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What do animals want?

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Abstract

Motivation is a central concept for animal welfare; it has inspired methodological breakthroughs and generated a wealth of crucial empirical work. As the field develops beyond its original mandate to alleviate the suffering of animals in intensive farming systems, the assumptions behind the current models of motivation may warrant closer scrutiny. In this paper, I examine some of the complexities of studying motivation — for example, that what an animal wants can depend on its welfare and that, through genetic selection and housing choices, we can modify what an animal finds to be rewarding versus punishing. The central theme of this paper is, therefore, that we cannot just ask the animals under our care (or even in the wild) what they want and assume that we will receive unadulterated answers, free from human influence. While asking questions about animal motivation with empirical research is invaluable and necessary, our models drive our research questions, methodologies, and results' interpretation. When the models we employ remain implicit (eg the only motivation questions worth asking are those that could be implemented within the current housing systems), they have ability to stifle progress in understanding animal welfare. Thus, in addition to the empirical work, we also need to expose and evaluate the models that drive the research. Making the models explicit will facilitate our ability to identify their areas of silence, assess their strengths and potential limitations, as well as examine how they conceptualise the relationship between motivation and animal welfare. I end with a discussion of the implications of a few relevant models, both implicit and explicit, noting how such consideration reveals exciting areas for future work, including, for example, research on the motivation to make choices and the motivation to learn.

Keywords: *agency, animal welfare, anthropocentrism, contrafreeloading, motivation, preference tests*

Introduction

Much of the work in animal welfare science involves motivation: asking animals what they want, what they find to be rewarding, what they find to be aversive, and what they prefer. Sometimes these data are used to rank the importance of various resources (Mason *et al* 2001). Sometimes they are used to assess the welfare state of the animal, eg using anhedonia as an indicator of poor welfare (Fureix & Meagher 2015). And, sometimes, they are used to argue for evidence of sentience in a species, eg observing changes in motivation after a potentially painful experience (Elwood & Appel 2009; Sneddon *et al* 2014; Weary *et al* 2017). Without assessing animal motivations, we would be at risk of being anthropocentric and circular, relying on our own experiences to understand what would constitute a good life for a member of another species and using the data thus gathered to validate that those are indeed good lives. The mere fact that we live in a radically different sensory world from other animals (eg we rely primarily on vision, whereas many species rely primarily on olfaction or hearing), limits the ability of our intuitions to provide direct insight into the experience of another animal. Empirically asking animals what they want can serve as a check on our intuitive limitations and creates an opportunity to test our ideas against information provided by the animals themselves.

But we can't stop there. Asking animals what they want is necessary, but there is a growing recognition that it is not sufficient to ensure welfare (eg Dawkins 2008; Yeates & Main 2008; Fraser & Nicol 2018). The particular concern of this paper is to highlight the ways in which our models of motivation drive the experiments we choose to conduct, which dictates the data we collect, the inferences we draw, and thus the lives we construct for the animals under our care. In other words, before the animals get a chance to tell us what they want, our models of motivation set the stage for what it is possible to want and, from what we leave out, what it is impossible to want.

The simple point is that there is nothing simple, direct, or value-free about asking animals what they want. These complexities do not mean that studying motivation is pointless. Quite the reverse: motivational data are invaluable to basic science and fundamental to understanding animal welfare. However, in addition to pursuing a diversity of empirical approaches, we must also make the models that are

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generating those approaches explicit. When they are explicit, we can take full advantage of their strengths, note their areas of silence, and contain their weaknesses. When models remain implicit, they still set the stage for which research questions are pursued and which remain unasked; it is just that these biases reside outside our awareness and restrict the range of what is possible to learn from the animals. By engaging in critical evaluation of models of motivation, therefore, we give animals a larger role in constructing lives that, from their perspective, are not only liveable, but worth living and meaningful (Purves & Delon 2017).

In this paper, I first examine some of the ways in which asking the animals what they want can lead us astray or at least leave us confused. I then explore a few models of motivation and their implications to illustrate their role in animal welfare. I end with suggestions for ways forward.

Why we can't *just* ask the animals what they want?

Throughout the history of animal welfare science, enthusiasm for motivational approaches and asking the animals what they want has been tempered by cautions (Dawkins 1990; Kirkden & Pajor 2006; Fraser & Nicol 2018). From the start, researchers noted that preference strength changes with time of day, age, and season, problematising inferences to species level 'needs' (Jensen & Toates 1993; Duncan 1998; Fraser 2008). Assembling the motivational data accumulated across the intervening decades reveals a suite of complexities in addition to motivation's temporal variability. I outline several of its most intriguing characteristics below.

Wants are conditional on welfare status

Most fundamentally, motivations are conditional: they depend on time (fluctuating diurnally, seasonally and developmentally) and experience (both recent experiences and developmental experiences; Kirkden & Pajor 2006). Motivation is also conditional on welfare state (Franks *et al* 2013; Fureix *et al* 2015; Weary *et al* 2017), which can create added complications for those interested in understanding which objects and experiences might help improve an animal's welfare.

For example, in the middle of the last century, a series of studies came out showing that rats were highly motivated to access various opioid substances (Kumar *et al* 1968). This work indicated that opioids were highly desirable, potentially even primary reinforcing substances for rats. From a welfare perspective, one might conclude that opioids have some role to play in creating a good life for a rat. A few years later, however, another set of studies showed that this strong motivation for opioids turned into an aversion when rats were housed in structurally and socially complex environments (Alexander *et al* 1978). The valence of the motivational target completely reversed based on the rats' developmental and current experiences.

While the opioid research might appear to be an extreme or artificial case, even natural substances that are widely considered to be primary reinforcers can be shown to be conditionally motivating depending on states associated with good and poor welfare. For instance, research on pigs and horses that shows that sugar water, a substance that is presumed to be fundamentally rewarding, is not motivating for animals with poor welfare (Figueroa *et al* 2015; Fureix *et al* 2015). Similarly, novelty is conditionally positively reinforcing (Wood-Gush & Vestergaard 1991) or aversive (Fox & Millam 2007), often because of how well the animal is coping. Moreover, much of the research on pain is predicated on the notion that the motivation for analgesics is dependent on the immediate welfare experience (eg pain) of the animal (Weary *et al* 2017). Thus, many of the motivational targets that matter most to welfare may be impossible to quantify in a single, independent and unqualified value.

As the science grows to include more species, especially ones radically different from ourselves (eg fish and invertebrates), the problem of motivational conditionality becomes more acute. Where should we begin for information about what an understudied species might want (eg a box turtle [*Terrapene*])? If the wants of the animal depend on developmental experience, current housing conditions, and welfare state, how should we house and treat the animals to know wants are 'normal?' Even relatively subtle environmental changes (from a human perspective) can produce radical changes in an animal's behavioural profile (eg Gaffney *et al* 2016; Makowska & Weary 2016). As such, in many cases, we may not know the full scope of the welfare conditionality of our motivational test results, just as we were initially blind to the conditionality of the opioid rat studies. Fundamentally, the notion of a 'normal' or single motivating force for any given target may be an illusion, complicating inferences about the role that the target resource may play in influencing an animal's welfare or what wanting it might say about their welfare state.

Further empirical study and careful attention to methodological detail can go some way to addressing these conditionality issues, but in empirical research, it is up to the scientists to choose which conditions to implement at the outset of a particular experiment (eg baseline housing, duration, frequency, and timing of testing) and which conditions are worth mentioning as qualifications to the conclusions. Models of motivation will influence these decisions as well as how the data are used to understand welfare. As a hypothetical example, imagine researchers who are interested in how blue crabs (*Callinectes sapidus*) respond to novelty. They find that when a plastic cube is dropped into the tank (ie a novel object test), the crabs avoid it. Is the conclusion written up as "blue crabs find novelty to be aversive" or as "blue crabs living in small, barren tanks find unnatural objects to be aversive?" Moreover, for welfare management purposes, does their aversion indicate that they should not be exposed to plastic cubes in the future or that the crabs in the present study may have poor welfare? Or, is any speculation about welfare unwarranted until other assessments of emotional experience and/or biological outcomes are measured? While additional empirical work can help resolve some of these questions, models of motivation will steer which empirical study to run next: eg try different novel objects, house the crabs in more complex

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environments, test for changes in cortisol in response to plastic cubes, or be content with the conclusion that blue crabs find novelty to be aversive. Making the models of motivation explicit will allow for greater clarity in results' interpretation, facilitate integrating data across studies, and help guide research priorities for future work.

Wants can conflict and be incommensurable

There are many ways in which one want can expressly contradict another want, the classic example being the desire to feel healthy versus the desire to eat foods that are fatty and sugary (or worse, poisonous, eg dogs and chocolate; Yeates & Main 2008). Feeling nauseous is a highly aversive experience for many animals (often requiring only a single training trial to achieve complete aversion) and it seems a fair assumption that most animals do not want to feel sick. Nevertheless, animals want many things that have the potential to make them feel sick and sometimes do not want things that are known to make them healthier. Such conflicts between wants may be especially prevalent in this moment in history as most animals (including wild animals) now live in environments that are radically different than those of their evolutionary ancestors.

When the wants of the animal come into conflict or are at least inconsistent, where can we turn for guidelines about which wants to prioritise? Asking the animals themselves to choose between conflicting wants may not produce sensible answers. First, we have empirical work showing that animals do not always work for things that confer known welfare benefits. For example, one study found no evidence that pigs are motivated to access a rubber mat, despite previous work showing that rubber mats are beneficial to the thermal comfort of pigs (Elmore *et al* 2012). Second, from a conceptual perspective, some questions are more difficult to ask than others. For example, it is more straightforward to ask a zebrafish (*Danio rerio*), "Do you want to eat bloodworms?" than it is to ask, "Do you want to feel healthy?" The extent to which some questions about motivation are easier to ask and answer than others could make it seem like animals want the easy-to-ask things more than they want the difficult-to-ask things.

Nevertheless, the goal of quantifying wants with a common currency has led to major breakthroughs and important insights in a number of species (eg Mason *et al* 2001; von Keyserlingk *et al* 2017). These studies are inspired by behavioural economics, which suppose that outcomes for which individuals will pay a higher cost to have higher value than those outcomes for which individuals will not pay such a high cost. The details of how cost is assessed (through maximum price paid, demand curves, etc) is an important consideration in this type of work, but beyond the scope of the present paper (for reviews, see Mason *et al* 1998; Cooper & Mason 2001; Kirkden & Pajor 2006; Jensen & Pedersen 2008; Fraser & Nicol 2018). The relevant issue here is that the very premise of behavioural economics may systematically undervalue certain elements in an animal's life and thereby bias the conclusions we make about what it is that animals want.

Specifically, the methodology of behavioural economic studies inevitably includes learning, choice, control, work, and exploration: animals learn how to access various resources, then have choice and control over which resources to work for, and finally, have the possibility of exploring less-frequented resource options. As such, using behavioural economics to ask whether animals want to have even more choices, for example, inevitably involves providing them with a baseline amount of choice: the choice of whether to work for more choices. Either way — work for more choice or not — the animal has made a choice. These methodological inevitabilities mean that behavioural economics is likely to undervalue the importance of going from (a) no choice to (b) some choice. Undervaluing this difference is concerning as going from a life that includes virtually no decision-making processes (eg choice, learning, control, work, exploration) to a life that includes some decision-making might be of great value to animals under human management. The same devaluation does not happen for resources that are only accessible as an *outcome* of the decision-making process: eg substrate, hide-boxes, swimming, etc. As such, behavioural economic methodology is a good candidate for comparing the value of these types of resources. Asking questions about the value of the decision-making processes themselves, however, requires methodology that minimises the degree to which animals are required to learn, choose, work and explore just to participate in the experiment.

For example, conditioned place preference tests allow animals to build-up associations between a neutral environment and potentially rewarding (or punishing) experience, eg sexual experience in hamsters (*Cricetidae*) (Bell *et al* 2010) or aggressive experience in anole lizards (*Dactyloidae*) (Farrell & Wilczynski 2006). After the association between environment and experience is formed, conditioned place preference tests then assess how much time the animal spends in the environment without the experience. In comparison to how much time the animal spent in the environment at baseline, the more time an animal spends in that environment during the post-conditioning test indicates a stronger preference for the experience (a positively valenced motivation). In this way, conditioned place preference tests minimise the active decision-making, while still retaining the ability to assess how much the animal values the experience.

Contrafreeloading studies, which allow animals to work for freely available resources, provide another example of a methodology that imposes lower learning and decision-making demands than behavioural economic studies. Even the term *contrafreeloading* derives from the absence of economically rational behaviour: rather than free-loading (as economists would have them do), animals often *contra*freeload, that is, they work for resources that are freely available. Contrafreeloading research spanning decades and species has shown that animals value effort and learning (Osborne 1977; Inglis *et al* 1997; Franks & Higgins 2012; Špinka & Wemelsfelder 2018). Economics, on the other hand, assumes that such processes are costs, things to be avoided or minimised.

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Thus, the methodologies for assessing motivation can have different models of motivation built into them, which means that the choice of methodology can itself systematically undervalue or overvalue aspects of an animal's life. While different methodologies have various empirical advantages (eg behavioural economics and experimental control versus contrafreeloading and ecological relevance), it is possible that no single paradigm will be able to address all questions about motivation, which would frustrate (if not obviate) efforts to rank motivations along a single dimension (Higgins 2012). Making the underlying models explicit will facilitate the synthesis of motivational studies that have employed different methodologies, clarifying, for example, that a methodology's inadequacy at assessing certain outcomes or processes should not be mistaken for evidence of a lack of value.

Wants vary by individual

Additional problems for the simplicity of the 'ask the animal' approach are presented by research on how animals differ in their motivational profiles. That some animals want things more than others is not a problem *per se* as it could potentially be addressed by including a diversity of resources in any given environment or housing system (though, of course, if those resources came into conflict with each other, we would run into the problem of prioritising wants; see *Wants can conflict and be incommensurable*). The novel complication lies in distinguishing between when those differences in motivation signal differential desires that need to be accommodated to maximise welfare — *provide* what the animals want — from when those differences signal variability in how the animals are coping, motivational differences that animal managers would try to eliminate or minimise — *change* what the animals want.

For example, across several studies, my colleagues and I showed that rats differed in the extent to which they were focused on maintaining darkness, which for rats is safer than being in bright light (Franks *et al* 2012, 2013a, 2014). Interestingly, the rats most focused on maintaining darkness in one context also spent the most time with a noxious novel object in another context, presumably burying it, which is a rat's natural defence mechanism (Franks *et al* 2012). Moreover, we found that the most security-motivated individuals were also the *least* stressed as measured by faecal boli production (Franks *et al* 2014). As such, these safety-focused rats were not classically fearful or anxious individuals, but somewhat the opposite: rats motivated to proactively secure and maintain safe states, what we call prevention-focused individuals (Higgins 1997). Furthermore, similar work in monkeys suggested that prevention-focused individuals may have distinct enrichment object preferences and interaction styles (Franks *et al* 2013b). This body of research shows that individuals differ in their prevention motivation and suggests ways to create welfare-friendly environments for the highly prevention-focused animals, eg by introducing objects that require vigilant behaviour.

However, described from the perspective of the low-prevention animal, we find that some animals do not want to engage in safety- and security-related behaviours. This lack of motivation could indicate that for these individuals to lead a good life, activities related to safety and security are not necessary. Alternatively, however, the lack of motivation to engage in safety-maintenance behaviours could be taken as a sign of dysfunction, a sign that these low-prevention individuals are experiencing worse welfare than the high-prevention individuals. In this poor-welfare interpretation, we might investigate interventions to raise these animals' motivation to engage in safety-maintenance behaviours (Franks *et al* 2014). The problem for animal welfare scientists is that without a clear model of motivation including how motivations are conceptualised to relate to welfare, data about an animal's motivational tendencies might not be able to tell us which version — accommodate the motivation versus change the motivation — is the correct path for improving welfare.

This problem of distinguishing between wants that signal poor welfare versus wants that simply signal healthy individual differences is pervasive. As another example, the motivation to explore is one of the most frequently studied individual differences *and* one of the most frequently used indicators of welfare. The field of animal personality has grown exponentially in the past few decades, with a large portion of the research focused on the bold-shy dimension (Sih *et al* 2014). The bold-shy dimension of personality is often assessed through various tests of exploratory tendency, eg number of perch hops in a novel room, (Dingemanse *et al* 2002). Equally popular, though much maligned (Ennaceur *et al* 2006), are open field tests, which measure how much animals investigate a novel, typically barren space. In contrast to the animal personality framework, which treats the differences in exploration tendency as an interesting component of who they are, open field tests measure exploratory tendency as a way of assessing welfare-like states (eg chronic anxiety or disproportionate fear), with the goal of determining the causal mechanisms of poor welfare.

Thus, across many contexts we find that if we simply rely on the data from the animals themselves, it might be impossible to distinguish between wants that should be accommodated to improve welfare and wants that should be changed to improve welfare. Models of motivation can help make explicit which motivations one would expect to see in a healthy animal, which motivations may, in and of themselves, be harmful, versus which motivations can safely vary across individuals without indicating any particular risks to welfare.

Wants can hide

Wants can hide from the subjective experiencer in the sense of the agitating feeling of not knowing what one wants or feeling bored (see Meagher 2019; this issue, for an in-depth discussion of boredom research as well as Burn 2017). Wants can also — and more easily — hide from an experimenter in the sense that within the confines of a motivation experiment, the animals can only tell us their preferences from among the array of choices we happen to provide for them. The animals in the motivation experiment are not able to indicate that we

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have left out some important option that they would prefer to have or prefer to be doing. Moreover, preferences can be non-transitive and change when the choice set changes: ie, A is preferred to B when C is absent, but when C is present, B is the most preferred (Bateson 2004).

From an empirical standpoint, value and influence of resources and activities that are not included in our motivational studies are effectively set to zero, with their potential importance hidden from science until it occurs to someone to include them in an experiment. Thus, before we even come upon the complications posed by temporal fluctuations, motivational conflicts, and individual differences, the data we generate with motivational experiments are contaminated by the fact that we humans have to generate hypotheses of what sorts of things animals might want and only can present the animals with a limited array of options — experimental choices that are directed by our models of motivation.

These silences are compounded by the fact that the wants themselves are not technically observable. While we can observe behavioural choices, we never observe the motivations themselves, which means the actual motivation driving the choice in any particular experiment can be difficult to discern. For example, through careful experimentation, researchers have been able to show that animals will sometimes choose stimuli that are known to be dispreferred, such as unpalatable food items (Addessi *et al* 2010). In these studies, scientists were able to determine that what the animal is choosing is not the material outcome of their choice, but the psychological experience that that choice represents: ie, the feeling of having greater control or learning about the choice set. While we can use these studies to draw conclusions about the importance of agency or mental stimulation (Burn 2017; Franks 2017; Špinka & Wemelsfelder 2018; Meagher 2019; this issue; Špinka 2019; this issue); they also demonstrate the possibility of misconstruing the meaning of an observed choice, leaving the true motivation of the animal hidden from us.

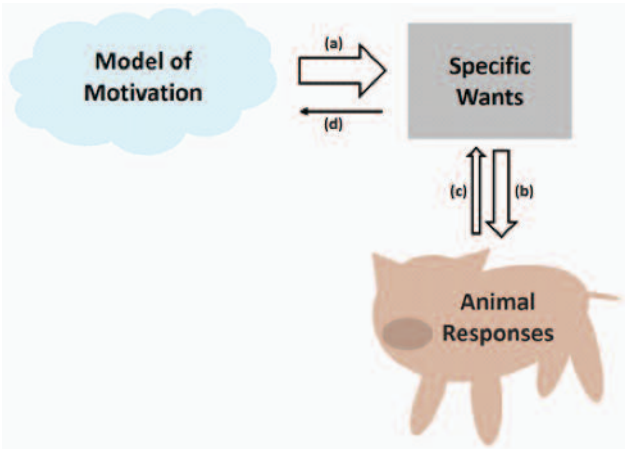
While further experimentation is needed to fill in our knowledge about motivational targets and conditions under which they are desired, the range of targets and conditions is bounded by details of the experimental design and the way in which the data are interpreted. Thus, in addition to the empirical work, we also need theoretical work scrutinising the limitations of the models of motivation that generated the choice arrays and interpretations of the data.

Attenuation of the animals' voice

In sum, the potential pitfalls in motivation research necessitate more than careful attention to experimental design. There are inextricable ways in which the questioner's model of motivation dictates the answers (Figure 1). Before we begin to ask questions about what the animal wants, we make decisions about the background experiences of animals we study (eg do we study feral pigs or ones raised in conventional farming systems). Our choice of developmental and current housing will impact the motivational profiles of the animals we study. Next, the choice array we present to animals may be the central limiting factor to gaining a full picture of the motivational make-up of a particular animal or species. For example, do we ask them questions about what they want to eat or what they want to learn? Moreover, we have various tools to get at various elements that animals might want in their lives, but it is possible that our most prized methodology leaves out or minimises certain types of questions (eg how valuable is choice itself?) It is even possible that, ultimately, motivation may not be something that can be measured and ranked on a single dimension of importance (Higgins 2012). Finally, our human perspective on the options we present to animals is inescapably different from the animals' perspective on those options. At a minimum, we have different perceptual apparatus than other species and might not be cued into the same sensory features as other animals. Thus, even when all the individuals in an experiment make the same clear choice, the true source of desire can yet be hidden from us, particularly if it is outside the scope of our model of motivation.

Thus, despite our efforts to give animals a voice, their voice is attenuated. Paradoxically, to remove ourselves from the picture, we have to turn away from the animals (for a moment) and examine our own mental models. In the next section, I provide an analysis of the consequences of a few example models of motivation.

Figure 1



Attenuation of the animal's voice. Showing (a) the model of motivation, whether it is implicit or explicit, determines the range of specific wants under consideration for being of potential importance to an animal, eg wanting to avoid rough handling, wanting to have access to the outdoors, or wanting to explore novel spaces, (b) of the potentially important wants, we design empirical studies to help quantify the value of a subset of those wants, (c) after observing the animal's responses, there is potential for information gain, but there is also potential for information degradation as the actual want remains unobserved, eg does the behavioural response indicate a motivation for having the lights on or for having control over the environment (being an agent). Moreover, specific methodologies can systemically undervalue certain wants, eg behavioural economic methodologies are likely to undervalue the motivation to have some choice (see *Wants can conflict and be incommensurable*). And, finally (d), only some of the information we gain about specific wants (eg an unexpected want) will influence our original model of motivation.

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Models of motivation

Atheoretical models of motivation

Animal welfare science grew out of concern about animals living in increasingly intensive farming situations (Fraser & Duncan 1998; Fraser 2008) and has accordingly focused on alleviating suffering. In contrast, understanding how to create positive welfare has been comparatively ignored until recently (Boissy *et al* 2007; Yeates & Main 2008; Balcombe 2009; Mellor & Beausoleil 2015; Lawrence *et al* 2018). As such, much of the work on motivation in animal welfare science is reflective of the original mandate — finding out what elements of intensive farming systems are most aversive or the absence of which environmental parameters might cause intense suffering (eg the debate over behavioural 'needs'; Jensen & Toates 1993). The 'constraints of the system' approach to motivation is not a formal model of motivation, but implicitly (and explicitly) assumes that the motivational tests that are worth conducting are those that could be implemented within the existing systems. For example, asking the animals if they want to leave captivity is the most fundamental motivation that would not be investigated under this model. Less extreme examples of questions that are not asked with this model include, the motivation to protect young or the motivation to engage in sexual behaviour. Thus, even without being a deliberately formulated model of motivation, it has served as a guiding framework for the research, setting the scope of and limits to what motivational questions are asked and thereby influencing how animal motivation is represented and understood in science.

As science, technology, and our duties towards animals advance, however, using the 'constraints of the system' framework is becoming increasingly problematic. For example, how much do we know about what a free-roaming or sanctuary chicken would ideally want (Marino 2017)? Or, more alarmingly, what if we could make a pig which wanted to live in a gestation stall? Would she have good welfare? While the idea of a pig wanting to live under such restrictive conditions might sound like science fiction, various gene-editing technologies (eg CRISPR) and improvements in our understanding of neuroscience (Shriver 2009) are making this seeming fiction a potentially near-term reality.

In fact, to some extent, we are already there. We have been structurally modifying the wants of animals to suit our needs for millennia. The most obvious example is selecting for docile animals: selecting for animals which are the least motivated to flee humans and escape confinement. Additional examples can be seen in the intense and specific motivations of various dog breeds: the motivation to run (greyhounds), chase (terriers), herd (shepherds), or retrieve (retrievers). Thus, the first step towards creating animals which want to live in our artificial housing systems and according to our rules was taken thousands of years ago; it's just that recently, the pace and scope have increased dramatically. Moreover, beyond its potential to lead us in morally questionable directions, an exclusive embrace of the 'constraints of the system' approach to motivation hinders scientific progress, impeding our ability to understand positive welfare and the fundamental structure of motivation across species.

As a corrective, animal welfare scientists turn to ethology and an animal's life in the wild or natural living, even while recognising that naturalness is a notoriously difficult concept to assess and define (Špinka 2006; Fraser 2008; Yeates 2018). Like 'the constraints of the system', natural living is not a deliberately formulated model of motivation, but it is a framework to which the field of animal welfare reliably turns to ask questions about motivation. As such, it also has a chance to play a role in what motivations animals are given the chance to express and how welfare is identified.

Natural living is undoubtedly a necessary and valuable starting place for understanding animal behaviour, but the level of analysis that is the most important to consider — eg natural physical materials, natural biological function, natural behaviour, natural psychological experience — is not always apparent (Špinka 2006). For example, decades of research has shown that running wheels are one of the most motivating resources for rodents, regardless of their captivity status (Sherwin 1998; Meijer & Robbers 2014). The material object of the running wheel is highly unnatural, as is the behaviour of running in place inside a circle, so from a physical material or purely behaviouristic perspective, the animals appear to be motivated for something unnatural. On the other hand, it is possible to conceptualise the desire to run or even, perhaps, the desire to engage in challenging, yet manageable, physical activity as natural motivations and thus rescue the naturalness of the motivation for running wheels. Nevertheless, 'natural living' does not make *a priori* predictions regarding the level of analysis on which to focus at the outset of a programme of research, eg psychology, biology, physical materials, etc, which leaves it susceptible to being hijacked by other, more directive models of motivation, such as materialism.

Materialism is one of the most pervasive implicit models of motivation in today's culture. Modern life steers us towards thinking about material outcomes, eg preferred foods, comfy beds, clean housing — more often than it steers us towards thinking about processes — eg learning, making choices, expending effort, engaging in behaviours for their own sake (Higgins 2012). This modern bias towards a material versus process model of motivation has been shown to be detrimental to human well-being (Dunn *et al* 2008, 2010; Franks *et al* 2015) and may have restricting effects in animal welfare science as well, prioritising research questions on the motivational valence of objects and things (food types, bedding, noises) over activities (socialising, learning, working, choosing).

Thus, even without a formal model of motivation, the way we think motivation works has the potential to guide our research and influence conclusions about how to produce

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and measure the good life. Developing and evaluating models of motivation can help make this process explicit, subject to scrutiny, and hopefully, eventually, to a more parsimonious view of welfare. Moreover, as notions about the good life and what is motivating are subject to historical and cultural drift, making models of motivation explicit will help situate them within their sociological context.

Theory-based models of motivation

The most important formal model of motivation is the Hedonic Principle (Fraser & Duncan 1998; Higgins 2006; Gjerris *et al* 2013). We can trace its origins at least as far back as the ancient Greeks, with the simple-seeming formula that humans and other animals approach pleasure and avoid pain. While intuitively appealing, this model does not provide clear guidelines about where to begin asking research questions. Recently, its main added value has been in elevating the importance of pleasure in contrast to the atheoretical models of welfare that guided us towards a science of suffering (Fraser & Duncan 1998). With our attention shifting towards questions regarding presence of good welfare and fundamental questions of what it means to live a good life (Yeates & Main 2008; Mellor 2014; Yeates 2016), what should be the first questions we ask about pleasure? What are the things that are positively wanted by animals and have the potential to make the biggest positive impact on their welfare? The Hedonic Principle sets the imperative for asking these questions but does not provide clear guidelines for where to begin.

Recent models of motivation developed in human psychology may prove to be useful in this regard. In particular, my colleagues and I have suggested that humans and other animals are not only motivated to have desirable outcomes (traditional rewards) and avoid undesirable ones (traditional punishers), but also to learn about and manage the world around them — what we call truth and control motivation, respectively (Franks & Higgins 2012; Higgins 2012; Cornwell *et al* 2014; Higgins *et al* 2014). Thus, our model of motivation generates hypotheses related to valued outcomes that animals might want (eg ingesting desired feed types and wanting safe hiding places) as well as the motivation to engage in certain processes (eg solving problems, making choices, taking control, and being the agent that achieves the goal). This model of motivation also suggests that animals with good welfare will be motivated to obtain not only material rewards, but also maintain their safety, learn, and take action. While not in conflict with the Hedonic Principle, this perspective on motivation thus expands out the range of important research questions for animal welfare scientists.

Animal welfare implications

Asking animals what they want is vital to the success of animal welfare science (Dawkins 2017; Gygax 2017). At their best, motivational tests can provide clear and valuable information regarding the basic priorities of the animals under our care. They can give animals a voice in the nature and trajectory of their own life. And, importantly, they can correct anthropocentric ideas about what a good life would look like for a non-human. Indeed, it is precisely because asking the animals what they want is such an important project that it is crucial that we get it right.

By asking the animals what they want, however, we do not remove ourselves from the equation. The convolutions within the motivation-welfare space conspire to create self-fulfilling prophecies that can reinforce rather than test our assumptions. At a minimum, different models of motivation have the potential to set very different research agendas for the field, eg prioritising research on motivation for material outcomes versus motivation for mental stimulation. Deciding between models is partially an animal-based, empirical endeavour (determining which model best accounts for the data), but also partially a non-animal based, theoretical and philosophical endeavour (Kornum *et al* 2017; Weary & Robbins 2019; this issue).

While there might be some resistance to the idea that applied animal welfare scientists should concern themselves with non-animal-based and/or non-empirical methods of theory evaluation — eg it is outside the scope of traditional scientific methods, or at least, perhaps, beyond our expertise — the influence of our mental models is present whether we want them to be or not. When we ask the animals what they want, we are also stating what we think they could or should want, which is a product of our own minds and one which the animals have limited chance to change (see Figure 1). It is therefore up to us to scrutinise our theories (implicit or explicit) for biases and areas of silence and then devise experiments to test our updated hypotheses and hunches.

For example, future work, could fill in our knowledge of recently proposed models of motivation regarding the importance of non-material experiences like engaging in decision-making and learning opportunities and the desire to have agency (Špinka & Wemelsfelder 2018; Špinka 2019; this issue). The choice of methodology here will be critical (see *Wants can conflict and be incommensurable*), with the assessment of the motivational value of such psychological processes potentially better served by conditioned place preference tests or contrafreeloading experiments rather than behavioural economics studies.

At this particular moment in the history, animal welfare research is more consequential than ever before (Walker *et al* 2014) and it is called upon to understand a greater range of species, eg cephalopods and decapods, living under a greater range of conditions — sanctuaries, rehabilitation facilities, private homes, semi-wild landscapes (Bekoff 2013) — than ever before. Examining our models of motivation can help move us forward into this new terrain deliberately, and, ideally, to the ultimate benefit of the animals themselves.

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