



HAL
open science

From human–animal relation practice research to the development of the livestock farmer’s activity: an ergonomics–applied ethology interaction

Joffrey Beaujouan, Damien Cromer, Xavier Boivin

► To cite this version:

Joffrey Beaujouan, Damien Cromer, Xavier Boivin. From human–animal relation practice research to the development of the livestock farmer’s activity: an ergonomics–applied ethology interaction. *Animal*, 2021, 15 (12), pp.100395. 10.1016/j.animal.2021.100395 . halshs-03469481

HAL Id: halshs-03469481

<https://shs.hal.science/halshs-03469481v1>

Submitted on 7 Dec 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Review: From human–animal relation practice research to the development of the livestock farmer’s activity: an ergonomics–applied ethology interaction



J. Beaujouan^a, D. Cromer^a, X. Boivin^{b,*}

^aLaboratoire ACTé, Université Clermont Auvergne, Aubière, France

^bUniversité Clermont Auvergne, INRAE, VetAgro Sup, UMR 1213 Herbivores, 63122 Saint-Genès Champanelle, France

ARTICLE INFO

Article history:

Received 1 February 2021
Revised 30 September 2021
Accepted 30 September 2021

Keywords:

Activity
Animal behaviour
Farmer practices
Interdisciplinarity
One welfare

ABSTRACT

Animal husbandry and working conditions for livestock farmers have changed significantly in recent years as agriculture has been exposed to economic as well as health, environmental and ethical challenges. The idea of interdependent welfare between humans and animals is more relevant now than ever. Here, we innovatively bridge two disciplines—ergonomics and applied ethology—to achieve an in-depth observational understanding of real husbandry practice (by farmers, inseminators, vets) at work. Ergonomics aims to gain a detailed understanding of human activity in its physical, sensitive and cognitive dimensions in relation to a task. It also aims to transform work situations through a systemic approach drawing on multiple levers for change. Here, we examine how this analysis holds up to the inclusion of animals as an integral component of the livestock farmer’s work situation. Applied ethology studies behaviours in animals managed by humans. It aims to understand how these animals perceive their environment, including how they construct their relationship with the livestock farmer. This paper proposes an original conception of the human–animal relationship in animal husbandry that employs core structural concepts from both disciplines. From an ergonomic point of view, we address the human–animal relations by examining the relationship between ‘prescribed’ and real work practices, between work and personal life situation, between professional task and human activity. On the applied ethology side of the equation, the human–animal relationship is a process built through communication and regular interactions between two ‘partners’ who know each other. The goal is to understand how each partner perceives the other according to their multimodal sensory world and their cognitive and emotional capacities, and to predict the outcome of future interactions. We cross-analyse these scientific views to show, based on examples, how and in what way they can intersect to bring better analysis of these human–animal relationships. We reflect on common working hypotheses and situated observational approaches based on indicators (behaviour and animal and human welfare/health). This analysis prompts us to clarify what human–animal relational practice means in animal husbandry work, i.e. a strategy employed by the livestock farmer to work safely and efficiently in a healthy environment, where the animal is treated as a partner in the relationship. In this perspective, the challenge is for the livestock farmer’s activity to co-build a positive relationship and avoid being subject to this one.

© 2021 The Authors. Published by Elsevier B.V. on behalf of The Animal Consortium. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Implications

Investigations in both ergonomics and ethology address the human–animal relationships as real work practices that channel the livestock farmer’s strategy for safe and efficient work in a healthy environment, where livestock is considered a partner in

the relationship. The ergonomics–applied ethology interaction considers actionable ways to globally improve the livestock farmer’s work-life balance and improve animal welfare. It examines possibilities for adaptation and regulation, enabling both worker and animal to build a positive relationship instead of enduring it.

Introduction

Livestock farming as a profession is undergoing unprecedented change, as citizens, NGOs, and media across the world are increas-

* Corresponding author.

E-mail addresses: joffrey.beaujouan@uca.fr (J. Beaujouan), damiencromer@uca.fr (D. Cromer), xavier.boivin@inrae.fr (X. Boivin).

ingly challenging the (long-held) legitimacy of producing meat from animals (In the present article, the term “animal” will always be used to describe a “non-human animal”) that are widely held to be sentient beings. Livestock farmers are being challenged not only on their societal, health and environmental responsibility but also on their competence to rear their animals properly following internationally recognised animal welfare standards (Leone, 2020).

This competence is under further challenge from progress in advanced technologies that mechanise husbandry tasks and monitor each animal’s diet, reproductive cycle, health, and welfare (Hostiou et al., 2017). These technologies are being developed as tools to facilitate the livestock farmer’s work, especially on arduous or routine farm tasks. For these authors, they also herald a transformation of human–livestock relations and human–animal interactions, by physically distancing the human livestock farmer from their animals. However, this visibly dehumanised vision of livestock farming, against a background of increasing herd sizes, does raise ethical and role-identity questions for the livestock farmer, as well as more pragmatic and organisational questions surrounding the changing nature of their profession. Questions are also raised on the constraints these technologies bring and the competencies needed, thus asking the livestock farmer to think about who he (We use « he » in convention to lighten the text. He refers to male and female) is, what he aspires to be, what he can and cannot do—and essentially asking him to stop and question their subjectivity with regard to his work (Clot, 2015).

Livestock farming practice, by definition, involves managing the animal. Ethically and biologically, animals are both legally and morally recognised as sentient beings (Leone, 2020). To our knowledge, the terms “sentient beings” are not defined in legislation such as in the European Lisbon treaty (Lisbon treaty, 2009). Scientific studies had more and more investigated animals as sentient beings not only for understanding and alleviate suffering and other negative feelings but also consider their positive emotions (Boissy et al., 2007; Mounier et al., 2008; Rault et al., 2020). This recognition has a potentially huge spectrum of consequences. It brings a paradigm shift away from simply protecting animals against acts of cruelty, neglect, and mistreatment and—for a number of stakeholders—towards giving consideration to animal welfare and a life worth living (Mormède et al., 2018, Mellor and Beausoleil 2019).

In this human–animal equation, the construct of animal welfare mirrors a cognate construct of human welfare, i.e. the livestock farmer’s welfare at work. Borrowing on the ‘One Health’ (Zinsstag et al., 2015) paradigm where human health is wholly interdependent on animal health, there is an emerging ‘One Welfare’ paradigm that sees human welfare and animal welfare as interdependent and bound to the state of the ecosystems in which they exist (Pinillos, 2018). The systemic conceptualisation of livestock farming and welfare through the angle of human–animal relations and livestock farmer–animal relational practice could bridge two disciplines—applied ethology and ergonomics—that have so far been largely divorced. Applied ethology has produced many published studies during the last forty years and many recent reviews of the existing literature on human–animal relationship (Waiblinger, 2017; Hemsworth et al., 2018; Mellor and Beausoleil 2019; Munoz et al., 2019; Rault et al., 2020; Jardat and Lansade, 2021). To our knowledge, this is less the case in ergonomics for academic work specifically interested in human–animal relationship. This explains why we have extended to academic work in the field of human and social sciences while questioning them (Hemsworth and Coleman, 2011, Hemsworth et al., 2018; Porcher, 2019; Porcher and Estebanez, 2019; Pol et al., 2021). This, by focusing on academic work from an ergonomics approach to the activity addressing the issue of the relationship in work with others (Cerf and Falzon, 2005). They address stockmanship in an effort to understand and improve relations between

the two. However, in order to become comprehensively systemic and answer the questions raised by learning relational practices and their consequences, both disciplines need to simultaneously factor in both animal and human determinants. How can ethological work and conceptions on farmed livestock influence ergonomics conceptions of stockmanship? Conversely, how can ergonomic concepts of stockmanship influence ethological work?

For readers that are unfamiliar with these two disciplines or only familiar with one of them, we shortly describe the academic background of these two disciplines, based on what we consider to be key conceptual papers, recently published reviews as the number of references is limited, or recent research papers. Then, we propose a novel conceptualisation of human–animal relations in stockmanship by studying relational practices framed in concepts borrowed from the two disciplines. Based on the extant literature in applied ethology and ergonomics, we use stockmanship and enactive interface to investigate the factors that lead livestock farmers to adopt positive or negative relational practices with their animals. As with any attempt to build interdisciplinary bridges, we will think through the epistemological stances that we need to put to work to iron out any interdisciplinary frictions.

Ergonomics and the human-animal relationship at work

Core concepts in ergonomics

Ergonomics—from the Greek *ergon* (‘work’) and *nomos* (law)—is the study of work, work factors and work-enabling environments to improve occupational health and organisational productivity (Falzon, 2005). Ergonomics as a field has historically been structured around two main schools of thought: human factor ergonomics, and activity-factor ergonomics. The lines of theory underlying these two schools are not incompatible but they do not perfectly overlap (Daniellou and Rabardel, 2005).

Broadly speaking, human factor ergonomics (HFE), which is the dominant Anglosphere model, produces and uses knowledge from disciplines that intersect with how the human body works and thinks (Bentley et al., 2021). HFE considers the capacities and limits of people to inform task-generic and generalisable standard-practice handbooks (Karwowski, 2005) or guidelines for integration into design processes. Activity-centred ergonomics (ACE) focuses more on understanding situated interactions in human activity and how situated action develops in occupational work settings (Dul et al., 2012; Wilson, 2014). Activity-oriented approach to ergonomics has historically been developed in franco sphere countries but has now gained a much wider global footprint. This situated frame of ergonomics task analysis focuses on what workers are asked to do and what it asks of them. This juncture hallmarks the historic and structurally decisive split between ‘prescribed work’ and ‘real work’, which Leplat conceptualised as ‘prescribed task’ and ‘real task’ (Leplat, 1990). Prescribed task refers to the objectives that workers need to achieve in a defined set of conditions (human, temporal, organisational, technical resources, etc.), and the activity here is the human body functions—in the broadest sense, such as motor function, multisensory integration, etc.—mobilised by the worker as they execute the task. From this perspective, any and all work—and livestock farmer is no exception (Cerf and Sagory, 2004)—will mobilise the worker’s physical, cognitive and emotional faculties. All need to be captured at the intersection of multiple prescriptions (in terms of quality, productivity, human–animal relationship, etc.). More specifically, the activity is finalised, oriented by a single goal that is specific to a given individual in a given setting (Daniellou and Rabardel, 2005).

Here, we adopt the activity-centred ergonomics thought. Analysis of the activity in action is a vital part of ergonomics methodology of working on the twin outcomes of worker welfare/health and organi-

sational performance—including here our focus on animal welfare/health. With this vision, ACE postulates health as something we can build rather than something that declines (Canguilhem, 2012). Health is linked to workers being able to act in problematic situations, to create and to be the author of his work. Therefore, the efficiency of the activity and health are interrelated: “there can be no well-being [at work] without doing one’s work well” (Clot, 2015).

Human-animal relationship, work and ergonomics

This paper approaches the human–animal relationship in livestock farming as an ergonomics problem through the focus of work in multifactorial contexts. We envisage it as an “interaction” between a subject (the livestock farmer) and his subjectivity (his characteristics, his history) and a set of determinants (material means, temporal constraints, self-prescription, colleagues, and—more specifically here—farmed animals) that he will have to “deal with” in a dynamic context (Coutarel et al., 2005). From this angle, studying the human–animal relationship in stockmanship practice means adopting a systemic–subjective approach that captures the constraints and resources that come with and through the work. The animal is considered not just as a resource or productive outcome but as a facilitative or constraint feature of the work through its behaviour. Here, we read the animal as a major determinant of the livestock farmer’s work.

‘Well-doing’ work with an animal means thinking about the position of the animal *in situ*: “The animal is there before me, there next to me, there in front of me—me behind it. Which also means, as it’s before me, that it is following me. It is all around me.” (Derrida, 2006). The animal is the livestock farmer’s ‘object of work’ (Object, here, is to be read in its psychological meaning (the focus of the work) and not in its mundane material sense (as some kind of thing)), the focus of the livestock farmer’s activity. The animal is also the ‘means’ of the livestock farmer’s work, in that it can potentially help to get the work done, as trimming a cow’s hooves in a trimming crate would be easier with the cow’s cooperation to squeeze into the crate. This prompts a closer look at the work analysis models identified elsewhere (Porcher, 2019) to establish a dialogue between the science of work and ethology, in a context marked by suffering that communicates and spreads from livestock farmer to his animals and vice versa.

Academic research in the field of occupational risk prevention (Coleman et al., 1998; Hemsworth and Coleman, 2011; Hemsworth et al., 2018; Lindahl et al., 2013; Fortune and Dassé, 2014; Grandin, 2014; Lindahl et al., 2015; Lindahl et al., 2016) has already led inquiry into the role of the human–animal relationship as a driver of health, safety and welfare for both livestock farmer and livestock. These works focused on factors such as job pressures, time spent in contact with animals during higher risk handling operations, training on handling of animals and their reactions, and the design of restraining devices. On the ergonomics side of the equation, there have been attempts to integrate the animal as a factor in understanding and engineering work. Despite the fact that little work has been done (Abadia and Mirabito, 2003), the issue is still relevant (Cromer and Beaujouan, 2019). There is ergonomics scholarship in other sectors, such as nursing, that has looked at the role and place of others in patient relationship management activities. Taken as a benchmark, this scholarship brings wider perspective to our concept of the human–animal relationship at work and its analytical focus cued by this conception. Literature to date on this issue has historically used four approaches (Falzon and Lapeyrière, 1998; Petit, 2005).

The first approach considers the ‘other’ as absent from the ergonomic analysis of the work, making the worker its central focus without considering the specificities of the ‘other’. In nursing for example, this would mean that the focus of analysis and intervention does not

integrate consideration of the patient by hospital staff. The underlying hypothesis is that changes made to benefit the worker would necessarily benefit the other (patients). Here, we could draw a parallel with measures that would improve work for the human livestock farmer but have uncertain knock-on effects on the animal. Studying the best place to install a hoof trimming crush to make it easier for the livestock farmer to get inside while keeping their hoof trimming hand-tools within reach would essentially fit this central premise without considering the animal’s universe.

The second approach integrates the ‘other’ through its defining properties and as one among a number of other determinants of the worker’s activity. Again, in nursing, the example would be the patient’s journey and integrating that journey into waiting-room design. This approach would be a step towards better integration of the animal’s physical and perceptual characteristics into the design of more animal-appropriate farm equipment, for example, as addressing dazzle factors or even floor slope to make it easier for the cow to move and thus move into the restrainer (Grandin, 2014).

The third approach considers the ‘other’ as the ‘object of work’ on which the worker aims to produce an effect, for example, the distinction made between cure (application of a treatment applied by the medical community) and care (provision of care by health professionals to the patient in order to optimise the conditions for successful treatment). If we project back to the presence of an animal in this work, the analytical focus would cue an analysis of the worker’s activity in connection with what they are trying to do with the animal by acting for and with them, including consideration of a situation that may be anxiety-inducing for the animal, for instance, analysing the strategies developed by the livestock farmer to habituate and then reward heifers for entering and then staying calm in the hoof trimming crush, but without actually trimming their hooves, which the animal may experience negatively, and to facilitate their entry into the crush at future dates.

The fourth approach considers the ‘other’ in the analysis as partner and agent in the situation (Cerf and Falzon, 2005). In nursing, this is the case when, for example, an elderly person cooperatively helps their care nurse gives them a bed bath, or when the patient participates in a diagnostic procedure in hospital with the doctor (co-diagnosis) by playing an active role (and not just simply answering the doctor’s questions) in the medical interview on admission. Again, projecting to the presence of an animal at work, this approach would advocate a joint analysis of the worker’s motivations and goals in performing their task and of the perception of the animal’s life objectives in the same situation. Here, the animal is considered as an active ‘partner’ or entity in this situation, with a crucial role to play in achieving the worker’s goals, and also with impacts on its own welfare.

Pursuing these working hypotheses for ergonomics hinges on gaining a better understanding of the farm animal, its characteristics, its perception of the world. And gaining a conception of the animal’s relationship with the livestock farmer, how—from the animal’s perspective—the relationship is forged and grows. In this sense, the way forward is clearly through applied ethology as the science of the behaviour of animals that are under some form of human management. How can we integratively rethink both sides of this human–animal relationship equation, i.e. livestock farmer to animal and animal to livestock farmer?

Applied ethology and the human-animal relationship at work

What is ethology and how its conceptual framework is changing our perception of non-human animal behaviour?

Like ergonomics, ethology is a systemic science. Ethology studies animal behaviour (including human behaviour) as well as its

physiological, psychological and environmental drivers (Breed and Moore, 2015). Behaviour can be defined as “the coordinated responses of the whole living organisms to internal and external stimuli” (Dugatkin, 2020). Research in ethology often refers to a conceptual epistemological framework known as the “Four Whys of Tinbergen”: (1) what are its proximal causes (immediate motivations); (2) what is its ontogenesis, i.e. how does it grow during animal life, particularly through experience and during sensitive periods; (3) what is its survival and reproduction value?; (4) what is its phylogenesis, i.e. genetic and evolutionary drivers (Breed and Moore, 2015; Dugatkin, 2020). For a long time, the main streams of ethology (behaviourism, objective ethology, behavioural ecology) largely ignored non-human-animal cognitive abilities and affective states. However, at the end of the 19th century, ethology started to discuss the phenomenological concept of Umwelt, developed by von Uexküll leading to another important branch of science named “cognitive ethology”, which was popularised by Griffin (Ristau and Marler, 2014). Umwelt for each individual is defined as its own perception of their world (an own private world) produced by their sensory, emotional and cognitive capacities and their way of interacting with it (Ristau and Marler, 2014). Such a world is built from animate and inanimate objects in the environment that can become meaningful to the individual, particularly during sensory periods of development or through learning processes. There is now a large body of literature on emotional and cognitive processes in non-human animals, with more and more studies to understand communication and the development of human-animal relationship (Le Neindre et al., 2017). Integrating these different perspectives, applied ethologists involved in the behavioural study of animals managed by humans are strongly engaged in the science of animal welfare (Nawroth et al., 2019). The Organisation for Animal Health (OIE) in their definition of animal considers “how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well-nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress” (©OIE – Terrestrial Animal Health Code, 2016). However, animal welfare definition has changed over time. The “coping” acceptance of D. Broom is based on adaptive cost for the animal regarding the breeding situation (Broom, 1986). More recent considerations relate animal welfare to positive affective states (Mellor and Beausoleil 2019). So, animal welfare can be described as a positive mental and physical state that is tied to the animal’s physiological and behavioural needs (Mormède et al., 2018). This state varies with the animal’s perception of its situation. These authors defined animal expectations as a mental state induced by the anticipation of a particular event the animal will refer to for evaluating its valence from positive to negative. Expectation will produce anticipatory behaviours that can be recorded such as searching behaviour and calls, physiological responses (and possibly frustration or redirection behaviour towards surrounding objects if not fulfilled (Greiveldinger et al., 2011)). Applied ethologists use the latest concepts and methods in behavioural science to understand how animals perceive their environment, including how they construct their relationship with humans and how human-animal relationship impacts animal welfare.

Do domesticated animals communicate with us, and how?

Individuals living in the same environment are regularly exposed to each other and will capture or exchange information through relatively specialised communication systems. This is a crucial fact to consider when the individuals belong to different species with different Umwelts, such as humans and non-human animals, and when anthropomorphic or maybe zoomorphic mech-

anisms occur (Grandgeorge and Boivin, 2019). These authors applied Tavolga’s concept of information to describe human-animal interactions, communications and relationships. On a first level, individuals can capture clues from the others (traces of activity, aspects, sounds, odours or behaviours) that are involuntarily transmitted. Each partner in the relationship can usefully associate these clues with reward or punishment for their interaction through associative learning processes (Hemsworth and Coleman, 2011), and use this learning in future interactions. According to Tavolga, this useful information is different from a signal which is specifically generated for communication purposes. In this sense, communication implies an emitter and a receptor sharing the coded information, i.e. the signal. With the same Umwelt within the same species, such multimodal communication can prove quite functional and highly specialised through evolutionary mechanisms developed over millions of years. Ontogenesis, i.e. experience, plays also an important role for intra- and inter-species communication.

All domestic species are social animals, possessing strong socio-cognitive abilities and communication systems. Domestic animals also have a good memory and can often discriminate among several conspecifics as well as among human partners using different cues (Nawroth et al., 2019). The recent review by Nawroth et al. (2019) highlighted that some animals are able to use very subtle behavioural cues of conspecifics and humans, such as head orientation or pointing gestures, probably in relation to their experience of humans. Domestic animals share with us a part of their sensorial spectrum, and over the course of millennia, the domestication process has probably helped to strengthen our mutual understanding (Kaminski and Nitzschner, 2013). For example, dogs are much better than wolves or chimps at following human gaze and human pointing (Hare et al., 2002). Pointing with an arm and finger has been tested in different domestic species such as goats, pigs or horses with variable results and dogs appear to perform best (Jardat and Lansade, 2021). However, for the present authors, the scientific knowledge of these species remains limited and needs to be much further explored with respect to their underlying determinants (species abilities or rearing conditions). In particular, domestic animals have strong sensory, communicative and cognitive differences among individuals and compared with humans. They were found to differentially perceive auditory frequencies, olfactory stimuli or intensity of lightening, which can create difficulties for handling (Grandin, 2014). Jardat and Lansade (2021) highlight that we need to be very careful in our human interpretation of animal communication towards us as we still have insufficient knowledge of their communication, in particular, our inability to perceive it correctly through our human senses.

The concept of inter-individual relationship in ethology

In ethology, an inter-individual relationship is built from regular interactions and communication processes and between two “partners” who know each other: interactions between two or more individuals are basic events in their relationships (Grandgeorge and Boivin, 2019). They are bounded in time and imply one or more actions in a behavioural sequence. An individual acting towards another, which may or may not respond (an absence of response can also sometimes be a behavioural response). Such interactions can be multimodal (tactile, vocal, olfactory) and are describable through their content, their valence (rewarding, neutral and punishing) and their frequency. So, using these descriptors, an inter-individual relationship is objectively accessible to an external observer. However, the development of cognitive approaches has prompted scientists to examine the perception of each partner by the other (Le Neindre et al., 2017). This conception of the relationship allows an external observer, but also

each partner according to their multimodal sensory world and cognitive and emotional capacities, to predict the outcome of future interactions. Depending on individual capacities, agonistic or affiliative behaviours generate emotions and memories that can be remobilised in subsequent interactions between the same individuals. This same conceptual framework of the relationship can be applied to human–animal interactions and relationships (Boivin et al., 2003).

What behavioural mechanisms are involved in the development of the human–animal relationship?

For many years, applied ethology has studied the development of the human–animal relationship based on simple habituation mechanisms such as associative learning to more affective learning involving attachment mechanisms (Rault et al., 2020). Two individuals regularly exposed to each other without any consequences will develop habituation, defined as each interaction having no effect for each of them. Taming can be assimilated with this habituation process when, in its strictest sense, it means action to reduce the flight distance of an individual (Price and Tennesen, 1981). It is important to understand that all individuals have a flight zone around them, defined as a surrounding area within which intrusion provokes a flight or sometimes fight response (Grandin, 2014). However, it is rare for a human–animal interaction to not have either a positive or a negative consequence for each partner. Many experiments in several species demonstrate that associative learning plays out and reinforces animal approach when there is a reward (stroking, feeding...) or flight reactions when there is aversive contact (hitting, shouting, excitable movements, painful procedures) (Munoz et al., 2019). Negative interactions, particularly when they are unpredictable, fuel chronic stress and fearful reactions towards humans, and can also affect production, reproduction, and state of health (Fernandes et al., 2021). Conversely, food, petting or even simply human presence have been shown to be beneficial in many species, not only on an animals' approach responses to humans but also on relaxation states (e.g., decreased heart rate or oxytocin release at least in lambs (Coulon et al., 2015, Guesdon et al., 2016) or in dogs (Kis et al., 2017). Animals also show anticipatory behaviour prior to human contact (Grandgeorge and Boivin, 2019). The effect of such contact can be particularly dependent on the period in which it occurs (early age, at forced weaning) or on the social context (presence or not of the mother; (Nowak and Boivin, 2015)). Young animals without their mother or with a tame mother will have much more chance of developing a positive relationship with humans than animals with a fearful or protective mother (Henry et al., 2005; Boivin et al., 2009).

It can be surprising to refer to the attachment concept for farm animal–farmer relationships rather than an affiliative relationship or bond as the attachment concept was originally developed for the mother–child bond (Carter et al., 2015). However, firstly, attachment clearly highlights the emotional dimension of such relationships that are accessible through behavioural and physiological indicators and is not only used in the context of child–mother relationships. Secondly, many farm animals are cared for by humans from an early age in absence of their mother. During these periods, and in agreement with attachment theory (Carter et al., 2015), the human could be seen as an attachment object, possibly serving as a reassuring touchpoint for the animal. This has been observed particularly with young animals reared in absence of their mother that can be distressed in social isolation in an unfamiliar environment and appeased by a human presence, and even more if it is in presence/absence of their familiar caretaker (Nowak and Boivin, 2015).

Finally, it is important to note that several studies on different species such as *Canidae* and ungulates find individual variability among animals, based on genetic predispositions (Belyaev et al., 1985; Haskell et al., 2014). Here, we conclude that such predispositions can affect not only temperament traits, i.e. general amenability to being approached or restrained, but also the animals' ability to build a relationship (from which point/age in their life, for how long the sensitive period lasts, and so on). This means that genetic selection or choice of breedstock within a farm is almost certainly a strong lever for improving livestock responses to humans (Haskell et al., 2014; Destrez et al., 2018a).

Whatever the mechanisms involved, Rault et al. (2020) or Mellor et al. (2020) recently reviewed several studies in ethology demonstrating or suggesting that positive human–domestic animal relationships provide many advantages for animal welfare, for example in social isolation, positive affective states through tactile or food rewards, as well as benefits to their role for humans, helping for example acceptance of handling or veterinary procedures. Nevertheless, Rault et al. (2020) remind us that if fearful animals are singled out for their risk of injury to humans or themselves, large or unfearful animals might be at risk of being sometimes difficult or dangerous to handle, especially in the case of inappropriate or negative behaviour of the human.

The ergonomics–applied ethology interaction: a valuable epistemological framework to foster the development of human–animal relational practice in stockmanship?

A conceptual framework using stockmanship as enactive interface

Our two perspectives (§1 and §2) share different points of entry—the human at work vs. the animal on a farm—but it could be instructive to see where they meet. Bridging these two disciplines carries potentially instructive value in terms of efficient and healthful farm-work for the livestock farmer and the welfare of their livestock. The frontier where they meet can thus be considered as the possibility (or not) for the worker to develop, *in situ*, relational practices with the animal that will be pro-welfare and pro-work-efficiency for both.

We thus understand the term 'practice' here as a sociocultural construct. Culture refers to a set of opportunities for experience (a "field of promoted action") (Reed and Bril, 1996) within a community of practice (Lave and Wenger, 1991). Practice does carry the idea of being applied but does not immediately refer to the 'doing' and 'actions' but more to the procedures involved. Practice is thus the complex construct of a rule-set for action (on technical, moral or religious grounds) and exercising or implementing that action (Beillerot, 2011). There are two facets to practise: on one side are actions, conduct, routines, languages, and on the other are rules and prescriptions with their goals, their strategies, and their philosophies (*ibid.*). Specifying what we mean by human–animal relational practice in stockmanship means considering practices aimed at improving handling -without being limited- (for easier, safer and more efficient work, which equates to greater job satisfaction) and animal welfare (less stress for the animal, enrichment, positive emotion) (Boivin et al., 2012; Rault et al., 2020). Built on a solid foundation of extant applied ethology scholarship, these 'relational' practices include the selection of breedstock for easier-handling progeny, exploiting receptive periods (young age, weaning, and so on), optimal reinforcement of positive interactions, etc. (Boivin et al., 2012). These strategy choices span the animal's whole life. It can be grounded in the very latest ethological science on animal behaviour in the presence of human caretakers such as the understanding of genetic predispositions of farm animals for tameness and its correlates (Agnavall et al., 2018), how

and when providing positive human-animal interactions (Rault et al., 2020), or how to communicate with animals (Jardat and Lansade, 2021).

Seen from this perspective, the practice is a proposed conduct on offer to the worker, who may or may not elect to adopt it. The livestock farmer will enact this practice in his own way, as just one of many other determinants of the work situation. One of the big questions in ergonomics resides in the way different people and/or communities enact and embody practices that they see as sociocultural norms in their work conduct and in multiple different contexts. Scientific knowledge of animal behaviour, which serves to vector 'ideal stockmanship practices', runs into the livestock farmer's in-practice activity that ergonomics seeks to apprehend:

- Integrative, in that it is constructed in response to a large number of determinants that need to be read and understood, including, but not limited to, prescribed tasks (Daniellou and Rabardel, 2005). What plays out in the livestock farmer's work cannot be reduced to human-animal relational practices alone. The work is complex and involves internalising other rationales (economic, social, organisational, regulatory, etc.) framing the livestock system.
- Intrinsic, even if it is grounded in what the agent actually does in the presence or absence of the animal, which is partly observable. It is about getting an 'inside story' of the rationalities that drive the regulations implemented by people at work (Fiorelli et al., 2012). In other words, it is about reading not only what is actually executed but also the affective and cognitive processes of the agents as they carry out the task (Récopé et al., 2019).
- Differentiative, between what the agent says about the work done (voicing their representation of the activity) and what he practises in a situation effectively by and in his body (Beaujouan et al., 2015). Differentiative too between what the individual does and what he would have liked to do, considering actions that are suspended, thwarted, prevented, and counter-actions that poison or pollute the activity (Clot, 1999).

Behind the idea of the possibility (or not) for the human to develop, *in situ*, relational practices with the animal that will be pro-welfare and pro-work-efficiency for both, there is the challenge of co-apprehending the livestock farmer's activity and the animal's behaviour from a cross-community perspective. For the livestock farmer, his perception of the animal and the work, his work organisation and routines, like the organisation and routines and views of his colleagues, will all have an impact on his behaviour and conduct. Therefore, it will have an impact on his relationship with the animal (among many recent studies, in beef cattle, (Destrez et al., 2018a; Ceballos et al., 2018) or in pigs (Pol et al., 2021). For the animal, the conduct and activity of the livestock farmer and any person working in contact with it affect its perception of humans in general and the livestock farmer in particular (Destrez et al., 2018b; Napolitano et al., 2019). This perception, just as with humans, depends on a number of factors specific to each individual (emotional-cognitive capacities, temperament, physiological state, etc.). It also depends on physical and social environmental factors and, crucially, on factors tied to the processes and mechanisms of action at work in human-animal interactions (attachment, familiarisation, positive or negative reinforcement, habituation to presence and contact, and so on) (*ibid.*). Some psychology research has shown that human factors play a huge role in animals' responses to humans and animal productivity performances. In their review compiling a large number of studies, (Waiblinger et al., 2006) conclude that the relative balance between 'positive' and 'negative' contacts and the associated emotions determines the quality of the human-animal relationship. A

relationship in which human presence and handling are not aversive for the animal can even prove a source of enrichment or appeasement for the animal as well as a source of job satisfaction and security for the livestock farmer. This area of research warrants far more investigation to understand the underlying processes involved (Rault et al., 2020). Seminal work (Hemsworth and Coleman, 2011; Hemsworth et al., 2018) shows that the livestock farmer's behavioural habits are heavily dependent on the representations he holds about the effect of his actions on the animals' behaviour. From several studies, we have demonstrated that animals' behavioural responses will, in return, reinforce these representations in a virtuous circle when the relationship improves or, conversely, a vicious circle when the relationship deteriorates. The more an animal is exposed to aversive and/or unpredictable handling, the more fearful it will become, thus forcing the handler to work harder to get what they want. In turn, this will have the knock-on effect of iteratively reinforcing his representations on the behaviour to adopt with that animal. These mechanisms were conceptualised in the human-animal relationship Model based on the Theory of Planned Behaviour (Hemsworth and Coleman, 2011; Hemsworth et al., 2018) that established that livestock farmer behaviour is likely to be determined by:

- (1) attitudes towards the behaviour, which refers to a person's beliefs of the outcome (favourable or unfavourable) of a specific behaviour,
- (2) subjective norms, which refers to a person's beliefs about other people expectations (e.g., parents, spouse, friends) or social pressures to perform a specific behaviour,
- (3) perceived behavioural control, which refers to a person's beliefs about the control they have (ease or difficulty) of performing a specific behaviour,
- (4) technical skills and knowledge.

Various training programmes for livestock farmers, in pigs (Coleman et al., 2000; Hemsworth et al., 1994) and for other species (Hemsworth et al., 2002; Ceballos et al., 2018), have been developed from this model to improve human-animal relationship and its consequences on humans and animals.

Below is a standard model of work analysis (Leplat and Cuny, 1977; Leplat, 2006) that we have adapted and enriched in order to jointly capture the animal's behaviour and the livestock farmer's activity beyond his behaviour (Fig. 1). Capturing this activity is a complex task. The livestock farmer is constantly required to manage a number of unknowns (unpredictable weather events affecting forage resources, disease onset, injuries, calving difficulties, equipment breakdowns, and the list goes on) and inter-animal variabilities (genetic potential of breeding stock, animal performances, traits such as temperature, flightiness, and ease of handling) for which they do not always have ready-made solutions. This model considers that beyond simply adapting as and when events arise, the livestock farmer actually has an active role in what happens to Him. For example, he constantly adjusts between the tasks to be done and the resources available, the goals he sets, all under a determinate set of conditions shaped by the outcomes and effects of his activity on himself, the animal, and the work environment. This model formalises a specific approach to studying and developing human-animal relational practices in livestock farming via stockmanship activity as an enactive interface. The numbers characterising the relationship between the elements of the model are illustrated below from a case study.

The livestock farmers' activity is understood from this perspective in a systemic [1] and dynamic [2] way. Let us stop to look closer at these two dimensions.

The systemic dimension of this model considers the link between the multiple determinants of the livestock farmer's activ-

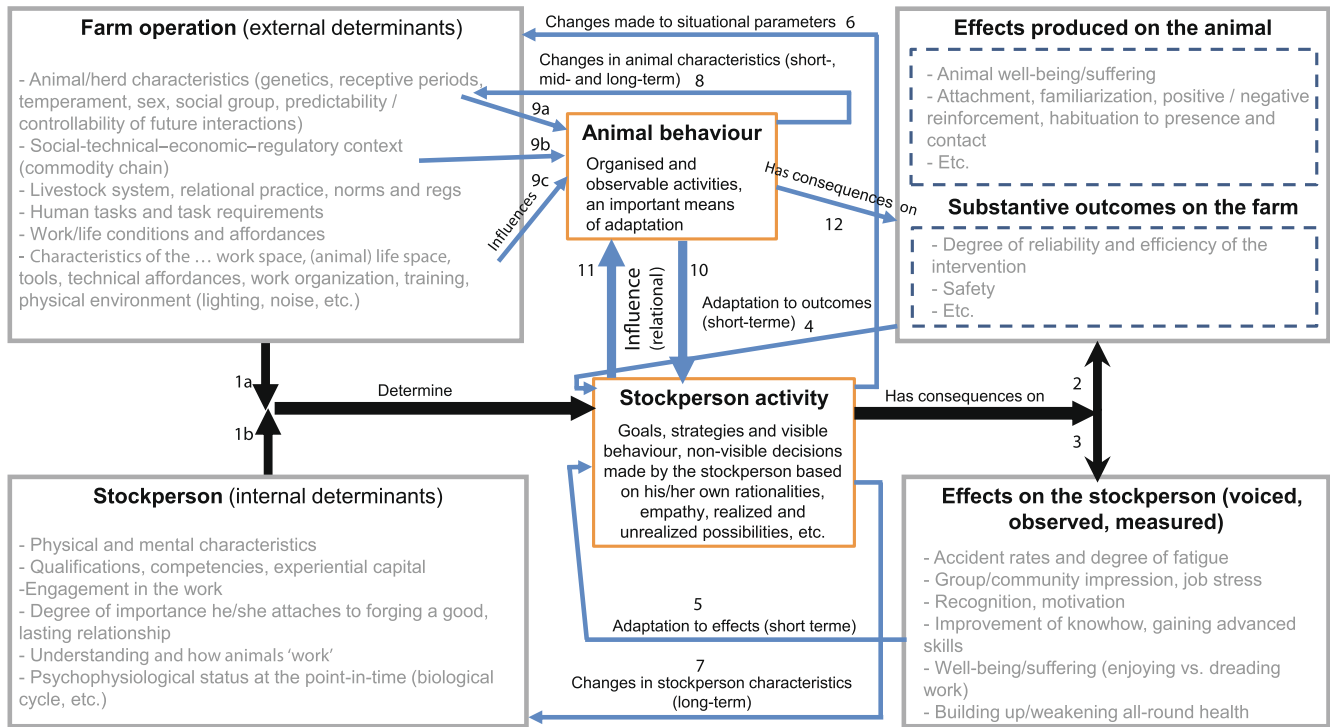


Fig. 1. Dynamic model of the dual regulation of work activity (Leplat and Cuny, 1977; Leplat, 2006) adapted for the study of human–animal relations in livestock farming.

ity (in particular those that—in situation—take precedence) and their relationship (**arrow No.1a coupled with No.1b**) with this situated activity (strategies, goals, impediments, arbitrations made by the livestock farmer, etc.) and its consequences (**arrows No.2 and No.3**).

Note here that the determinants of the activity can be external to the individual at the macro-level (e.g. the breeding system adopted) and at micro-level (e.g. the characteristics of the tools at hand, the animal and the herd). It can be also internal to the livestock farmer (e.g. the degree of importance he attaches to forging a positive relationship with the animal, his experiential capital, their level of general fatigue, etc.). The animal's behaviour takes on special status here, as both a *determinant of (arrow No.10)* and *determined by (arrow No.11)* the livestock farmer's activity.

Note here too that the consequences of the activity take three inseparable yet simultaneous directions: actual outcomes on the farm (work performance), effects on the livestock farmer, and effects on the animal beyond production factor. Simultaneously does not, however, mean that these consequences are expressed in the same way for human and animal—neither in their valency (positive or negative) nor through their underlying processes (inherent or distinct). This intersubjectivity is problematic here (Jerolmack, 2009; Porcher and Estebanez, 2019) as it challenges the symmetrical understanding of the human–animal interactions and the conditions and reality of shared welfare between livestock farmer and farm animal. Here, we mobilise ergonomics, a science of human work, and applied ethology, a science of animal behaviour, in an effort to advance this issue.

The dynamic dimension of this model surfaces the dynamic and evolutionary nature of the livestock farmer's activity, its determinants and its outcomes. *Determinant of and determined by* the activity is a frame that highlights how the transformative nature of the features of the system through different regulations. We distinguish two intermeshed plans to study these regulations/transformations: their temporality (short-term, mid-term, long-term), and their focal object. There are task-oriented regulations—which sometimes involve the animal—and worker-oriented regulations.

- Short-term adaptation of the livestock farmer's activity to the effects of his activity on himself (**arrow No.5**);
- Short-term adaptation of the livestock farmer's activity in response to the outcomes of his activity for the farm (**arrow No.4a**);
- Short-term adaptation of the livestock farmer's activity to the effects of his activity on the animal (**arrow No.4b**);
- Mid-to-long-term activity-mediated change in livestock farmer factors (**arrow No.7**);
- Mid-to-long-term livestock farmer-led adjustment of work situation parameters (**arrow No.6**);

This modelling frame firmly anchors the need to understand and intertwine the farm animal's perspective and the livestock farmer's perspective, as each influences the other through the activity (**arrow No.10 and arrow No.11**). Applied ethology once again brings crucial insights from two complementary directions, on one hand, by proposing a better understanding of the animal's behaviour (how it is forged and grows, how its self-coherence is organised) articulated with (and influenced by) the livestock farmer's activity framed in a specific work/life environment tied to a particular livestock management system (**arrows No.9abc and arrow No.11**), on the second hand, by proposing a sharper objectivisation of the short- and mid-term consequences of human-animal interaction. This, in terms of the predictability/controllability of the human–animal interaction mediated by the animal, the animal's welfare/suffering (**arrow No.12**) and the longer-term consequences on habituation, attachment and familiarisation, which reflect modifications of these features in the ontogeny of the animal (**arrow No.8**). By focusing on animal behaviour and looking to accommodate this animal-centred perspective as much as possible, this approach can beneficially operate a critical distance enabling the human agents to reframe their own perception of the situation setting and their goals. The animal factor is crucial to the success of livestock systems. Internalising animal welfare as both an ethical and a legal responsibility requires us to step back and reframe this issue in order to ask the right questions and make progress. Applied ethology brings not only scientific knowledge

and concepts but also a set of observational tools that complement those offered through livestock management practices (production performance), veterinary medicine (animal health) and ergonomics as defined and mobilised here.

The work analysis model described is complementary to the HAR Model proposed by [Hemsworth and Coleman \(2011\)](#) and [Hemsworth et al. \(2018\)](#):

- (1) The focal length is not limited to behaviour (what is done or not done in a situation). The activity prevented, the trade-offs made by the livestock farmer in situation are central to the analysis, even if he aspires to adopt positive behaviours towards the animals. For example, the livestock farmer taking over a farm inherits the choices made by their predecessor(s) which may restrict the time spent with their animals: including scattered parcels of land, feed preparation areas far away from the animals, barriers preventing easy access and movement of the livestock farmer “close” to the animals.
- (2) The determinants linked to the conditions of performance of the work are understood in a specific way, for example, spaces and work organisation that can keep the livestock farmer away from his animals or unsuitable tools slowing him down in carrying out his tasks and limiting the time he could spend with the animals. Ergonomics has developed concepts and methods to influence these design processes during investment projects ([Cayon et al., 2018](#)).
- (3) This model emphasises the processes that regulate the activity of the livestock farmer and the behaviour of animals (short-, medium- and long-term). The construction and evolution “over time” of the human-animal relationship are apprehended.

The illustrated account ([Fig. 2](#)) of a cattle-farm milking-task situation exemplifies some of these dynamics at work. These data used here were collected as part of a project to develop primary prevention programmes by integrating occupational health and safety issues into workplace design projects ([Cayon et al., 2018](#)).

It is 1950 hrs on a Thursday evening. Milking normally starts 20 minutes earlier.

George is behind schedule. He prepares the walk-way that takes the cows from their stall to the milking parlour. Some of the cows get up while others move around with no purposeful pattern (**arrow No.9**). George then activates the motorised scraper in the main alley, which was originally designed to scour the floor but which he has since fitted with a barrier that he uses as a “cattle race” to help drive the cows towards the milking parlour (**arrow No.1**). The cows do not balk at moving to the parlour, and they gather in the holding area that leads directly out to two badly lit milking alleys separated by a recessed central pit (**arrow No.9**). In this area, the livestock farmer has to clean and check the udders, fit the eight milk teats (four per lane), then start the milking cycle.

After each cycle, George struggles with the same issue, and tells us that he has grown used to what he identifies as a major problem in this building. The cows are reluctant to continue on downstream and exit the milking area to let the other cows follow in upstream, despite George urging them to do so by firmly raising his voice (**arrow No.10 and arrow No.11**). The cows “defecate” (**arrow No.12**), which means more cleaning work at the end of milking (**arrow No.9**). George is forced to go back to the upstream area at each new milking cycle, trying as best he can, with or without a stick, to get the cows to start moving in (**arrow No.4**). He tries to make his way through, trying to push them on as he goes, even if [he tells us] it does not always work (**arrow No.2**) and it wears him out at the end of the day (**arrow No.3**). He tells us that he would like it all to go more smoothly and has the feeling he is largely wasting his

time. This is confirmed from the outside (**arrow No.2**), not to mention the risk of slipping (**arrow No.3**) when systematically rushing backwards and forwards from the milking-parlour pit upstream to the pen area where the cows are packed together. His vision of events is that milking is far from efficient because his animals “make things difficult”. He has little contact with his cows during the day although he would like more. The circulation spaces on the farm and the installation of barriers greatly limit contact with the animals for feeding, mulching the stalls, managing the flow of straw and feed, observing animals closely, etc. (**arrow No.1a and No.1b**). He wonders if he could overcome these recurring bottlenecks by doing things a different way (**arrow No.4**), much as he had done by customising the scraper (**arrow No.6**) to make it easier for him to move the cows on.

Seen through this lens, the place of the animal in the livestock farmer’s activity clearly reaches beyond a simple ‘presence’, and this has several consequences. Addressing the livestock farmer’s activity without taking into account the (physical or symbolic) place of the animal limits the scope to understand and transform the work in order to engineer better health and efficiency at work. The relationship that the livestock farmer builds with the animal and vice versa is always mediated by the object of the livestock farmer’s work. In other words, this relationship will always be connected to the specific task in a specific context. From a temporal perspective, the features of the work that have settled and crystallised in the livestock farmer’s long experience capital may or may not find expression in his own uniquely configured activity. He always does his job with application and with the possibilities at his disposal, but also with the impossibilities he has run into and the scars it has left on both himself and the animal. We now turn to the ethological analysis that will focus on the cows’ perception of the situation and the roots of their behaviour. Are there differences between the animals (old and experienced cows, new cows bought in from outside or heifers that are inexperienced in the situation, or dominant, or that remain subordinate)? Why are the cows unmotivated to move on? Are there anxiety-generating features in the environment that can be removed (poor light, potentially painful or aversive (temperature, wind, etc.) corners to negotiate)? Can they be re-motivated by associative learning (typically food rewards), knowing that even after negative events, the animals can still be retrained to move forward down the race? Can young animals be trained in this environment well before the first milking sessions, or can naïve, fearful animals be mixed with experienced or more docile animals? There are many pathways to explore in the analysis and construction of the animals’ perception of the situation, and failure to do so affects not only the work and subsequent human-animal relations but also animal health and productivity ([Hemsworth and Boivin, 2011](#); [Grandin, 2014](#); [Rault et al., 2020](#)).

Human-animal relational practice, as advocated based on the latest animal behaviour science, therefore, offers both realised and unrealised possibilities for the stockmanship activity. This practice, like a historical-proven cultural proposal coming from the outside (an ‘artefact’), can under certain conditions become an ‘instrument’ in the psychological sense of the term ([Rabardel and Beguin, 2005](#); [Bonnemain et al., 2019](#)) (Here we flag an ambiguity in the use of this terminology. The instrument here references the human-animal relationship at work and is considered in its psychological sense, referring to the Vygotskian conception of activity in which the relationship between a human subject and an object (here, the animal) is never direct, always mediated), i.e. a tool internalised by the subject to mediate the effectiveness of the action. We hypothesise—at this early stage and bounded by conditions—that the human-animal relationship, as an instrument for mediating the livestock farmer’s action, would be a key factor in the efficiency and quality of livestock work and in the animal’s



Fig. 2. Human intervention in a milking parlour.

Table 1
Potential targets for shaping a positive human–animal relationship in stockmanship work.

Perspective	Potential targets	Strategic point(s) in time
Adapting the environment to human work and animal's needs	The choice of the adopted livestock system	Farm venture project (leasehold or new freehold venture)
	The characteristics of work and living spaces, tools, work organisation, adapted physical environments (lighting, etc.): (1) the requirements of the tasks to be carried out with the animals and with them without acting on them. (2) the needs of animals (perceptual, cognitive, and sensory worlds) from an early age or in handling situations.	Investment project (farm-building design and layout, automated systems, etc.) Initial and ongoing in-service training
	The development of the livestock farmer activity as a step to improving the effectiveness of relational practices implemented within a professional community The possibilities for genetic selection consistent with the livestock system and personal lifestyle planned by the livestock farmer.	Initial and ongoing in-service training Investment projects Farm venture projects
Shaping man and animal	Emergence of livestock farmer receptiveness to building a positive human–animal relationship as a key factor in health, safety, efficiency, and qualitative performance in work	Initial and ongoing in-service training Farm venture project Investment project
	The relational process in the ontogeny of the animal, aiming to foster a positive perception of people in contact with them	Farm venture project Initial and ongoing in-service training

welfare. However, this shift from artefact to instrument is not an ‘automatic’ transition. Indeed, the quality of the human–animal relationship is evaluated against how far the livestock farmer actively adopts a relational practice in his activity that promotes (or not) ‘positive’ contacts between himself and the animal. Here, care for the work almost certainly means working on providing conditions and affordances to improve the welfare of both animal and livestock farmer.

A framework for action to foster the development of human–animal relational practices

Our underlying hypothesis is that there are conditions framing the process of building a positive human–animal relationship in stockmanship work. Among the actionable ways to harness these conditions, we single out those aimed at adapting the environment to human work and animal's need, and those aimed at ‘shaping’ man and animal for a positive human–animal relationship. It has already been demonstrated that certain training actions on improving behaviours towards animals are effective (Hemsworth et al., 1994; Coleman et al., 2000; Hemsworth et al., 2002; Hemsworth and Coleman, 2011, Ceballos et al., 2018). Other targets to support a holistic approach may well be envisaged (Fortune and Dassé, 2014). The person-in-training does not systematically have the choice (possibility or impossibility not yet realised) in their activity to forge a positive relationship with their livestock animal in their ‘home’ structure. Having robust models for evaluating interventions aimed at changing the behaviour of the livestock farmer is not obvious and is a current need

(Glanville et al., 2020). These evaluations would make it possible to better identify obstacles to the livestock farmer's implementation of the practices encouraged in the context of training in the concrete conditions of carrying out work.

Table 1 below lists these different potential targets and the strategic points in time when they can be worked on.

These targets cannot be considered in isolation. For example, the choice of livestock system (beef or dairy) will partly shape choices for deciding how the animal's living environment and the livestock farmer's work are conceived. In a beef suckler farm, the handling of calves is an ideal window of opportunity for building a good relationship with humans (Boivin et al., 1992). This implies that this concern should be integrated into the design of work-spaces and work organisation, as the animal's living environment is also the livestock farmer's working environment. In a dairy cattle or goat system, the animal's relation with humans is shaped from a very young age (Rault et al., 2020) and involves other organisational and spatial responses. If the animals go through different systems, i.e. different types of farms, livestock markets, abattoirs, then action on the genetic predispositions of the animals (conductive to plasticity/adaptability processes) becomes an important lever.

Interdisciplinary epistemological and methodological implications for research into relational practices

The goal of our interdisciplinary approach to relational practices is to pinpoint the gaps between the kinds of conduct being ‘encouraged’ within communities of practice based on beliefs, empirical

knowledge or the latest science (e.g. on animal behaviour), and the reality of the livestock farmer's work in context (their activity), the possibilities and impossibilities encountered, human regulations, etc. Considering this practice–activity dialectic opens up perspectives for co-constructing livestock practices that are constantly evolving in and through the activity of livestock farmers.

This vision of a 'situational coupling' between the livestock farmer's work situation and the animal's life situation necessarily requires a bridging of disciplines on these questions (Lindahl et al., 2015) that is far from self-evident on an epistemological level. The standards to be met, which are more qualitative in the activity-oriented ergonomics side of the equation and more quantitative and statistical on the applied ethology side, make it a real challenge to design shared paradigms.

Nevertheless, once they address practice, ergonomics and applied ethology share epistemological overlap that are conducive to multidisciplinary collaboration based on converging orientations that can be profitably operationalised in future studies:

- Understanding of the multi-determined and dynamic nature of human activity in the workplace and of animal behaviour, based on experiences lived by and in the presence of both (longitudinal systemic approach);
- Accounting for different dimensions of human activity and animal behaviour—biological, cognitive and sentient—in the understanding of the phenomena at work (holistic approach);
- Iterative intermeshing between a comprehensive perspective of phenomena and perspectives for acting on the world: tools for multidisciplinary and multicriteria assessment (livestock performances and ethological, ergonomic, psychological, health, etc.) of the livestock farmer–animal relationship, counsel and guidance, training, adapted design of farm-work equipment, genetic selection, etc.).

A better understanding of animal behaviour, human activity in the workplace and their reciprocal impacts is a broad field of research in the domain of complex system sciences. The ergonomics–applied ethology dyad can offer an insightful perspective to the question: how are relational practices articulated in and by the activity of livestock farmer? This insight is needed to advance our scientific understanding in near-fieldwork conditions, and consequently our fieldwork processes and how to assess them.

There are also several specific sub-questions to address:

- How and under what conditions can relational practices become an instrument to deliver safer and more efficient, worker action and better worker and animal welfare?
- How do relational practices in the livestock farmer's activity take on realised and unrealised possibilities?
- To what extent do livestock farmers actually internalise the animal's behaviour, its emotional and cognitive capacities (real or supposed), and the herd system in their work activity?
- What are the barriers and/or drivers of this internalisation in their activity?

We propose three research strategies framed in the study of relational practices captured through the lens of stockmanship activity and animal behaviour:

The first strategy is grounded in the contribution of scientific knowledge produced in ethology to assess the transformative action of the ergonomist as a research object in itself (Daniellou, 1992; Petit et al., 2007). It could, for example, be applied in the context of an investment project like design of a new livestock building (Beaujouan and Escouteloup, 2014), an organisational reconfiguration, or a transition to agroecological principles. We could then evaluate the ergonomist's intervention in the project

and the way in which different rationales (technical, regulatory, economic, human work demands, human and animal function) are or are not articulated in the design choices made, and thus assess the consequences for both human and animal. The target outcome of this research process is to develop scientific knowledge operable by practitioners based on experiential knowledge of other practitioners (Albert and Avenier, 2011). This could be assessed via indicators iteratively enabling the ergonomist's intervention to be adjusted based on new proposals involving:

- management of the investment project and the role of the ergonomist in this process (how these different rationales articulate throughout the project in order to document the final choices made),
- transformative reconfigurations of the work and living environments for the animal (before and after the investment project),
- activity-mediated dynamics for humans, e.g. based on the gestures/movements and affective and cognitive processes at work collected and analysed by methodological triangulation articulating an observational approach with self-confrontation interviews for reflective analysis by the professional on traces of their own activity or that of a peer (Rix-Lièvre, 2010),
- animal behaviour, for example using protocols developed to assess the animal responses to humans as input to multicriteria assessment of on-farm animal welfare (Velarde et al., 2009),
- effects produced on human work (efficiency, health or safety indicators, e.g., time required to complete a task, physical strain, occupational welfare) with data gathered and analysed by methodological triangulation (observation–interview–questionnaire),
- effects produced on the animal (welfare, health).

The second research strategy also starts out from the scientific knowledge produced in ethology to model and test different living conditions for animals in 'system trials' on experimental farms (e.g., three experimental treatments involving different human–animal contacts applied to calves, to test out hypotheses on the course and path of the human–animal relationship). This strategy joins up with a wider and often participatory (researcher, developers and users) approach to the design of innovative production systems (Le Gal et al., 2011). Where the activity-centred ergonomics has so far been little considered but could lead to proposing a complementary qualitative reading. This by making an effort to identify how experimenters 'enact' these proposals, the dynamics of transformation in what they do, what is important for them, what they try to do without necessarily succeeding, how they organise themselves, and so on (Coleman et al., 1998; Hemsworth and Coleman, 2011; Coquil et al., 2018). We thus consider, and it is undoubtedly here where we differ from the works mentioned, their possibilities and impossibilities for implementing these proposals in their activity, given the many constraints involved (regulatory, task requirements, etc.). This depth of analysis, obtained through the methodological triangulations mentioned in the first research design, would allow us to refine our conclusions. Indeed, when a worker does not manage to implement proposed relational practices, is it that they do not want to? Or that they cannot, even if they would like to, as they are being held back? And if so, for what reasons? How to transform the work situation (spaces, tools, work organisation)? The framework of study proposed here (experimental farms) is completely transferrable to a framework for studying instructional material designed to equip livestock farmers with the latest scientific knowledge of animal behaviour with a view to them implementing relational practices with their livestock from/on their farms. Some researchers, without referring to an ergonomic framework, have adopted this strategy to explore or test the effect of handling training on groups of volunteer livestock

farmers, analysing their representations, their human–animal interactions, and their animals' responses in standardised tests (Coleman et al., 2000; Hemsworth et al., 2002; Ceballos et al., 2018;).

A third research strategy could also be proposed that works up from an objective finding by means of a qualitative work-situated ergonomics analysis including an ethological analysis of how the animals respond. An illustrative example is the narrative developed above in this farm-context paper that highlights systematic difficulties in moving cows from stalls to the milking parlour. This then leads to a more quantitative approach on a group of reference farms to test ethological hypotheses and then validate them via a more analytical approach in experimental farms (e.g. human–animal relations influenced by the conditions surrounding mother/calf separation). Such an approach, considering the interaction between ergonomics and ethology, has not been described in the literature. But here again, by way of reference, we can draw inspiration from Paul Hemsworth's multidisciplinary approach (livestock science/ethology/physiology of stress). Observational inquiry on animal handling difficulties experienced by pig farmers on commercial farms subsequently led Hemsworth to investigate and test certain mechanisms for constructing pig responses to livestock farmers, under standardised conditions on an experimental farm (Hemsworth and Coleman, 2011). Further research followed in various livestock farming settings (Waiblinger et al., 2002; Waiblinger et al., 2003; Waiblinger et al., 2004; Hemsworth and Boivin, 2011; Rault et al., 2020) but without including the conceptual framework around relational practices was outlined here.

Without exhaustively covering all the options, we anticipate the three pathways proposed will allow prospects for study, action and evaluation of the development of stockmanship activities to forge a positive relationship with the farm animal. Indeed, we take the stance that, in both disciplines—ergonomics and applied ethology—any good theory essentially proves its worth in real-world in-practice problems, and becomes valuably useful when it can iteratively return to the problems, find more insight, and advance. It is this vision that sparked our initial desire to bring ergonomics and applied ethology together.

Conclusion and perspectives

Stockmanship work necessarily implies the presence of an animal in the livestock farmer's work situation. This 'encounter' and the relationship that is created between these two living beings do not, however, happen directly but are always mediated through a relationship that the livestock farmer holds with his work in a given social environment. As a result, here we conceive of relational practices, considered as fields of action endorsed 'top-down' by an outside community, through the lens of the livestock farmer's activity as he engages the on-farm livestock, the tasks to be performed, and 'others' (regulatory landscape, economic context, etc.). Consequently, as explained above, we find it impossible to consider the development of this livestock farmer–animal relationship without taking into account various parameters of the work situations in which the professional farmer operates. It is in this sense that we undertaken, through this article, to open a first level of dialogue between ergonomics and applied ethology. This encounter between disciplines and the epistemological challenge it implies (articulation of qualitative and quantitative approaches) becomes a will to overcome, through actions and difficulties in the field, the fact that the construction of this human–animal relationship is a further burden on the shoulders of stockpeople is an additional constraint on livestock farmer who already have multiple demands to manage in the running of their farms.

Here, the construct of activity historically mobilised by ergonomics brings fresh insight from an epistemic and pragmatic perspective. In the livestock farmer's activity, which is always directed at the object-purpose of their work (whether the object is directly or indirectly the animal), the construction of the relational practice, whether realised or repressed, emerges as a possibility, an artefact, to accomplish good-quality work. This, both in terms of livestock farmer's efficiency at work, his health, and the welfare of his animals. Seen as a potential 'instrument' of the livestock farmer's action, relational practice invites a more holistic approach to the work as a starting point for development beyond its status as constraint. But for this to happen, the livestock farmer has to play the lead in this bottom-up transformation, where the models of expertise that aim to prescribe 'good practices' top-down show their limits. The active relationship that the farmer maintains with his work is the key prerequisite for any transformation or training action aimed at improving stockmanship work and practice. In this respect, some periods prove more conducive as windows of opportunity than others: change of farm ownership, livestock transitions, the design of new livestock buildings, investments (in the broadest sense), and more. In a profession where there are many outside contributors (technical designers, technical advisers, ethologists, ergonomists, safety and prevention consultants, etc.), the livestock farmer's active proactive connection to their work is a key factor in successfully navigating between these different professional worlds with their different rationales and mindsets. One major challenge in this context is designing organised action frameworks conducive to engaging and integrating these different rationales for constructing a positive relationship with the farm animal.

Ethics approval

This paper is a review paper. No ethical concern was raised in relation to animal experimentation.

Data and model availability statement

None of the data were deposited in an official repository.

Author ORCIDs

Beaujouan Joffrey: <https://orcid.org/0000-0002-8633-9915>

Cromer Damien: <https://orcid.org/0000-0002-7696-1700>

Boivin Xavier: <https://orcid.org/0000-0002-4518-5454>

Author contributions

J. Beaujouan and D. Cromer: Writing original draft ergonomics and general discussion.

Xavier Boivin: writing original introduction and ethological draft.

All authors revising the draft and final approval of the version to be published.

Declaration of interest

The authors declare no conflict of interest.

Acknowledgements

None.

Financial support statement

This study received funding and logistics support from the French Ministry of Agriculture, in particular via the CASDAR-programme [special research credits] RHAPORC project and the joint technology networks (RMT) 'Animal Welfare' and 'One Welfare'. This support has no bearing on the authors' intentions.

References

- Abadia, G., Mirabito, L., 2003. Influence des modifications des systèmes d'élevage sur la santé des éleveurs. In: Cinquièmes journées de la recherche avicole, 26–27 March 2003, Tours, France, pp. 1–8.
- Agnvall, B., Béteky, J., Katajamaa, R., Jensen, P., 2018. Is evolution of domestication driven by tameness? A selective review with focus on chickens. *Applied Animal Behaviour Science* 205, 227–233.
- Albert, M.-N., Avenier, M.-J., 2011. Légitimation de savoirs élaborés dans une épistémologie constructiviste à partir de l'expérience de praticiens. *Recherches qualitatives* 30, 22–47.
- Beaujouan, J., Aubert, S., Coutarel, F., 2015. Construction de l'intervention ergonomique. D'une préoccupation de montée en cadence à la décision d'investir pour transformer le travail: embûches et stratégies. *Perspectives interdisciplinaires sur le travail et la santé* 12, 17–22. <https://doi.org/10.4000/pistes.4599>.
- Beaujouan, J., Escouteloup, J., 2014. Ergonomie et Architecture: contribution des ergonomes à la conception des espaces de vie et de travail. *Pathologie professionnelle et de l'environnement* 7, 70–78. [https://doi.org/10.1016/S1877-7856\(14\)63061-0](https://doi.org/10.1016/S1877-7856(14)63061-0).
- Beillerot, J., 2011. L'analyse des pratiques professionnelles: pourquoi cette expression? *Cahiers Pédagogiques* 416, 9–59.
- Belyaev, D., Plyusnina, I., Trut, L., 1985. Domestication in the silver fox (*Vulpes fulvus* Desm): Changes in physiological boundaries of the sensitive period of primary socialization. *Applied Animal Behaviour Science* 13, 359–370.
- Bentley, T., Green, N., Tappin, D., Haslam, R., 2021. State of science: the future of work – ergonomics and human factors contributions to the field. *Ergonomics* 64, 427–439. <https://doi.org/10.1080/00140139.2020.1841308>.
- Boissy, A., Manteuffel, G., Jensen, M.B., Moe, R.O., Spruijt, B., Keeling, L.J., Winckler, C., Forkman, B., Dimitrov, I., Langbein, J., Bakken, M., Veissier, I., Aubert, A., 2007. Assessment of positive emotions in animals to improve their welfare. *Physiology & Behavior* 92, 375–397.
- Boivin, X., Bensoussan, S., L'Hôtelier, N., Bignon, L., Brives, H., Brule, A., Godet, J., Granne, M., Hausberger, M., Kling-Eveillard, F., Tallet, C., Courboulay, V., 2012. Hommes et animaux d'élevage au travail: vers une approche pluridisciplinaire des pratiques relationnelles. *INRAE Productions Animales* 25, 159–168. <https://doi.org/10.20870/productions-animales.2012.25.2.3205>.
- Boivin, X., Gilard, F., Egal, D., 2009. The effect of early human contact and the separation method from the dam on responses of beef calves to humans. *Applied Animal Behaviour Science* 120, 132–139.
- Boivin, X., Le Neindre, P., Chupin, J., 1992. Establishment of cattle-human relationships. *Applied Animal Behaviour Science* 32, 325–335.
- Boivin, X., Lensink, J., Tallet, C., Veissier, I., 2003. Stockmanship and farm animal welfare. *Animal Welfare* 12, 479–492.
- Bonnemain, A., Bonnefond, J.Y., Fontes, F.F., Clot, Y., 2019. Vygotsky and work: an activity clinic to change the organization. In: Bendassolli, P.F. (Ed.), *Culture, work and psychology: invitation to dialogue*. Information Age Publishing, Charlotte, USA, pp. 59–80.
- Breed, M.D., Moore, J., 2015. *Animal behavior*. Academic Press Inc, Cambridge, MA, USA.
- Broom, D.M., 1986. Indicators of poor welfare. *The British Veterinary Journal* 142, 524–526. [https://doi.org/10.1016/0007-1935\(86\)90109-0](https://doi.org/10.1016/0007-1935(86)90109-0).
- Canguilhem, G., 2012. *Writings on medicine*. Fordham University Press, New York, NY, USA.
- Carter, C.S., Ahnert, L., Grossmann, K., Lamb, M.E., Hrdy, S.B., 2015. Attachment and bonding: A new synthesis. The MIT Press, Cambridge, MA, USA.
- Cayon, M., Aubert, M., Detraye, R., Lavallee, D., Beaujouan, J., Escouteloup, J., 2018. Développer la prévention primaire en s'impliquant dans les projets d'investissement, de conception des lieux de travail. *Archives des Maladies Professionnelles et de l'Environnement* 79, 337. <https://doi.org/10.1016/j.admp.2018.03.280>.
- Ceballos, M.C., Sant'Anna, A.C., Boivin, X., de Oliveira Costa, F., Monique, V.D.L., da Costa, M.J.P., 2018. Impact of good practices of handling training on beef cattle welfare and stockpeople attitudes and behaviors. *Livestock Science* 216, 24–31.
- Cerf, M., Falzon, P., 2005. *Situations de services: travailler en interaction*. PUF, Paris, France.
- Cerf, M., Sagory, P., 2004. *Agriculture et développement agricole*. In: Falzon, P. (Ed.), *Ergonomie*. PUF, Paris, France, pp. 621–632.
- Clot, Y., 1999. *La fonction psychologique du travail*. PUF, Paris, France.
- Clot, Y., 2015. *Le travail à cœur: pour en finir avec les risques psychosociaux. La découverte*, Paris, France.
- Coleman, G.J., Hemsworth, P.H., Hay, M., 1998. Predicting stockperson behaviour towards pigs from attitudinal and job-related variables and empathy. *Applied Animal Behaviour Science* 58, 63–75.
- Coleman, G.J., Hemsworth, P.H., Hay, M., Cox, M., 2000. Modifying stockperson attitudes and behaviour towards pigs at a large commercial farm. *Applied Animal Behaviour Science* 66, 11–20.
- Coquil, X., Franck, C., Veyssier, P., Pailleux, J.-Y., Fiorelli, C., Hostiou, N., Godfroy, M., Fombaron, S., Anglade, J., 2018. Richesse créée, rémunération et transformations du travail en systèmes laitiers économiques et autonomes en agriculture biologique. *Fourrages* 235, 175–180.
- Coulon, M., Nowak, R., Peyrat, J., Chandéze, H., Boissy, A., Boivin, X., 2015. Do lambs perceive regular human stroking as pleasant? Behavior and heart rate variability analyses. *PLoS One* 10, e0118617.
- Coutarel, F., Daniellou, F., Dugué, B., 2005. La prévention des troubles musculo-squelettiques: quelques enjeux épistémologiques. *Activités* 4, 2. <https://doi.org/10.4000/activites.1550>.
- Cromer, D., Beaujouan, J., 2019. La prise en compte du bien-être de l'éleveur et de l'animal par l'ergonomie dans la conception des situations de travail. *Colloque Bien-être animal: des valeurs à partager*, 1–2 July 2019, Strasbourg, France.
- Daniellou, F., 1992. Le statut de la pratique et des connaissances dans l'intervention ergonomique de conception. Editions du Laboratoire d'Ergonomie des Systèmes Complexes, Bordeaux, France.
- Daniellou, F., Rabardel, P., 2005. Activity-oriented approaches to ergonomics: some traditions and communities. *Theoretical Issues in Ergonomics Science* 6, 353–357.
- Derrida, J., 2006. *L'animal que donc je suis*. Editions Galilée, Paris, France.
- Destrez, A., Haslin, E., Elluin, E., Gaillard, C., Hostiou, N., Dassé, F., Zanella, C., Boivin, X., 2018a. Evaluation of beef herd responses to unfamiliar humans and potential influencing factors: An exploratory survey on French farms. *Livestock Science* 212, 7–13.
- Destrez, A., Haslin, E., Boivin, X., 2018b. What stockperson behavior during weighing reveals about the relationship between humans and suckling beef cattle: A preliminary study. *Applied Animal Behaviour Science* 209, 8–13.
- Dugatkin, L.A., 2020. *Principles of animal behavior*. University of Chicago Press, Chicago, IL, USA. 10.7208/chicago/9780226448441.001.0001.
- Dul, J., Bruder, R., Buckle, P., Carayon, P., Falzon, P., Marras, W.S., Wilson, J.R., van der Doelen, B., 2012. A strategy for human factors/ergonomics: developing the discipline and profession. *Ergonomics* 55, 377–395.
- Falzon, P., 2005. Ergonomics, knowledge development and the design of enabling environments. *Proceedings of the Humanizing Work and Work Environment HWWE*, 10–12 December 2005, Guwahati, India.
- Falzon, P., Lapeyrière, S., 1998. L'usager et l'opérateur: Ergonomie et relations de service. *Le Travail Humain* 61, 69–90.
- Fernandes, J.N., Hemsworth, P.H., Coleman, G.J., Tilbrook, A.J., 2021. Costs and Benefits of Improving Farm Animal Welfare. *Agriculture* 11, 104.
- Fiorelli, C., Mouret, S., Porcher, J., 2012. Les rationalités du travail avec les animaux d'élevage: produire, vivre ensemble et se construire. *INRAE Productions Animales* 25, 181–192. <https://doi.org/10.20870/productions-animales.2012.25.2.3207>.
- Fortune, A., Dassé, F., 2014. Docilité et santé au travail. In: Davoine, J.-M. (Ed.), *Domestiquer autrement*. Cardère, Avignon, France, pp. 23–25.
- Glanville, C., Abraham, C., Coleman, G., 2020. Human behaviour change interventions in animal care and interactive settings: a review and framework for design and evaluation. *Animals* 10, 2333.
- Grandgeorge, M., Boivin, X., 2019. Les Relations humain-animal: éthologie animale et humaine. In: Darmaillacq, A.-S., Lévy, F. (Eds.), *Éthologie animale: Une Approche biologique du comportement*. De Boeck, Paris, France, pp. 241–262.
- Grandin, T., 2014. *Livestock handling and transport: theories and applications*. CABI, Wallingford, UK.
- Greiveldinger, L., Veissier, I., Boissy, A., 2011. The ability of lambs to form expectations and the emotional consequences of a discrepancy from their expectations. *Psychoneuroendocrinology* 36, 806–815.
- Guesdon, V., Nowak, R., Meurisse, M., Boivin, X., Cornilleau, F., Chaillou, E., Lévy, F., 2016. Behavioral evidence of heterospecific bonding between the lamb and the human caregiver and mapping of associated brain network. *Psychoneuroendocrinology* 71, 159–169.
- Hare, B., Brown, M., Williamson, C., Tomasello, M., 2002. The domestication of social cognition in dogs. *Science* 298, 1634–1636.
- Haskell, M., Simm, G., Turner, S., 2014. Genetic selection for temperament traits in dairy and beef cattle. *Frontiers in Genetics* 5, 368. <https://doi.org/10.3389/fgene.2014.00368>.
- Hemsworth, P.H., Boivin, X., 2011. Human contact. In: Appleby, M.C., Mench, J.A., Olsson, I.A.S., Hughes, B.O. (Eds.), *Animal Welfare*. 2nd ed. CABI, Wallingford, UK, pp. 246–262.
- Hemsworth, P.H., Coleman, G.J., 2011. Human-livestock interactions: The stockperson and the productivity of intensively farmed animals. CABI, Wallingford, UK.
- Hemsworth, P.H., Coleman, G.J., Barnett, J., 1994. Improving the attitude and behaviour of stockpersons towards pigs and the consequences on the behaviour and reproductive performance of commercial pigs. *Applied Animal Behaviour Science* 39, 349–362.
- Hemsworth, P.H., Coleman, G.J., Barnett, J.L., Borg, S., Dowling, S., 2002. The effects of cognitive behavioral intervention on the attitude and behavior of stockpersons and the behavior and productivity of commercial dairy cows. *Journal of Animal Science* 80, 68–78.
- Hemsworth, P.H., Sherwen, S., Coleman, G., 2018. Human contact. In: Appleby, M.C., Olsson, A.S., Galindo, F. (Eds.), *Animal Welfare*. 3rd ed. CABI, London, UK, pp. 294–314. <https://doi.org/10.7120/09627286.27.4.327> PMID: 31244511.

- Henry, S., Hemery, D., Richard, M.-A., Hausberger, M., 2005. Human–mare relationships and behaviour of foals toward humans. *Applied Animal Behaviour Science* 93, 341–362.
- Hostiou, N., Fagon, J., Chauvat, S., Turlot, A., Kling-Eveillard, F., Boivin, X., Allain, C., 2017. Impact of precision livestock farming on work and human–animal interactions on dairy farms. A review. *Biotechnologie, Agronomie, Société et Environnement/Biotechnology, Agronomy, Society and Environment* 21, 268–275.
- Jardat, P., Lansade, L., 2021. Cognition and the human–animal relationship: a review of the sociocognitive skills of domestic mammals toward humans. *Animal Cognition*. <https://doi.org/10.1007/s10071-021-01557-6>. Published online: 02 September 2021.
- Jerolmack, C., 2009. Humans, animals, and play: Theorizing interaction when intersubjectivity is problematic. *Sociological Theory* 27, 371–389.
- Kaminski, J., Nitzschner, M., 2013. Do dogs get the point? A review of dog–human communication ability. *Learning and Motivation* 44, 294–302.
- Karwowski, W., 2005. The Discipline of Ergonomics and human factors. In: Salvendy, G. (Ed.), *Handbook of Human Factors and Ergonomics*. John Wiley & Sons Inc., Hoboken, NJ, USA, pp. 3–37.
- Kis, A., Ciobica, A., Topál, J., 2017. The effect of oxytocin on human-directed social behaviour in dogs (*Canis familiaris*). *Hormones and Behavior* 94, 40–52.
- Lave, J., Wenger, E., 1991. *Situated learning: Legitimate peripheral participation*. University Press, Cambridge, UK.
- Le Gal, P.-Y., Dugué, P., Faure, G., Novak, S., 2011. How does research address the design of innovative agricultural production systems at the farm level? A review. *Agricultural Systems* 104, 714–728.
- Le Neindre, P., Bernard, E., Boissy, A., Boivin, X., Calandreau, L., Delon, N., Deputte, B., Desmoulin-Canselier, S., Dunier, M., Faibre, N., Giurfa, M., Guichet, J.L., Lansade, L., Larrère, R., Mormède, P., Prunet, P., Schaal, B., Servière, J., Terlouw, C., 2017. *Animal consciousness* 14, 1196E.
- Leone, L., 2020. Farm animal welfare under scrutiny: issues unsolved by the EU legislator. *European Journal of Legal Studies* 12, 47–83.
- Leplat, J., 1990. Relations between task and activity: elements for elaborating a framework for error analysis. *Ergonomics* 33, 1389–1402.
- Leplat, J., 2006. La notion de régulation dans l'analyse de l'activité. *Perspectives interdisciplinaires sur le travail et la santé* 5, 8.
- Leplat, J., Cuny, X., 1977. *Introduction à la psychologie du travail*, Vol. 68. PUF, Paris, France.
- Lindahl, C., Lundqvist, P., Hagevoort, G.R., Lunner Kolstrup, C., Douphrate, D.I., Pinzke, S., Grandin, T., 2013. Occupational Health and Safety Aspects of Animal Handling in Dairy Production. *Journal of Agromedicine* 18, 274–283. <https://doi.org/10.1080/1059924X.2013.796906>.
- Lindahl, C., Pinzke, S., Herlin, A., Keeling, L.J., 2016. Human–animal interactions and safety during dairy cattle handling—Comparing moving cows to milking and hoof trimming. *Journal of Dairy Science* 99, 2131–2141.
- Lindahl, C., Pinzke, S., Keeling, L.J., Lundqvist, P., 2015. The effect of stress, attitudes, and behavior on safety during animal handling in Swedish dairy farming. *Journal of Agricultural Safety and Health* 21, 13–34.
- Lisbon Treaty, 2009. Retrieved on 15 September 2021 from https://ec.europa.eu/food/animals/animal-welfare_fr.
- Mellor, D.J., Beausoleil, N.J., 2019. Moving beyond a problem-based focus on poor animal welfare toward creating opportunities to have positive welfare experiences. In: Mc Millan, F. (Ed.), *Mental Health and Well-being in Animals*. 2nd ed. CABI, Wallingford, UK, pp. 50–66.
- Mellor, D.J., Beausoleil, N.J., Littlewood, K.E., McLean, A.N., McGreevy, P.D., Jones, B., Wilkins, C., 2020. The 2020 five domains model: including human–animal interactions in assessments of animal welfare. *Animals* 10, 1870.
- Mormède, P., Boisseau-Sowinski, L., Chiron, J., Diederich, C., Eddison, J., Guichet, J.-L., Le Neindre, P., Meunier-Salaün, M.-C., 2018. Bien-être animal: contexte, définition, évaluation. *INRA Productions Animales* 31, 145–162.
- Mounier, L., Colson, S., Roux, M., Dubroeuq, H., Boissy, A., Veissier, I., 2008. Positive attitudes of farmers and pen-group conservation reduce adverse reactions of bulls during transfer for slaughter. *Animal* 2, 894.
- Munoz, C.A., Coleman, G.J., Hemsworth, P.H., Campbell, A.J., Doyle, R.E., 2019. Positive attitudes, positive outcomes: The relationship between farmer attitudes, management behaviour and sheep welfare. *PLoS One* 14, e0220455.
- Napolitano, F., Serrapica, F., Braghieri, A., Masucci, F., Sabia, E., De Rosa, G., 2019. Human–animal interactions in dairy buffalo farms. *Animals* 9, 246.
- Nawroth, C., Langbein, J., Coulon, M., Gabor, V., Oesterwind, S., Benz-Schwarzburg, J., von Borell, E., 2019. Farm animal cognition—linking behavior, welfare and ethics. *Frontiers in Veterinary Science* 6, 24.
- Nowak, R., Boivin, X., 2015. Filial attachment in sheep: Similarities and differences between ewe–lamb and human–lamb relationships. *Applied Animal Behaviour Science* 164, 12–28.
- ©OIE – Terrestrial Animal Health Code, 2016. Retrieved on 15 September 2021 from https://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/2016/en_chapitre_aw_introduction.htm.
- Petit, J., 2005. *Organiser la continuité du service: intervention sur l'organisation d'une mutuelle de santé*. Editions du Laboratoire d'Ergonomie des Systèmes Complexes, Bordeaux, France.
- Petit, J., Querelle, L., Daniellou, F., 2007. Quelles données pour la recherche sur la pratique de l'ergonomie? *Le travail humain* 70, 391–411.
- Pinillos, R.G., 2018. *One Welfare: a framework to improve animal welfare and human well-being*. CABI, Wallingford, UK.
- Pol, F., Kling-Eveillard, F., Champigneulle, F., Fresnay, E., Ducrocq, M., Courboulay, V., 2021. Human–animal relationship influences husbandry practices, animal welfare and productivity in pig farming. *Animal* 15, 100103.
- Porcher, J., 2019. Quelle place pour la psychodynamique du travail dans les recherches sur les relations entre humains et animaux en SHS? *Travailler* 1, 53–60.
- Porcher, J., Estebanez, J., 2019. *Animal labor: at the forefront of innovative research*. Transcript Verlag, Bielefeld, Germany.
- Price, M., Tennesen, T., 1981. Preslaughter management and dark-cutting in the carcasses of young bulls. *Canadian Journal of Animal Science* 61, 205–208.
- Rabardel, P., Beguin, P., 2005. Instrument mediated activity: from subject development to anthropocentric design. *Theoretical Issues in Ergonomics Science* 6, 429–461.
- Rault, J.-L., Waiblinger, S., Boivin, X., Hemsworth, P., 2020. The power of a positive human–animal relationship for animal welfare. *Frontiers in Veterinary Science* 7, 857.
- Reed, E.S., Bril, B., 1996. The primacy of action in development. In: Latash, M. (Ed.), *Dexterity and its development*. Erlbaum, Hillsdale, NJ, USA, pp. 431–451.
- Ristau, C.A., Marler, P., 2014. *Cognitive Psychology: Essays in Honor of Donald R. Griffin*. Psychology Press, London, UK.
- Rix-Lièvre, G., 2010. Différents modes de confrontation à des traces de sa propre activité. *Revue d'anthropologie des connaissances* 4, 358–379.
- Récopé, M., Fache, H., Beaujouan, J., Coutarel, F., Rix-Lièvre, G., 2019. A study of the individual activity of professional volleyball players: Situation assessment and sensemaking under time pressure. *Applied Ergonomics* 80, 226–237. <https://doi.org/10.1016/j.apergo.2018.07.003>.
- Velarde, A., Dalmau, A., Keeling, L., Veissier, I., 2009. *Welfare Quality® assessment protocol for pigs (sows and piglets, growing and finishing pigs)*. INRAE.
- Waiblinger, S., 2017. Human–animal relations. In: Jensen, P. (Ed.), *The ethology of domestic animals: an introduction text*. CABI, Wallingford, UK, pp. 135–149.
- Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.-V., Janczak, A.M., Visser, E.K., Jones, R.B., 2006. Assessing the human–animal relationship in farmed species: a critical review. *Applied Animal Behaviour Science* 101, 185–242.
- Waiblinger, S., Menke, C., Coleman, G., 2002. The relationship between attitudes, personal characteristics and behaviour of stockpeople and subsequent behaviour and production of dairy cows. *Applied Animal Behaviour Science* 79, 195–219.
- Waiblinger, S., Menke, C., Fölsch, D., 2003. Influences on the avoidance and approach behaviour of dairy cows towards humans on 35 farms. *Applied Animal Behaviour Science* 84, 23–39.
- Waiblinger, S., Menke, C., Korff, J., Bucher, A., 2004. Previous handling and gentle interactions affect behaviour and heart rate of dairy cows during a veterinary procedure. *Applied Animal Behaviour Science* 85, 31–42.
- Wilson, J.R., 2014. *Fundamentals of systems ergonomics/human factors*. Applied ergonomics 45, 5–13.
- Zinsstag, J., Schelling, E., Waltner-Toews, D., Whittaker, M., Tanner, M., 2015. *One Health: The Theory and Practice of Integrated Health Approaches*. CABI, Wallingford, UK.