Complementary Roles for Systematic Analytical Evaluation and Qualitative Whole Animal Profiling in Welfare Assessment for Three Rs Applications

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Summary

Application of the Three Rs involves prospective evaluation of potential negative welfare impacts of scientific procedures, while assessment of the success of Three Rs applications requires retrospective evaluation of the actual impacts. Two complementary approaches to animal welfare assessment are available to assist with this: Systematic Analytical Evaluation (SAE) and Whole Animal Profiling (WAP). SAE aims to comprehensively anticipate functional disruptions, rank scientific procedures according their actual negative impacts, and guide the development and application of methods to mitigate such impacts. A key focus of SAE is to assess the likely impacts on subjective mental states adduced from objective behavioral, physiological, and pathophysiological knowledge. In contrast, WAP involves observers scoring subjective impressions of appearance, demeanor, and behavior in terms of overall welfare status at the time of the evaluation. Conclusions based on qualitative WAP have been validated using key quantitative behavioral and physiological indices of welfare status. These two approaches are complementary. For example, WAP can be used to verify welfare impacts anticipated using SAE, whereas SAE may be used to elucidate the factors that contribute to a particular welfare state identified using WAP. It is suggested that combining both approaches in assessments of laboratory animal welfare will facilitate more thorough evaluation of welfare status, enable immediate or future mitigation strategies to be identified, and thereby enhance application of Three Rs measures.

Keywords: animal welfare assessment, systematic analytical evaluation, whole animal profiling

1 Introduction

In all scientific research using animals there is the potential for animal welfare to be compromised, due both to the experimental procedures themselves and to features of their husbandry and management. The Three Rs aim to minimize animal welfare compromise, ideally by replacing animal use with other methods. In situations where the use of animals is unavoidable, care is taken to reduce the number of animals used to the minimum needed to achieve the desired outcome and to refine interventions in ways that minimize actual or potential negative impacts on animal welfare (Russell and Burch, 1959).

In order to successfully implement refinement strategies, indicators of animal welfare are required. The first step is a prospective evaluation of the potential negative welfare impacts of the scientific and associated husbandry procedures. Once these have been identified, specific mitigation strategies (refinement) can be developed to address them. Following implementation of refinement strategies, a retrospective evaluation of the actual welfare impacts is required to appraise their success.

Two complementary approaches to animal welfare assessment are available to assist in successful Three Rs application. They are Systematic Analytical Evaluation (SAE) and Whole Animal Profiling (WAP), the former having strongly quantitative elements related to measurement of functional indices and the latter a strongly qualitative orientation towards assessment of animal demeanor and behavior. Quantitative (SAE) and qualitative (WAP) methods for welfare assessment reflect differing philosophical approaches to the conceptualization and investigation of subjective phenomena such as animal consciousness, emotion, and experience (Wemelsfelder, 2001). The focus of this paper is not the philosophical bases of the different approaches, although an understanding of these enhances appreciation of their value, but instead it focuses on the roles that each may play in understanding the experiences of animals. More specifically, the purposes of this paper are as follows: to describe these two approaches, to identify their strengths and weaknesses and the situations in which each approach may be most valuable, and to highlight the complementarity of the two systems for comprehensively assessing animal welfare.

Current concept of animal welfare

According to our current conception, welfare is a state within an animal, and most directly relates to what the animal itself experiences (Mellor et al., 2009). Briefly, welfare is considered

here to be the integrated balance of all sensory inputs to the animal's brain that are cognitively processed and experienced as emotions or feelings (Mellor et al., 2009). Sensory mechanisms continuously scan the internal functional state and external environment of the animal. These sensory inputs are then processed and interpreted within a framework relevant to the species and individual animal. The integrated cognitive and emotional outcomes of this process are reflected in the individual's welfare state, which can range from very bad to extremely good (Mellor et al., 2009).

2 Quantitative approaches to welfare assessment: Systematic Analytical Evaluation

Quantitative or "objective" methods for animal welfare assessment involve measurement of discrete variables, followed by interpretation of the data collected in terms of the animal's likely subjective experience (Meagher, 2009). One quantitative approach, Systematic Analytical Evaluation (SAE), provides a way of methodically assessing the potential welfare impacts associated with a particular event, situation, or procedure. An effective systematic approach is that based on the "Five domains of potential welfare compromise" model proposed by Mellor and Reid (1994), with subsequent minor modifications (Mellor and Stafford, 2001; Williams et al., 2006; Mellor et al., 2009). This model provides a means of clearly separating physical or functional impacts on the animal from the emotional or affective experiences, mental states or feelings that ultimately determine its welfare or well-being.

According to this framework, potential or actual welfare compromise is identified in four physical domains and one mental domain (Fig. 1). Briefly, when considering a procedure or situation, researchers use their knowledge and relevant literature to predict the potential compromise relating to: nutrition, the animal's environment, its health or functional status, its behavioral needs, and its overall mental state. Actual impacts in the four physical domains can be evaluated by measuring quantitative changes in behavior, physiology, and neurophysiology, including cognitive brain function, along with pathophysiological indicators of functional disruption (Mellor et al., 2009). Detailed knowledge of the species and the procedure or situation limits or accentuates the confidence that can be placed in such assessments. Compromise in one or all of the physical domains is used to infer potential negative impacts in the fifth domain, as shown in Fig. 1. Mental states detrimental to welfare (domain 5), that arise due to compromise in domains 1-4, may include negative experiences such as fear, anxiety, pain, breathlessness, and others, as well as the absence of positive experiences such as contentment, satiety, and companionship (Mellor et al., 2009). For more detailed information on this framework, see Mellor (2004) and Mellor et al. (2009).

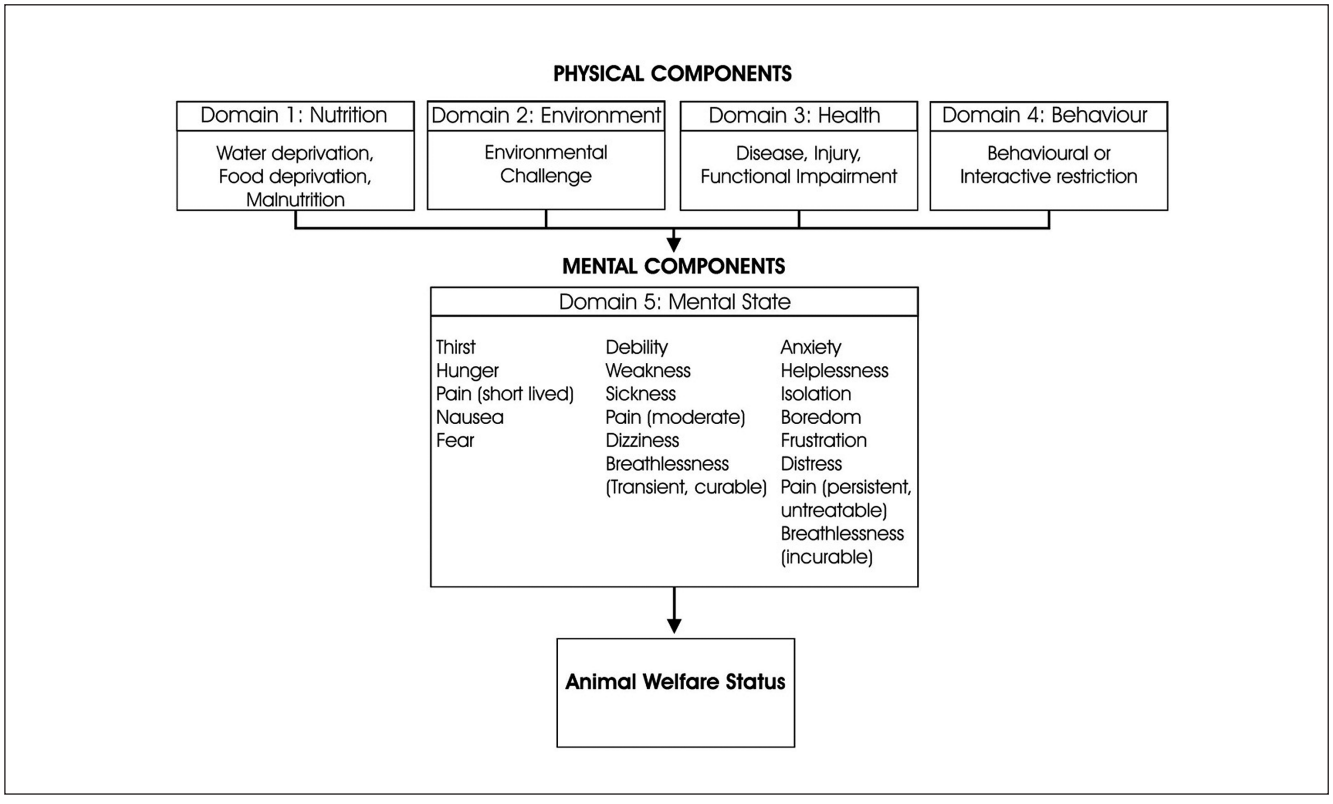

Fig. 1: Domains of potential welfare compromise divided into physical and mental components, the integrated effects of which give rise to the welfare status of the animal
Diagram modified from Mellor et al. (2009).

Advantages of SAE approach

There are a number of significant advantages to the application of the SAE approach in welfare assessment. First, SAE using the "Five domains" framework can accommodate all imaginable features of welfare compromise associated with scientific endeavors involving animals (Mellor, 2004). This makes the approach both comprehensive and relatively future-proof.

Second, SAE allows researchers to undertake prospective evaluations of the potential welfare impacts associated with proposed procedures. The information gained from such prospective analyses provides a basis for researchers and animal ethics committees to decide whether the proposed procedure is ethically permissible and also the degree of benefit required for justifying the likely harms (Mellor, 2004). In addition, specific analysis of impacts in each of the five domains allows identification of those impacts that may be minimized or avoided, along with possible strategies to do so. In other words, prospective SAE may allow targeted development and application of mitigation strategies before procedures are undertaken.

Alternatively, retrospective SAE of the actual impacts resulting from a procedure can indicate the accuracy of prospective analyses for future use, as well as highlight any unforeseen welfare impacts. In addition, retrospective analysis can be done to gauge the success of any mitigation strategies applied.

Finally, SAE using the "Five domains" framework allows relative ranking of various procedures based on potential or actual welfare impacts. In each of the five domains, the severity of the predicted or actual compromise can be graded. The overall grading for the procedure is usually that assigned to domain 5, mental state, as this indirectly incorporates the grades from the four physical domains and most directly relates to the animal's welfare state (Mellor, 2004). Such ranking can be used to compare the relative impacts of various procedures, situations or events, and to aid in the welfare assessment of new procedures.

Limits to SAE approach

A key limitation of quantitative approaches in general relates to the fact that mental experiences relevant to welfare are considered inherently private and therefore not directly accessible to empirical observation (Wemelsfelder, 2001). These states can only be inferred using proxy measures, and there can be no certainty that the measured variables always reflect the same subjective experience (Wemelsfelder and Farish, 2004). In practice, this can lead to ambiguity, with results from various tests purported to measure the same internal state or multiple variables measured within the same test often failing to co-vary (Meagher, 2009).

This ambiguity can mean that quantitative approaches provide a less holistic view of the animal's state of well-being than qualitative approaches (see below). The SAE approach, in particular, is less useful for evaluating welfare compromise associated with longer-term procedures or non-specific features of the animal's environment than impacts associated with specific and acute scientific procedures. This is partly because short-term behavioral, physiological, neurophysiological, and pathophysiological changes are more easily recorded and interpreted than changes due to chronic states. Many of the limits associated with the SAE approach are addressed by a second approach to welfare assessment: Whole Animal Profiling.

3 Qualitative approaches to welfare assessment: Whole Animal Profiling

In addition to quantitative approaches, a number of subjective or qualitative methods are available for assessing animal welfare. These methods are subjective in that they rely strongly and openly on the perceptive and integrative capabilities of human observers to evaluate aspects of an animal's welfare state (Meagher, 2009). The observer, who may be the researcher or an independent rater, plays a more active interpretative role in the process of data collection than is required in quantitative approaches: in effect, the observers become the research instrument (Wemelsfelder, 2007).

Two main subjective methods are currently used for the assessment of animal welfare (Meagher, 2009). The first involves provision of descriptive terms to observers who use these terms to subjectively score animals on various characteristics relevant to their welfare (Meagher, 2009). For example, Visual Analogue Scales (VAS) are commonly used to rate animals in terms of their behavior, products of behavior, or physical characteristics (e.g., personality traits, pain behavior; nest quality, body condition score, respectively – see Meagher, 2009 for review). As for quantitative approaches, the animal's subjective experience is still inferred from the observers' ratings.

In contrast, Qualitative Behaviour Analysis (QBA) operates on the assumption that behavior is a direct expression of an animal's personal experience (i.e. its subjective state), meaning that these experiences are open to empirical observation and scientific evaluation (Wemelsfelder, 1997). According to this approach, behavior is a dynamic, expressive body language that is subjectively experienced by the animal and therefore provides the basis for assessing the quality of that animal's experience (Wemelsfelder, 2007).

The methodological keystone of QBA is the generation of descriptive terms for scoring by the observers themselves (for details on methodology see Wemelsfelder et al., 2000, 2001). Wemelsfelder contends that free choice of descriptors requires observers to truly engage with the process of integrating and judging animals' behavioral expression and that the provision of pre-fixed terms may bias observers in their evaluations, as well as reduce their ability to focus on the animal as a dynamic whole (Wemelsfelder, 2007). The aim is to evaluate not what is done by the animal but how it is done to understand "what it is like to be" that animal at that moment in time (Wemelsfelder, 1997). In this regard, QBA is considered a truly holistic and integrative approach to assessment of animal behavior and welfare. For this reason, we refer to QBA as Whole Animal Profiling (WAP). This is the subjective approach that will be discussed in the remainder of this paper.

The use of WAP for assessing animal welfare was proposed by Francoise Wemelsfelder and colleagues almost fifteen years ago and has since been shown to be a reliable and internally valid method for evaluating the behavior of production and companion animals. Both inter- and intra-observer reliability are consistently high (e.g., Wemelsfelder et al., 2000, 2001), and the findings of WAP analyses are coherent with results from quantitative and other qualitative studies of subjective states, demonstrating WAP's biological validity (e.g., Rousing and Wemelsfelder, 2006; Napolitano et al., 2008; Minero et al., 2009; Stockman et al., 2011).

To produce reliable and valid results using WAP requires that the following criteria relating to the observers be satisfied:

1. Knowledge of species-specific behavior
2. Experience interacting with and observing animals in various contexts
3. Willingness to engage with animals as sentient beings
4. Adoption of a whole animal perspective to describe how the animal interacts with its environment

In addition, observers must be shown dynamic behavior in the context in which it was expressed if accurate judgments are to be made (Wemelsfelder, 2007).

Advantages of WAP approach

The advantages of WAP relate primarily to its holistic and integrative nature. Observers integrate multiple pieces of information about the whole animal, including the context in which behavior is expressed (Wemelsfelder, 2007). Such integration provides information that may not be available from quantitative ethological evaluations that fragment behavior into discrete movements and postures. WAP also provides information on the flow of behavior, changes in behavior over time and context, and includes subtle or rare behaviors that may not be accurately quantified in traditional evaluations. Therefore, WAP may more accurately reflect the individual's experience of its total environment, including both negative and positive experiences, making it particularly useful for evaluations of Quality of Life (Wemelsfelder, 2007).

We propose that WAP is particularly useful for evaluating putative subjective experiences for which there are currently no validated physiological or specific behavioral indicators. These may include positive experiences such as contentedness and satisfaction (Wemelsfelder and Farish, 2004), as well negative experiences such as nausea. WAP can also play an important role in interpreting behavioral and physiological responses measured using quantitative methods in terms of the animal's welfare state (e.g., Rousing and Wemelsfelder, 2006; Minero et al., 2009; Walker et al., 2010; Stockman et al., 2011).

WAP is also advantageous in practical terms in that it is relatively non-invasive and cost-effective (Meagher, 2009; Walker et al., 2010) and is applicable as a method for on-farm welfare assessment of individuals and groups of animals (e.g., Rousing and Wemelsfelder, 2006; Minero et al., 2009). These strengths make WAP well suited to assessments of housing and social conditions, as well as enrichment and other non-specific refinement strategies.

Limits to WAP approach

While WAP is useful for providing information about an animal's overall welfare status, it is not useful for identifying specific factors contributing to the development of that state (Walker et al, 2010). Therefore, WAP does not lend itself to prospective evaluation of the potential welfare impacts of proposed studies or to the development of specific mitigation strategies.

In addition, WAP may not be equally effective for evaluating all aspects of welfare compromise nor for all animal species. For example, WAP may be less useful for evaluating acute animal pain than for other subjective experiences or states. Indeed, several studies suggest that human observers are relatively poor at subjectively assessing animal pain, even when they are highly experienced in interacting with and observing the species under study (Roughan and Flecknell, 2006; Leach et al., 2011). This problem may be exacerbated by the requirement for observers to generate their own descriptive terminology for scoring purposes. While we have an extensive vocabulary to describe our own pain (e.g., Fernandez et al., 2011), our vocabulary for describing the pain behavior of others may be more limited.

The efficacy of WAP for evaluating subjective experiences may vary according to our current knowledge of the specific behavior of the species. Species with limited behavioral repertoires, those that use modes of communication outside our sensory ranges (e.g., ultrasonic vocalizations), or whose anatomy and behavior is greatly divergent from our own may be more difficult to assess using subjective ratings (Meagher, 2009).

Finally, WAP may be more vulnerable to contextual bias than other methods. Observers may be systematically biased in their interpretations of behavior due to the context in which observations are made (Meagher, 2009). For example, Wemelsfelder et al. (2009) found that environmental background (indoor/outdoor) had a minor but significant effect on observer ratings of pig behavior. The risk of contextual bias may be greater when WAP is applied for on-farm welfare assessment and in clinical settings. Appropriate observer training, including exposure to animal behavior in a range of contexts, may reduce contextual bias (Wemelsfelder et al., 2009).

4 Complementarity of two approaches

As outlined above, both approaches to animal welfare assessment have advantages, but each is inherently limited for certain purposes. Each approach is valid and valuable in its own right, but neither is sufficient to fully explain subjective phenomena relevant to animal welfare (Wemelsfelder, 2001). Rather than representing separate and incompatible approaches to welfare assessment, SAE and WAP approaches are complementary and synergistic. In fact, truly comprehensive assessment of welfare impacts associated with scientific teaching, testing, and research will combine both approaches (Wemelsfelder, 1997, 2007; Wemelsfelder and Farish, 2004; Meagher, 2009).

Each approach has a different intent and begins at the opposite end of the welfare assessment spectrum. As noted above, the intent of SAE is to anticipate, rank, and guide application

of strategies to mitigate negative welfare impacts. In contrast, the intent of WAP is to observe the overall welfare state of the animal at a particular point in time, i.e. evaluate the integrated effect of environment, husbandry practices, and procedures on the animal. Each approach fulfils a different, though related, purpose. The hope is that both will lead to the same conclusion regarding the animal's welfare.

The complementarity of SAE and WAP can be illustrated as follows. The welfare impacts associated with a particular procedure may be anticipated using SAE. After the implementation of the procedure, WAP can be used to verify the anticipated impacts. Likewise, WAP may be used to evaluate the overall effect of implementing a refinement strategy. Conversely, WAP can be used in an exploratory sense, to highlight situations requiring systematic evaluation (Stockman et al., 2011). SAE can then be used to elucidate the specific factors that contribute to the particular welfare state identified using WAP and to design mitigation strategies to address those factors. Neither approach can provide all the necessary information, but used together they provide a more comprehensive and internally valid assessment of welfare.

5 Application to laboratory animal science

Systematic analytical evaluation of welfare impacts using quantitative methods is an integral part of scientific research involving laboratory animals in many countries. Whole animal profiling has become an accepted approach for welfare assessment in farm and companion species (e.g., Wemelsfelder et al., 2001; Rousing and Wemelsfelder, 2006; Napolitano et al., 2008; Minero et al., 2009; Walker et al, 2010; Stockman et al., 2011). However, thus far, formalized and validated WAP approaches to the assessment of laboratory animal welfare have not been published, although other subjective approaches are commonly used, e.g., VAS (Meagher, 2009).

Combining both approaches to assessment of laboratory animal welfare will enhance our understanding of how these animals experience their lives. For the reasons outlined above, incorporating WAP into laboratory animal welfare assessments will be particularly valuable for evaluating housing systems and environmental enrichment strategies. Key to the success of WAP in this context will be knowledge of the specific behavior of species used in the laboratory, as well as a willingness to engage with these animals as sentient beings. Because of their extensive experience interacting with and observing the animals, animal technicians and other caretakers are very well suited to apply the WAP technique (Meagher, 2009).

6 Conclusion

Two different approaches are available to assist with assessments of the animal welfare impacts associated with scientific procedures. Systematic Analytical Evaluation aims to comprehensively anticipate functional disruptions, rank scientific procedures according to their actual negative impacts, and guide the development and application of methods to mitigate such impacts. In contrast, Whole Animal Profiling involves observers scoring subjective impressions of appearance, demeanor and behavior in terms of overall welfare status at the time of the evaluation. The two approaches are complementary, as each can address the limitations of the other. It is suggested that combining both approaches in assessments of laboratory animal welfare will facilitate more thorough evaluation of welfare status, enable immediate or future mitigation strategies to be identified, and thereby enhance application of Three Rs measures.

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