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Environmental Challenge and Animal Agency

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ABSTRACT

Challenges are there to be overcome – seen usually as problems to avoid rather than as opportunities to enjoy. However, for humans a life without challenge would be likely to be dull and boring, lacking the enthusiasm and satisfaction that come with individual development. Could this also be true for animals? This chapter looks at the positive value of engaging with environmental challenges for animal welfare, proposing that this value lies in an animal's expression of agency and the enhanced functional competence that it gains through this. It explores the different facets of agency, and provides more detailed discussion of key elements such as problem solving, exploration and play, as well as discussing responses to challenge and how an animal's welfare affected if it is prevented from performing behaviours of this kind. The final sections of the chapter consider how monotonous, predictable, captive environments may lead to apathy and boredom, and prevent animals from experiencing a positive quality of life. Agency should be regarded as an integrative capacity that works across specific modules of organization and, as such, forms an important condition for an animal's overall well-being and health.

1. Introduction

Animals in the wild face many challenges. Predators, food shortage, social competition and intricacies, weather, illness – all these threaten their health and survival and hamper their reproductive efforts. For any species and any individual, the natural environment is complex and in an ever-fluid state as a result of fluctuating physical conditions and the actions of cohabiting living beings. Animals are adept at turning challenges into opportunities, sometimes through mastery in a specific task, sometimes through flexibility of response, yet such capabilities are often not enough to stay fit, survive and reproduce. Challenges are intrinsic and natural yet, if they are too severe or too many, animals fail to cope with them and their individual welfare deteriorates, frequently to the point of premature death.

By contrast, animals in captivity often live in simple, monotonous and predictable environments, where they are challenged infrequently or not at all. One might expect this to be an improvement: the animal can relax and get on with its life. But could it go too far the other way – might animals also suffer from a lack of environmental challenge? How much of a welfare problem is the fact that captive animals live in barren environments that give them very little opportunity to engage actively with meeting the needs of their own life?

Before turning to this question, it is necessary to look at how wild-living animals deal with challenges. Some challenges come with little novelty but still demand a lot of attention, time or energy because they pose an important threat or opportunity. For instance, coping with seasonal temperature stress or defending a position in a stable dominance hierarchy are serious challenges, but the aspect of novelty may not play an important role in them. Animals can overcome these challenges by being masters in specific behavioural or physiological tasks and responses. Other challenges are highly unpredictable, such as predator attacks, sudden turmoils in social situations or random changes in food accessibility.

Such challenges are much more likely to present animals with novel problems, for which they must be able to find new solutions. While challenges of the first type (such as social stress, hunger, illness) are dealt with in other chapters, in this chapter we focus on challenges induced by novelty. Our discussion of an animal's ability to deal with such challenges will centre around two key concepts, *competence* and *agency* (White, 1959). We see these terms as reflecting complementary aspects of the animal's engagement with novel challenges, and in this chapter we will explore the evidence and interpretations that support their relevance to the study of animal welfare.

We use the term *competence* to denote the whole array of cognitive and behavioural experience, tools and strategies that an animal possesses at any given moment to deal with novel challenges. How do animals acquire and enhance such competence? As for any biological trait, animals inherit genetic predispositions that feed into and support the different aspects of competence. These predispositions unfold through developmental maturation and sensory experience (Rogers, 2008), and by learning through interaction with the hard-and-real everyday striving for food, security, partners, social ties etc. However, if competence could be stepped up only as a result of reaction to external events, the process would be haphazard and risky. It may be too late to start looking for a solution when the challenge is already arriving. Therefore, it is also worth it for the animal to invest in the future, i.e. to expend time and energy in exposing itself to a degree of risk in order to have better chances at dealing with unexpected events later on. Many animals hoard food or build body reserves for lean times – but they also gather information and/or train their own abilities for later times and moments of need.

In this chapter, we label as *agency* the propensity of an animal to engage actively with the environment with the main purpose of gathering knowledge and enhancing its skills for future use. In other words, agency is the intrinsic tendency of animals to behave actively beyond the degree dictated by momentary needs, and to widen their range of competencies. In goal-oriented behavioural sequences such as foraging, mate seeking and predator avoidance, the animal will mostly use existing skills, whereas through agency-based patterns such as exploration and play, it is building novel competencies. In reality, however, these two aspects of a day's ongoing problem-solving activities are often intertwined, because features of the environment are rarely sharply divided into 'old' and 'new' challenges, and the animal's response will often be a mixture of reactive and proactive decision making. One could say that agency and competence reflect, respectively, the procedural (more proactive) and functional (more reactive) aspects of the animal's ability to prepare for, discern and resolve challenges that are meaningful to it in the context of its ecological niche (White, 1959).

2. Facets of Agency/Competence

What then should we think of as the main features of animal agency/competence? In this section, we list several major aspects of environmental challenge and link these aspects with complementary facets of animal agency/competence.

First, the environment is *rich* and *complex*. Most animal species live in complex ecosystems that offer a plethora of stimuli and their inter-contingencies. Only few of the apparent associations between environmental features reflect true causal links, and even fewer can be harnessed, but the utility of those few can be pivotal. For instance, food can often be discerned only through very subtle or highly complex cues. Therefore, animals need a highly developed ability of *associative learning*.

Secondly, elements of the natural environment, especially other organisms, often *resist* attempts to harness them. For example, plants and animals defend themselves from being eaten through structural and/or behavioural defences, such as hard shells, or poisonous skins or stings. Thus, animals need to

learn how to overcome such hindrances effectively, and to develop good *operant or instrumental learning* capability.

Thirdly, the environment continually presents the animal with *new objects, situations* and *events*. It is important to learn more about the nature of these as soon as possible, and it is safer to do this when other challenges are not looming; therefore animals tend to react to novel objects with *inspective exploration*.

Fourthly, most wild animals live in an *open world*. That is, they live in an environment where there is a possibility to expand their horizon of knowledge and activity – a valuable resource could be hidden just behind the next bush or stone. Therefore, in addition to inspective exploration, *inquisitive exploration* is a fundamental element of the animal's competence.

Fifthly, from the animal's perspective, the environment is highly *probabilistic*. That is, because of the intrinsic variability of so many features of the environment, the same action by the animal works on some occasions but not on others. This probability may change in time and it may also contain a hidden regularity or combination of contingencies that the animal might be able to detect through more intense engagement. In order to allocate its time, energy and attention efficiently, the animal should be motivated to track the environment's stochasticity, i.e. it would have to be able to *assess uncertainty* and *update this information* regularly.

Sixthly, many sources of environmental variability, especially those generated by other animals, interfere with the animal's activities and this often leads to *lack or loss of control* over its own movements and actions. Therefore, animals possess not only species- and situation-specific skills but also a general behavioural, cognitive and emotional *flexibility*. One prominent way to train for the unexpected is through *play*.

Lastly, but not least, others living in the natural environment are also *knowledgeable*. Conspecifics and other organisms also gather and appraise information about the environment, and it is often faster, more precise and/or more efficient to use, share and combine this available knowledge than to rely solely on one's own experience and assessment. Therefore, animals are adept at *observational and social learning*, and at *communicating with others around them in general*.

The list of challenge types in this section does not aspire to be comprehensive but it shows that in order to live and reproduce in the natural world, animals need a large array of behavioural and cognitive activities, such as associative, operational/instrumental and social learning, information gathering and updating, flexibility in the face of atypical events and/or loss of control and, generally, a sophisticated capacity for communication. These facets continuously interact with and enhance each other; for instance, regular patrolling in order to update information can reveal novel features in the environment that stimulate exploration, which, in turn, may produce incentives to employ operational learning, e.g. on a potential food source. The concepts of agency and competence can thus best be regarded as denoting the animal's ability to integrate these various facets into effective, intelligent conduct that will optimize its survival and wellbeing. Such a view sits well with the growing tendency among scientists no longer to regard 'intelligence' as the prerogative of a select few so-called 'higher' animal species, but rather as a systemic characteristic of adaptively behaving organisms (e.g. Manrod *et al*., 2008; Matzel and Kolata, 2010).

3. The Expression of Agency/Competence in Problem Solving, Exploration and Play

In this section, we focus on problem solving, exploration and play as examples of prominent facets of agency/competence. These three facets illustrate well how agency and compentence are intertwined,

although functional competence-oriented aspects are more pronounced in problem solving, while procedural agency-based aspects prevail in play.

Problem solving

Problem solving comes into action when previously applied behavioural solutions no longer work to attain a goal such as obtaining food. The animal then switches back to appetitive behaviours and modifies them, but also engages 'off-line' higher levels of cognitive control where representations of the world beyond the current sensory input as well as memories of the animal's own past actions, successes and failures are stored (Toates, 2004). So problem solving is initially driven by an external situation, but it triggers cognitive processes that have many degrees of freedom and that may well continue beyond the instant when the animal solves the actual problem.

Harlow (1950) was one of the first to demonstrate that problem solving itself is intrinsically rewarding to animals when he showed that rhesus monkeys will manipulate and learn to open a complex six-step mechanical puzzle even when no explicit reward is given for either manipulating or solving the puzzle. Recent evidence for an intrinsic motivation for problem solving came from Langbein *et al*. (2009), who taught dwarf goats to discriminate between sets of visual shapes with water as a reward. When the goats were later presented both with freely available water and water attained through the cognitive task, the goats still oriented about one-third of their drinking activity towards the cognitive task. Such data illustrate that problem solving encompasses an element of active cognitive engagement that goes beyond the immediate problem at hand, and that animals continue to exercise even when the problem no longer exists.

This propensity appears to have longer term beneficial consequences for the animal's ability to cope with its environment. For instance, Bell *et al*. (2009) rearranged the spatial configuration of the living environment for laboratory rats frequently for several weeks and made it more complex every 10 days. Rats living in this dynamic, enriched and cognitively demanding space were subsequently shown to be faster learners in spatial memory and danger avoidance tasks than control rats. Another example is a study by Ernst *et al*. (2005), who provided individual pigs with an automated feeding system that summoned them to the feeding station by individually distinct acoustic stimuli. Pigs cognitively challenged in this way showed fewer aberrant behaviours in the home pen and less fear in a novel environment than conventionally fed pigs, indicating an improvement of their coping abilities (Puppe *et al*., 2007).

Exploration

Exploration is a form of behaviour that appears to be directly aimed at gathering information (Archer and Birke, 1983; Wemelsfelder and Birke, 1997). If, for example, we observe a laboratory rat placed into an unfamiliar arena, or cattle entering a new pasture, what we are likely to see is the animals moving around inspecting all kinds of stimuli in their new surroundings. However, animals not only explore in response to new situations, but also go out and actively seek novel stimuli, which is often referred to as 'inquisitive exploration'. For instance, piglets prefer to visit places where they can expect novel objects to places where they will encounter familiar objects (Wood-Gush and Vestergaard, 1991). Thus, exploration has its own motivation that is expressed, for instance, in the strong rebound of explorative activity that can be observed when animals housed in impoverished conditions are presented with a novel object or situation (Stolba and Wood-Gush, 1981; Wood-Gush and Vestergaard, 1993).

The motivation for exploration (labelled 'curiosity drive' by Berlyne, 1960) probably evolved because animals need to reduce the environmental uncertainties that they are constantly faced with in the wild (Inglis, 1983, 2000; Dall *et al*., 2005). Recent research has identified the neural mechanisms that underlie

the motivation for exploration. For instance, Cohen *et al*. (2007) argue that the trade-off between the exploitation of known resources and the exploration of new alternatives is governed by a complex interplay of brain systems in which the forebrain cholinergic and adrenergic systems monitor the expected and unexpected forms of environmental uncertainty, medial frontal brain structures report about rewards and costs, and the locus coeruleus noradrenergic system integrates these inputs and shifts the behaviour either towards exploitation or exploration. Intensive research is also being pursued on many other aspects of exploration such as evolutionary modelling (Dall *et al*., 2005), or the social dimension of information gathering. Seppanen *et al*. (2007) for example, review evidence that animals explore the environment not only directly but also indirectly, through paying specific attention to cues and signals from both conspecific and heterospecific animals. The common theme of all such research is that active gathering of information brings animals crucial advantages for the future, and they are therefore well equipped and strongly motivated to engage in it.

Play

One of the defining features of play behaviour is that it is a spontaneous, intrinsically motivated activity that is being performed for its own sake rather than to achieve a consummatory goal such as to obtain food, escape a predator or gather information (Burghardt, 2005). It has, therefore, always been assumed that play has deferred, long-lasting positive effects on the development of young animals. More recently, it has been documented that play can also have immediate functions. For instance, domestic dogs seem to confirm their dominance relationships during play (Bauer and Smuts, 2007), and post-pubescent laboratory rats use social play initiation to maintain friendly relationships with the dominant male (Pellis and Pellis, 2009). Nevertheless, the delayed, lasting functions of play are still considered very important. It seems that what animals mainly learn and train for in play are not so much physical fitness/endurance (which fades away quickly; Byers and Walker, 1995), or specific skills such as prey catching in cats (Caro, 1980) or fighting proficiency in meerkats (*Suricata suricatta*) (Sharpe, 2005), as these seem to mature to full function even if play is prevented or reduced, but rather various kinds of general physical and/or psychological flexibility. This is underscored by the facts that the neurobiology of play is distinct from that of 'serious' adult types of behaviour such as social, sexual or aggressive behaviour (Vanderschuren *et al*., 1997) and that play repertoires include many elements totally dissimilar to 'serious' behaviours (Petrů *et al*., 2009).

Play has several features that channel it towards creating novelty: play elements are incomplete, exaggerated or awkward compared with elements used in 'serious' contexts; play elements follow each other in variable sequences; and many play elements have a self-handicapping character, that is, they put the playing animal into unnecessary disadvantageous positions and situations where the animal loses control over its movements (Petrů *et al*., 2009). For instance, vigorous and variable head rotations, torso twists and body pirouettes are among the most widely occurring elements of play (Byers, 1984). Petrů *et al*. (2008) analysed the kinematics of play head rotations in Hanuman langurs (*Presbytis entellus)* and found that they include different, sometimes extreme positions of the head that follow each other in variable sequences; vision is most probably blurred during such rotations owing to the high angular velocities. Špinka *et al*. (2001) specifically suggested that one major and widely present function of play is to train for unexpected situations and mishaps, i.e. to practice in a 'relaxed field' how to handle, behaviourally and emotionally, situations where external forces kick the animal out of control and routine. In their book on rat play fighting, Pellis and Pellis (2009) conclude that juvenile play fighting enhances the experience of unpredictability and thus provides a perfect means by which to fine-tune emotional reactivity, and so to produce an animal that is capable of subtle and nuanced responses to novel and potentially dangerous situations. According to Pellis and Pellis, deprivation of play fighting during rat ontogeny does not take away specific social or cognitive skills but, rather, impairs the ability of the

animals to calibrate their emotional response; hence, play-deprived animals are unable to apply their motor, social, or cognitive skills effectively in challenging situations.

These examples from different fields of behavioural research indicate and support that animals possess a general skill to initiate, and persist in, interaction with their environment in a way that appears directly beneficial to a range of specific skills and their ability to cope with adverse, restrictive conditions.

4. Agency Responds to Appropriate Challenge

The examples of agency/competence in the preceding sections illustrate that an animal may be intrinsically motivated to engage with the environment, but still requires certain conditions to be met before it will do so. Not all types and levels of challenge elicit exploration or play equally – it seems that a moderate degree of challenge is most likely to evoke a positive interactive response. To capture this, Hebb (1955) proposed a model in which he linked the occurrence of explorative behaviour to optimal levels of arousal, postulating that too little novelty would fail to arouse the animal's attention, whereas too much would startle or frighten it into a fear or stress response. This idea was further developed by Inglis (1983), who suggested that an animal prefers the greatest degree of discrepant input to occur when it is best able to assimilate that input. Watters (2009) takes this notion further in a zoo context, arguing that apparently paradoxically, zoo animals are most motivated to interact with types of enrichment that produce a pay-off that is uncertain, i.e. that is neither guaranteed nor highly improbable. For example, play behaviour tends to be stimulated by environments that are slippery or otherwise tricky to such a degree that full control over the animal's own movements becomes difficult, yet the risk of injury or serious mishap is small, such as is the case for shallow water, fresh snow, sloped terrains, thin flexible branches or swinging suspensions (Byers, 1977; Heinrich and Smolker 1998; Petrů *et al*., 2009).

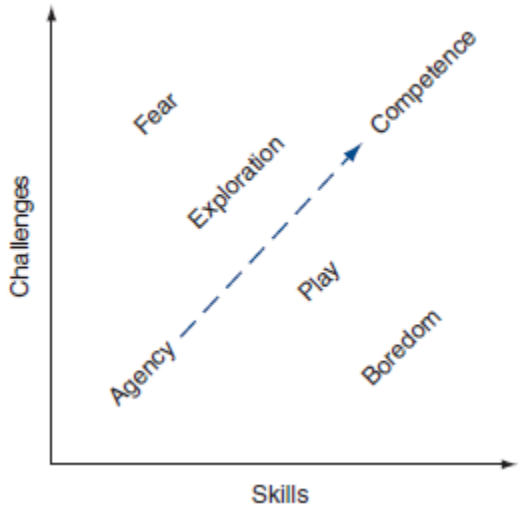

Fig. 1. Schematic depiction of the relationship between the strength of a challenge and the strength of an animal's skill.

Not only is agency best stimulated by intermediate levels of challenge, it also affects the animal's competence most positively at such levels. This notion is akin to the idea of 'eustress': the idea that moderately challenging environments can evoke a stress response in the animal which in the longer term has a positive effect on its survival and welfare (Langbein *et al*., 2004; Moncek *et al*., 2004). Summarizing

such information, Meehan and Mench (2007, p. 248) propose the notion of 'appropriate challenge', defined as 'problems that may elicit frustration, but are potentially solvable or escapable through the application of cognitive and behavioural skills'. Fig. 1 illustrates this notion. If challenges are too strong for the skills of the animal, fear will freeze agency; if challenges are not up to the skills, boredom will result. An appropriate level of challenge stimulates agency and this engagement, in turn, enhances competence. The type and relative level of challenge may also influence the type of agency in which the animal will engage. For instance, relatively high levels of uncertainty or novelty may incite exploration, but as the confidence of the animal with the situation grows, exploration may give way to play (Špinka *et al*., 2001).

5. The Importance of Agency/Competence for Welfare

Agency and competence are clearly important for the survival and reproductive success of wild animals. But do these abilities also play an important role for the welfare of captive animals whose survival and concomitant needs are mostly met by the captive environment? In the following paragraphs, we argue that there might be a threefold positive relevance of agency/competence for animal welfare. In Fig. 2a (and also in Fig. 2b, as discussed in Section 6), we illustrate our argument with the simplifying assumption that feelings (i.e. sentient experiences) are at the core of animal welfare (Duncan, 1996), although more complex approaches that also include health (Dawkins, 2008), naturalness (Appleby, 1999; Fraser and Weary, 2005) and indeed the wholeness of the animal (Wemelsfelder, 2007; see also Section 3.8) may be more appropriate.

First, there is growing evidence that expressions of agency are rewarding for animals independently of any functional outcome that they may have. We know, as argued above, that animals will engage in solving problems without any apparent form of external reward, and this suggests they may enjoy the process of learning itself (Harlow, 1950). For example, pigs, cattle, chickens and other species engage in what is known as 'contra-freeloading'; that is, they will make an effort to work for a reward even if the reward is also available freely (Inglis *et al*., 1997; de Jonge *et al*., 2008; Hessle *et al*., 2008; Lindqvist and Jensen, 2008). Combining a cognitive task with a food reward in an otherwise barren environment can lead to overeating in rats and goats; this also supports the rewarding value of such tasks over and above obtaining food (Johnson *et al*., 2004; Langbein *et al*., 2009). Physiological evidence in support of such value comes from a study by Kalbe and Puppe (2010), who found that long-term cognitive enrichment for pigs in the form of an operant feeding system significantly affects gene expression of reward-sensitive cerebral receptors in the amygdalae of the animals concerned.

In addition, a number of studies indicate more directly that the process of problem solving affects an animal's mood. Hagen and Broom (2004) set five heifers (the experimental animals) the task of learning how to open a gate to gain access to a food reward, and matched these animals with five control heifers for whom the gate opened automatically the moment that the experimental animals had succeeded in opening the gate. Detailed comparison of fluctuations in the heart-rate and behavioural vigour of the two animal groups led the authors to suggest that progression of the problem-solving process in experimental animals was associated with raised arousal and agitation, and that this may in turn reflect an awareness by the animal of its progress in learning – in other words, an understanding of, and excitement about, 'getting there'. Whether this was mainly a positive or negative excitement (i.e. frustration or enjoyment) cannot be told from these quantitative data. A qualitative assessment approach addressing an animal's 'body language', such as developed by Wemelsfelder *et al*. (2001, 2009), may shed further light on the actual experience of such experimental animals. Langbein *et al*. (2004), in a study of instrumental learning in dwarf goats, also looked in detail at correlations between the learning process, learning success and physiological indicators such as heart rate and heart rate variability. Like Hagen and Broom (2004), they suggest that the observed response patterns reflect a process of understanding of, and gaining control over, the task – a process they interpret in terms of 'positive stress'. Yet this term still

reflects an abstract scientific understanding; what precisely this means for the actual experience of the animals requires more direct qualitative investigation of their behavioural expression (Wemelsfelder, 2007).

Expressions of agency other than problem solving appear to be similarly self-rewarding. Play routinely tends to be considered as self-rewarding because it does not result in any obvious goal, and often emanates a sense of relaxed and intensive in-the-moment enjoyment (Fagen, 1992). Common ravens, for example, will fly upside down, slide down snowy slopes on their backs, play tug of war, or play 'pass the stick' in mid-air (Heinrich and Smolker 1998); Siberian ibex kids may jump into the air from overhangs and perform two or three neck twists and heel kicks before landing (Byers, 1977); and domestic piglets can stimulate each other into a playing frenzy in which the whole litter sprints around barking excitedly (Špinka, personal observation). Such behavioural examples are complemented by evidence that the performance of play instigates an increase in brain opioid levels (Vanderschuren *et al*., 1995).

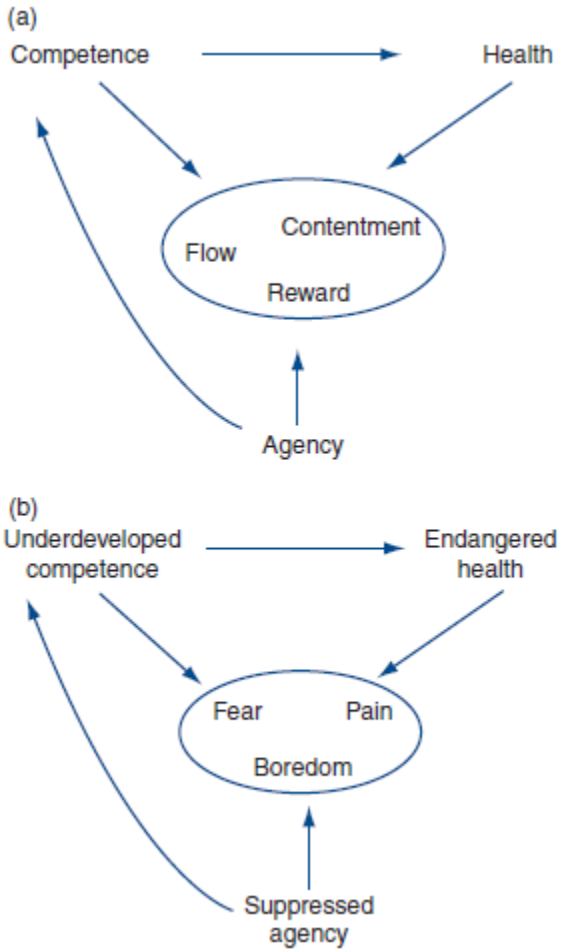

Fig. 2. Welfare effects of agency (a) expressed and (b) suppressed.

Exploration, too, is positively valued by animals, even when the acquired information has no immediate use for feeding, sexual behaviour or other actions leading to consummatory rewards. Wood-Gush and Vestergaard (1991) demonstrated that piglets select an arena containing a novel object rather than one

containing a familiar object, even though neither object was of any utility. Moreover, the piglets displayed an increase of locomotor play near the novel objects, indicating their positive experience from the exploration. Newberry (1999) showed that domestic chickens value the possibility of exploring novel objects of zero utility as much as the exploitation of non-essential resources such as peat moss or straw bale.

The second way in which agency may benefit welfare stems from the self-building nature of agency/competence. The idea is that because animals benefit from being as competent as possible, and because exercising agency engenders competence, animals will get 'drawn into' agency-based activity through positive competence–reinforcement loops. Inglis *et al*. (2001) and Inglis and Langton (2006) showed that mathematical modelling of behaviour based on such starting points could indeed simulate empirically observed behaviour in, for example, studies of contra-freeloading and latent learning. Csikszentmihalyi (1992) is an author well known for his studies of the interaction between competence and happiness in humans, which resulted in what he calls a 'theory of flow'. This theory posits that a person's experienced happiness is a function of the interaction between perceived challenge and skill levels. If the level of challenge is perceived to be higher than the level of skill, a person will try to learn new skills, while if perceived skills are greater than the challenge, he/she will seek more challenge. Thus, perceived challenge and skill chase each other, which, Csikszentmihalyi argues, leads to 'reorganization and growth in the order and complexity of consciousness' (Moneta and Csikszentmihalyi, 1996, p. 277), a process subjectively experienced as 'flow'. The greatest experience of 'flow', and the greatest associated happiness, arise when both perceived challenges and skills are high and the person is intensely engaged with what he or she is doing through focused attention and sustained concentration and activity. So for animals as well, opportunities to initiate and maintain meaningful cycles of behavioural and cognitive effort are likely to produce a similar feeling of 'flow', and thereby contribute significantly to their longer term welfare.

The third welfare effect of agency arises from the influence that increased competence potentially has on an animal's physical health and fitness, and thereby on positive feelings such as contentment. In the first place, increased levels of interaction and mobility may have direct physical benefits, such as stronger bones, stronger muscles, a stronger heart and higher physical endurance (Spangenberg *et al*, 2005, 2009; Schenck *et al*., 2008), while improved sensorimotor coordination has been shown to lead to greater neural complexity and plasticity which, in turn, may enhance physical fitness and rehabilitation (Kleim and Jones, 2008). More generally though, through the skills and information that they acquire, active animals are likely to be more confident and perform better in fulfilling their daily needs – ending up better fed, better protected and socially better positioned than animals that are highly restrained. Evidence is growing that such general improvement of an animal's ability to cope can affect its health and fitness even in captive environments; for example, rats exposed to spatially demanding tasks are subject to lower mortality rates (Bell *et al*., 2009), while pigs taught to discriminate between sounds to obtain food showed faster wound healing and better overall immunity than pigs not exposed to these challenges (Ernst *et al*., 2006). So allowing an animal to exercise agency not only affects its immediate welfare, but is also likely to improve its longer term physical health and fitness.

6. The Consequences of Suppressed Agency/Competence in Restrictive Environments

What happens when animals adapted to deal with the vagaries of natural environments are born and raised in simple, restrictive captive environments? Does this affect their expression of agency/competence, and concomitantly, the richness of their behaviour and experience? Also, most importantly in the context of this book: what are the consequences of such behavioural and cognitive changes for their welfare?

Agency is intrinsic to the way animals behave, and animals will therefore engage with their environment even if it is unchallenging, restrictive and unresponsive. However, such environments will limit the frequency and diversity with which agency is expressed. For instance, enclosures are often much too small to allow animals to go out and look for novelty, and prevent the expression of inquisitive exploration; at best, an opportunity for inspective exploration may occasionally arrive. Equally, if social partners are few, of the wrong category, or absent altogether, an animal will not be able to engage in social play (Pellis and Pellis, 2009) With the animal's agency suppressed this way, its development of competence will soon hit a limit too (Fig. 3.3), and the animal's scope for interaction will remain limited and stagnant (Von Frijtag *et al*., 2002).

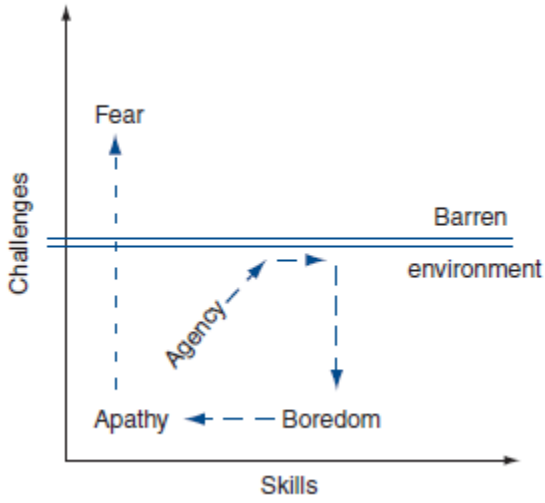

Fig. 3. Effects of suppressed agency on animals living in barren environments.

There is considerable evidence indicating that animals housed in restrictive environments show reduced behavioural diversity both in their home pens (Gunn and Morton, 1995; Haskell *et al*., 1996) and in response to novel objects (Beattie *et al*., 2000; Wemelsfelder *et al*., 2000; Meehan and Mench, 2002), and use a large proportion of their time lying down, sleeping or dozing (Gunn and Morton, 1995, Zanella *et al*., 1996). They may also spend extended periods of time in motionless sitting or standing, often with drooping heads and ears, half-closed eyes, abnormally bent limbs, or pressed against a wall or stall division. Such passive postures have been characterized qualitatively as apathetic, helpless or depressed (Wood-Gush and Vestergaard, 1991; Martin, 2002). In addition, certain behaviour patterns appear to become less versatile, and more fixed and compulsive in their execution; stereotyped pacing in captive polar bears, for example, has been linked to the frustration of their freedom to patrol (Clubb and Mason, 2004), while food-related stereotypies in intensively farmed animals are linked to, among other factors, the prevention of foraging (Mason and Mendl, 1997). Stereotyped animals may also show an overly aggressive and/or fearful reaction to novel or unexpected events (Broom, 1986).

Thus, captive animals may be physically mobile and respond to perceived stimuli, but the question is whether such activity is reflective of normal agency. Do the animals interact resourcefully and playfully with their environment, are they busy and absorbed in organizing their lives? The passive, unvaried and sometimes rigid nature of behavior patterns that are, as discussed in the paragraph above, observed in captive animals, suggests this may not be the case. Wemelsfelder (2005) proposes that such characteristics, in their multifaceted complexity, reflect a chronic disruption of 'flow' in the organization of

an animal's behaviour (cf. Csikszentmihalyi, 1992, see section 3.5), and with that a potential suppression, or even dismantling, of its agency (Fig. 3). Animals are prevented from sustaining activities that they are motivated to perform, and so their engagement with the environment deteriorates, and the versatility and flow of their behaviour dries up.

What are the welfare consequences of such deterioration? First, the suppression of agency will directly affect an animal's emotional state in various ways. For a start, inability to express agency will deprive animals of experiencing the positive feelings that accompany agency (Fig. 2a,b). In recent years, there has been increasing emphasis on the importance of the positive aspects of welfare for an animal's well-being, related for example to social interaction or exploration and play (Boissy *et al*., 2007; Napolitano *et al*., 2009). Welfare is no longer viewed solely in terms of functional health and the absence of suffering, but also in terms of positive experiences or, generally, good 'quality of life' (McMillan, 2005). In Section 5 the expression of agency was described as being associated with the positive interest and excitement of exploration and problem solving, the relaxation and enjoyment of play, and the contentment and happiness of experiencing sustained competence and 'flow'. Depriving animals of opportunities for agency would therefore deny them a source of naturally sustained positive experience. Clearly, more research is needed to investigate whether, and under what circumstances, animals experience states of pleasure, enjoyment or contentment.

In addition, various authors have suggested that the suppression of agency is also associated with an experience of boredom and, in the longer run, perhaps also with states of depression and/or helplessness. Glanzer (1958) argued that suboptimal levels of information processing induce boredom, but adds that animals growing up in impoverished environments may adjust to such conditions and not acutely suffer. Inglis (1983) postulates as well that animals may get used to discrepancies between expected and actual levels of novelty, and although initially bored, may eventually settle down. So one could argue that passivity in captive animals could be seen as an adaptive strategy or life history avenue designed for highly predictable environments. However, the question is to what extent such assertions correspond with actual observed behavioural processes in captive animals. Wemelsfelder (2005), as discussed above, argues that a multifaceted range of behavioural symptoms in captive animals reflects chronic disruption of behavioural 'flow', and that, as such, this should not be regarded as a form of functional adaptation. Rather, in analogy with human behavioural organization, such symptoms may be considered indicative of chronic boredom and depression, or general psychological atrophy (cf. Csikszentmihalyi, 1975; Harris, 2000). Early discussion of this condition in animals was provided by McFarland (1989), who characterized states of chronic behavioural deprivation and indecision as 'limbo'. In the more recent experimental literature, the term boredom is frequently used to interpret the observed effects of impoverished environments on animal welfare (e.g. Newberry, 1999; Ernst *et al*., 2005; Manteuffel *et al*., 2009). Therefore, if we can accept that through active engagement with their environment animals experience meaning and enjoyment in what they do, then there seems to be no reason why chronic disruption of such engagement should not be experienced as debilitating, boring, or even depressingly dull.

A second way in which declining agency may affect welfare is through the consequences of underdeveloped competence, such as heightened fear and anxiety and compromised social coping. Not exercising competence may lead animals to regress in their ability to develop appropriate expectancies and act upon these; they become less well able to classify and evaluate perceived environmental stimuli, and will be less ready to deal with challenges once they arise. As a consequence, unexpected or novel events will startle and arouse animals more, and they will fail to exploit the novel information available. Laboratory animals, for example, may adjust poorly to experimental procedures which involve transport and handling (e.g. Rennie and Buchanan-Smith, 2006), while for farm animals, arrival at a

slaughterhouse, with its crowded, noisy, unfamiliar conditions, may be particularly stressful (Deiss *et al*., 2009). Rats and pigs deprived of natural amounts of play during early periods of ontogeny have compromised ability to solve social conflicts and therefore experience more prolonged and/or more intense fights (Pellis and Pellis, 2009; Newberry *et al*., 2000). Thus, rather than living in quiescent adjustment to their barren surroundings, animals from impoverished backgrounds may be overwhelmed by events when they arise, fail to cope and experience intense fear or anxiety (Von Frijtag *et al*., 2002; Chaloupková *et al*., 2007).

A third potential implication of declining agency for welfare lies in health-related effects. As described at the end of Section 3.5, animals living permanently in impoverished surroundings may heal from injuries less well (Ernst *et al*., 2006), and are therefore likely to experience more pain. Farm animals living in more restrictive systems generally suffer from a higher incidence of painful production-related diseases, such as mastitis and lameness in dairy cows (Laven *et al*., 2008a,b), or leg problems in pigs (Kilbride *et al*., 2009a,b).To what extent these deleterious health effects are indeed a result of the effects of impoverished agency remains to be established.

7. Is the Expression of Agency/Competence the Same in All Animals?

The ability of animals to act competently in a challenging environment does not imply that animals always tackle challenges in innovative or complicated ways. In everyday tasks, animals use well-proven strategies, long-adopted behavioural routines, simple rules of thumb and direct cues from the environment whenever possible (e.g. McLinn and Stephens, 2006). For instance, after dwelling in a locality for some time, the process of motor learning trains the animal to move quickly and efficiently through the environment, with little further cognitive processing (Stamps, 1995). Also, animal species, populations and individuals often specialize on a limited diet, even though other types of food in the environment are available and potentially equally rewarding (Tosh *et al*., 2009). So many everyday tasks are performed in a skilled, routine way, and yet the mastery of routine is complemented by the astuteness and flexibility of competence (when challenges arise) and by the self-driven dynamism of agency.

Notwithstanding the fundamental value of agency, its expression can differ to considerable extent between species, age groups, gender categories and individuals. In other words, the quantitative balance between application of routines and the utilization of competence- and agency-related behaviours varies across species, animals and situations. For instance, among non-human primate species, the proportion of time devoted to social play ranges between 1 and 22% (Lewis and Barton, 2006), a variation that correlates closely with differences in relative volume of the amygdala and hypothalamus, two brain regions involved in the organization of social and emotional responsiveness. In polygynous and promiscuous mammal species, males engage more frequently in social play than females, whereas in monogamous species there is no difference between the sexes (Chau *et al*., 2008). Even in closely related species, the amount and complexity of play can differ considerably, such as between the Norway rat and domestic mice (Pellis and Pellis, 2009), or between kaka and kea parrots (Diamond and Bold, 2004). Such variations can be due to the different demands of species niches. For instance, migratory garden warblers explore more over a wide area, perhaps because they need to find food quickly during short stays on stopover sites, while the related resident Sardinian warblers are much less keen to explore widely (Mettke-Hofmann and Gwinner, 2004). However the amount of everyday expressions of agency is not in any obvious way related to the apparent intelligence of a species. For instance, wild-living orang-utans are renowned for their tendency to spend several days on one tree with abundant fruits just sitting, eating and sleeping (Lhota, personal communication), while some reptiles, such as monitor lizards, may be agile learners when it comes to novel ways for acquiring food (Manrod *et al*., 2008).

Ontogenetic variation in agency can also be prominent. During the later phases of ontogeny, expressions of agency should theoretically decrease because the shortening remainder of lifespan diminishes the value of future competence in relation to the current costs of agency. Indeed, declining levels of exploratory behaviour after the prepubertal peak have been documented in rats and mice (Arakawa, 2007). Some facets of agency are mostly expressed during a well-defined period of ontogeny. For instance, play has a typical inverted U-shaped ontogenetic occurrence with the highest levels during the juvenile period in mice, rats, cats and pigs (Byers and Walker, 1995; Blackshaw *et al*., 1997)

Furthermore, the expression of agency varies considerably within age and gender categories of the same species. It has long been recognized that individual animals respond to challenges in different ways, and this fact has been the focus of intensive study over the past two decades, often under headings such as 'individual difference', 'coping style', or 'temperament' (Croft *et al*., 2009; Jones and Godin, 2010), although where such studies include the tendency of animals to explore, play and be sociable, researchers are more likely to speak of 'personality dimensions' (Svartberg *et al*., 2005; Smith and Blumstein, 2008). From such differences, it follows that restrictive environments and their inhibiting effect on agency may affect some individuals more than others, and will certainly affect different individuals in different ways. Research with captive orang-utans for example, has indicated that animals scoring highly on 'extraversion' and 'agreeableness' personality factors and low on 'neuroticism' factors also score highly on a subjective well-being questionnaire (Weiss *et al*., 2006).

Finally, even within one individual animal, the propensity to explore, play or patrol may vary with different locations, seasons, times of day or even moods. Theoretically, an animal should engage in such behaviours if and when this is likely to provide benefits that are greater than the costs, relative to the other things that it could be doing (Dall *et al*., 2005). In times of nutritional hardship, many mammalian species will dramatically reduce their engagement in play, focusing instead on essential foraging and maintenance behaviours (Baldwin and Baldwin, 1976; Muller-Schwarze *et al*., 1982; Stone, 2008). It has been suggested that, in this light, play may be considered a 'luxury behaviour' (Lawrence, 1987). While there may be clear prioritization of life-sustaining and reproductive behaviours over play, and possibly over other types of agency in many instances, agency-type behaviours are often reinstated at an early occasion, indicating that they do have long-term fitness benefits. Moreover, agency-type behaviours, including play, may actually increase during tense times, such as pre-feeding periods or crowded indoor housing (Palagi *et al*., 2006; Tacconi and Palagi, 2009), because they enhance competence through, for instance, relieving tension or signalling friendly intentions. The term 'luxury behaviour' is also misleading from a welfare point of view because it disregards how systematically important agency-type behaviours are for the positive side of animal welfare.

As we argue throughout this chapter, the continuous opportunity to engage in agency and thus to enhance competence is fundamental for the welfare of any animal. However, the variability in quantity and quality of agency expression that we have just discussed indicates that how specifically welfare will be compromised as a result of the suppression of agency in captive environments depends very much on the species and category of animals.

8. The Integrated Nature of Agency and Competence – What Does It Mean?

We have discussed different expressions, functions and benefits of agency and competence. However, iit is important to note that in the end agency is an integrative capacity that works across specific modules of organization. The neuroscience literature also agrees that there are common neuromotivational pathways connecting specific modules and integrating emerging information into anticipatory, flexible, reward-sensitive patterns of behavior (Van der Harst and Spruijt 2007). Yet, in the neuroscience literature that discusses such integrative systems, one seldom finds references to agency and/or competence.

‘Integration’ is not necessarily conceived as something actively *done by* the animal, but rather as something that *happens in* the animal, a systemic feature of behavioural organization which can at best be regarded as possibly a ‘higher-order’ neural state (e.g. Sterelny, 2001). This may perhaps seem a small semantic disparity, but philosophically it lies at the heart of what it means to talk about agency. In the final section of this chapter we will, therefore, briefly touch on the philosophical debate surrounding this concept.

Philosophical discussions of agency tend to centre around the question to what extent, if at all, humans and animals can be considered ‘do-ers’, that is, ‘authors’ of their own conduct (Hyman and Steward, 2004; McFarland and Hediger, 2009). Traditionally, in this context, agency is seen as yet another signifier of the human–animal divide: humans behave intentionally, with insight and foresight, and hence can be held responsible for their conduct, whereas animals behave instinctively, blindly and cannot. In recent times, however, this ground has begun to shift. Animal intentionality, the question of whether or not animals act ‘knowingly’, is the subject of a rapidly growing field of research covering an ever-widening range of species (e.g. Hurley and Nudds, 2006). In this field, a wide range of evidence supporting the cognitive mediation of animal behaviour has emerged, such as, for example, evidence for foresight in pigs (Špinka *et al*., 1998); yet scientific opinion on the extent to which such mediation reflects ‘true understanding’ remains deeply divided. There is much talk about ‘lower-order’ and ‘higher-order’ levels of intentionality, with recent studies proposing that it is not basic cognition, but ‘metacognition’, an ability apparently shown by few animal species, that reflects true intentionality (Smith, 2009). At present, it remains extremely difficult to find criteria of any kind that unambiguously distinguish ‘true’ from ‘apparently’ intentional behaviour, and discussions of what such a distinction might imply continue with unabated vigour.

But there is also a second way in which traditional views of agency are shifting. In this, the notion of agency is used to emphasize the integrity of the whole animal, and to discuss critically mechanistic/ informational models that typically separate (‘lower’) bodily behaviour and (‘higher’) mental processing of information into different conceptual realms. Cognitive approaches have, for example, been criticized for over-intellectualizing agency, making application to animals less likely (e.g. Hurley, 2006; Steward, 2009). A more holistic approach would regard animals generally as integrated sentient beings and, in this context, the notion of agency would not primarily refer to the direction of action by thought, but to the centrality of the whole animal in directing action (Hornsby 2004; Hurley, 2006). Such a notion does not encounter the need to distinguish between ‘blind’ and ‘knowing’ behaviour, because it regards all behaviour as sentient, and all animal sentience as embodied, and thus views sentience and intelligence as fundamental and gradually evolving properties of behavioural organization. Whether or not this is a reasonable, scientifically acceptable proposition is a question that goes to the heart of what it means to do science; clearly, there is not the space here to discuss that question at any length. One advantage of this approach for animal welfare, however, is that an animal’s experience is conceived as an integrative aspect of its behavioural expression, and hence becomes more directly observable, and more amenable to description and interpretation, than it would have been if it were purely regarded as an ‘internal mental state’ (Wemelsfelder, 1997, 2007).

The material discussed in this chapter is not meant to support any of these approaches in particular – we have drawn equally on physiological, health-related, behavioural and cognitive studies wherever these were relevant to the theme of the chapter. That theme was to discuss and provide scientific support for the propensity and ability of animals to engage proactively with their environment, and to learn to deal skilfully and flexibly with novel and existing challenges. We think this ability is real, and that in addition to more specific abilities, plays a vital role in ensuring an animal’s health and quality of life. Taking agency seriously as a topic for ethology and for animal welfare science and practice is bound to lead to more

incisive observation of how animals behave, and therefore to inform the philosophical debate in scientifically relevant ways.

9. Conclusions

- Natural environments expose animals to many varied and novel challenges. We argue that animals possess an integrated yet multifaceted ability, which we call competence, to deal with such challenges.
- Competence is reinforced by an animal's agency, i.e. its intrinsic propensity to engage with the environment beyond the degree dictated by momentary needs, with the main purpose of gathering knowledge and enhancing the animal's skills for future use.
- As agency/competence concerns the integration of different levels of organization, it provides animal welfare scientists with an opportunity to address the wholeness of animals, an aspect of welfare that tends to be overshadowed by the focus on specific modules of animal welfare.
- The agency/competence complex is relevant for animal welfare for at least three reasons. First, performance of agency is directly rewarding for the animal. Secondly, when allowed its full course, agency makes the animal competent to meet high challenges with high skills, a state that has been described as fulfilling in humans, and that presumably would also be in other animals. Thirdly, highly competent animals deal with challenges more efficiently and successfully than less competent ones, and thus end up healthier and less fearful.
- It is, therefore, likely that when captive environments deny animals the opportunity to unfold their agency, they prevent those animals from achieving better welfare in all three aspects: immediate reward value, long-term build-up of positive psychological constitution and the ability to maintain health and psychological balance in the face of challenges.

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