measure our proposed components (Newing et al. 2011). The focus of questionnaires may depend on the amount and type of existing information that is related to our framework and available at the site. However, for our purposes we will target all components described earlier (Figure 12.1 and 12.3). We recommend that questionnaires follow the time-scale presented in our PE framework; with questions that target information before, during, immediately and long after implementation of interventions. At the same time, we suggest following the construct of our proposed integrative framework to design questions that measure each component. For example, questions can be in the form of statements for each variable within components, using Likert scale answers (from strongly agree to strongly disagree) (Newing et al. 2011). This is a commonly used method to measure latent constructs such as attitudes and behaviours. Here are some examples of statements for each component: (1) *I am confident about continuing using the intervention* (ability to implement), (2) *I feel social pressure to use a specific intervention* (side-effects and outside group influences), (3) *The intervention has been very effective in reducing attacks on livestock* (uncertainty of effectiveness) (see Marchini & Macdonald 2012; St. John et al. 2014). To test, we can use a general linear model (GLM) between integrative framework variables as predictors (e.g. ability to implement, uncertainty of effectiveness, social norms) and the binary result of the intention or not (0 or 1) to implement the proposed intervention as response variable.

Table 12.1 Guidelines to measure perceived effectiveness of interventions.

Timing relative to implementation	**Response Variable**	**Predictors**		
		Uncertainty of effectiveness	**Social Norms** (measured within participants and outside interest groups)	**Ability to implement**
Before	Intention to implement?	Measure the participant's appraisal of future effectiveness	- Measure the likely gain or loss of social status if they implement (based on perceptions relative to others) - Measure side-effects from outside interest groups as perceived by participant and associates	Measure anticipated feasibility (cost, skill, time, side-effects other than social ones)
During	Maintain implementation?	Measure the participant's appraisal of ongoing effectiveness	Measure the actual gain or loss of social status as perceived by participant, associates, and outside interest groups (based on perceptions relative to others)	Measure ongoing actualized feasibility (cost, skill, time, side-effects other than social ones)

Shortly after	Appraisal of outcomes?	Measure the participant's conclusion about effectiveness	Measure the actual gain or loss of social status as perceived by participant, associates, and outside interest groups (based on perceptions relative to others)	Measure final, actualized feasibility (cost, skill, time, side-effects other than social ones) and the benefits – costs of outcomes
Long after	Adopt and promote with others?	Measure the participant's willingness to continue use or communicate outcomes to others	Measure the actual gain or loss of social status as perceived by participant, associates, and outside interest groups (based on perceptions relative to others)	Measure long-term side-effects and the costs and the benefits – costs of outcomes

12.4 Conclusions: Tying Back to Coexistence

Interventions aim at reducing negative interactions between wildlife and humans, promoting coexistence. Under our integrative framework, we hypothesize that the successful adoption of proven effective interventions are more likely if functional and perceived effectiveness align (PE $\geq$ FE and FE is high), which in the long term should promote and foster coexistence. Similarly, Heberlein (2012) argued that to approach environmental problems successfully, more than one of his proposed fixes (e.g. technical, cognitive and structural) need to be addressed. Analogously, our framework is proposing to address both technical (i.e. technical solution to reduce livestock losses - functional effectiveness) and structural-cognitive fixes (indirect solution that attempts to address peoples attitudes and behaviours towards wildlife - perceived effectiveness, also see Treves et al. 2006, 2009) to improve coexistence. We recommend interdisciplinary measurement of both human cognition and behaviour as well as experimental tests of functional effectiveness. By promoting PE and FE alignment, we fall to the right side of the conflict-to-coexistence continuum, aimed at improving positive attitudes/behaviours towards wildlife (Frank 2016).

Our framework (Figure 12.2) predicts that political conflicts will arise in two different ways when FE ≠ PE. When PE > FE and FE is low, technical experts will object to the implementation of an ineffective intervention, and the political conflicts and disputes that ensue will focus on trust in science, as well as legitimacy of unscientific decisions, among others. If opposing interest groups are involved, the interest group that either ideologically prefers the intervention or prefers science-based decision-making will take sides. When PE < FE and FE is high (case study 3), we predict technical experts will find themselves trying to persuade lay people to implement something they are resistant to try. If technical experts fail, then the likely outcome would be the case where a lower FE method is implemented (PE > FE, FE is low).

Without evidence for high FE, PE tends to sway decisions and will determine which intervention is implemented. Confirming that FE is high before implementing an intervention is especially important if decision-makers perceive that nonhuman animals do not deserve moral consideration. If an intervention has low FE and is implemented nonetheless, nonhuman animals - wild and domestic - are likely to suffer. Moreover, our inability to deliberate fairly with nonhumans and the power asymmetry between parties will tend to undermine coexistence between humans and nonhumans (Favre 1979; Hutchins & Wemmer 1986). Within this social and structural context, the implementation of interventions with PE > FE that can be harmful or lethal to nonhuman animals (e.g. lethal methods, translocation) should be viewed most sceptically by youth and future generations and by current adults concerned with ethics, legitimacy, and precautionary principles. Here, emerging fields such as compassionate conservation and practices such as predator-friendly farming can help in providing principles and guidance on the implementation of socially acceptable interventions that promote animal well-being (Ramp & Bekoff 2015; Wallach et al. 2015; Johnson & Wallach 2016). By emphasizing coexistence with individual nonhumans (not just species), these fields promote the moral standing of nonhumans and attempt to equitably consider individual nonhuman interests when deciding if and when to intervene in their lives (Santiago-Ávila et al. 2018b).

12.5 Recommendations and Future Directions

- Strengthen the rigor of science for understanding adoption and maintenance of interventions for coexistence.
- Collect both ecological (FE) and social-psychological (PE) variables when evaluating an intervention aimed to reduce conflict. This would enable a more balanced interdisciplinary understanding of social–ecological systems, such as human-wildlife interactions.
- Test hypotheses of particular interventions in a rigorously designed study. This would help in better design and implementation of interventions to reduce conflicts (see guidelines in Table 12.1).
- Address current gaps in the use of gold-standard designs to evaluate both FE and PE of methods and their implications for carnivore and wildlife conservation in general.
- Address current gaps in knowledge on possible unexpected effects of non-lethal interventions on predators and other wildlife (e.g. disruption of behaviour and social organization).

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