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Review

Assessing and influencing personality for improvement of animal welfare: a review of equine studies

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Abstract

Personality and its various sub-traits such as temperament can be defined as behavioural attitudes that remain relatively stable across time and situations. However, various personality models exist. Contrasting their strengths and weaknesses leads to the conclusion that there is presently no model that is truly superior to others in depicting animal personality. Furthermore, the present review highlights aspects in which animal, and in particular equine personality potentially relate to animal welfare. Three approaches are examined which may be taken to improve welfare: (1) genetically selecting for personality traits that make the horses better adapted to their designated work and/or husbandry conditions, (2) assessing personality in individual horses to optimize matching with owners and type of work and (3) influencing the ontogeny of personality traits, e.g. by specific training and husbandry regimes. Each of these strategies has its merit, but as a prerequisite, valid personality assessment methods are required. Although publication bias is likely present, most testing procedures yield acceptable inter-observer reliabilities and repeatabilities across time, even if repeatability across situations tends to be comparably low. Heritability estimates ranging mostly between h^2=0.15 and h^2=0.40 for traits assessed in personality tests are likewise promising. Research has paid less attention to intra-observer reliability, construct validity or discriminant ability, but based on pleiotropy it is argued that the latter is not essential for a trait to be valid. Therefore, some valid methods are available for use in assessment and subsequent selection of horses or personality-influencing strategies, ultimate resulting in reduction of stress in horses' everyday life.

Keywords: Personality, Welfare, Genetics of behaviour, Horse, Temperament, Human–animal interaction, Character

Review Methodology: The search machines and databases CAB Abstracts, Medline/PubMed, Agricola and Google Scholar were used for the literature search, using the following keyword search terms in different combinations: horse, equine, personality, temperament, character, behaviour, genetic, heritability, fear, reactivity, test, welfare, human–animal interaction, match, ontogeny. Furthermore, I used my personal literature database, which includes, in addition to English articles, articles written in several European languages. Once suitable articles had been identified, their references were used as well as the possibility to search within publishers' databases for related articles and further articles relating to the above keywords. Finally, I spoke to colleagues working in the area of equine personality to check for missed as well as upcoming studies.

Animal Personality

Methods to categorize human personality into distinct personality types has been documented as early as by Hippocrates (ca. 460–370 BC), although it was not until 2000 years later that research into animal personalities has gained some acceptance. However, individual differences in personality are thought to have adaptive value in animals [1–3], and today there is little doubt that distinct animal personalities exist. While the first research in this area focused on species acknowledged to be capable of higher cognitive processes, such as primates [4], dogs

[5, 6] and later other mammals [7], present research indicates the existence of personality-like, individual-specific behavioural attitudes in other taxa and phyla such as birds [8], amphibians [9], fish [10, 11] and even invertebrates such as arthropods [12], molluscs, [13] and insects such as firebugs [14] and honey bees [15]. Gosling [16] undertook a comprehensive review of personality studies across various species. Given the relevance to human safety, economics, management and animal welfare, much interest has been devoted to the study of personality in livestock [17–19] and companion animals [6, 20–22]. The horse falls into both categories [23] and thus has received particular attention.

Definitions of Personality and Classification Schemes

For the purpose of the present review, personality is defined as the animal's basic stance towards environmental stimuli that is expressed by behaviour patterns and remains relatively stable across time and situations ([24, 25] based on definitions of temperament).

However, as frequently pointed out [16, 24, 26], a multitude of definitions of personality exists, and the use of terminology is rather inconsistent. Indeed, regarding animals the term personality itself is somewhat contradictory. Perhaps for fear of anthropomorphism, earlier researchers seemed to be reluctant to use the term personality in relation to animals, leading to suggestions for alternative descriptions, such as 'horsonality' [27]. More commonly, terms such as 'temperament' [24–26, 28–31] or 'character' [32] are used as an equivalent of personality, but a variety of other terms such as 'timidity' [33, 34], 'nervousness' [35], 'nervous balance', '-activity' or '-irritability' [36–38], 'emotionality' [39–41] or 'mental traits' [42, 43] has also been used. However, the use of the latter expressions is not very widespread. Furthermore with regard to horses, the terms 'temperament' and 'character' may be confusing as both are used in equine breeding [44, 45] to label specific sub-categories of personality. Therefore, it is suggested that also in animals 'personality' may be the most suitable term to embrace all behaviour-related traits.

While there is limited agreement regarding the labelling and definition of personality in animals, there is yet less agreement regarding the dimensions or sub-traits that comprise personality and the models used to categorize specific types of personality, as outlined in Table 1. The concepts have usually been adapted from personality research in human psychology or research in non-livestock species, but no consensus on terminology and model choice exists there either [74]. This is not surprising as researchers do not even agree on what constitutes behaviour [75], and for example behaviour ratings by scientists [76] or judges [77] may differ from ratings given by practitioners. These disagreements point to the complexity of issues related to behaviour and personality. Some of the most commonly used classification schemes include the theory of active versus passive coping styles [46], the temperament-character inventory based on a model suggested by Cloninger [52], and the five-factor model [48]. Approaches based on multivariate analyses, such as factor analysis or principal component analysis used to define study-specific sets of traits that may or may not be fitted to an existing model, are also common. However, various other personality models exist in the literature on both human and animal personality. In view of this variety of approaches, many researchers call for a better standardization of classification schemes [16, 78]. Although comparability of results from different studies could be increased, based on a subjective evaluation of advantages and disadvantages (Table 1), it appears that there is no particular classification that is superior to all other models under all circumstances. For example, the classification based on active and passive coping strategies [46] is simple, but does not seem to fit well to most livestock personality traits as they tend to exhibit a continuous rather than binary or bimodal distribution [79–81]. Also, a direct comparison of the five factor model and temperament-character inventory did not reveal major advantages for either of the models regarding construct validity in humans [82]. Neither model was superior in predicting a real-life outcome, i.e. the development of personality disorders, from the presence of particular personality characteristics as assessed by the respective model. However, the temperament-character inventory [52, 53] appears to have particular merit in the context of animal breeding. The personality dimensions are each based on a distinct genetic background linked to neurotransmitter pathways: the trait novelty seeking is linked to basal dopaminergic activity, harm avoidance is linked to serotonergic activity, and reward dependence is linked to noradrenergic activity [52, 53]. These relationships could be confirmed in humans [83–85], and the model has also been successfully applied in a study aiming at detection of QTL affecting feather-pecking in chickens [86]. Similarly, genetic polymorphisms in the dopamine D4 receptor gene have been linked to differences in traits such as vigilance and curiosity in horses [55] and behaviour during handling in cattle [87]. Nevertheless, it remains open to debate as to which individual, phenotypically expressed behaviour traits are valid measurements of the underlying, genetically determined personality dimension, and some traits important to equine practice seem to be missing in that model. Of particular interest to breeders are also models that attempt to distinguish between the inherited component of personality (i.e. the form of behaviour: how quickly and for how long, etc. the animal conducts a behaviour pattern) and the component shaped by the present and previous environment during ontogeny of the trait (i.e. the content of the behaviour: what the animal decides to do), and this differentiation is planned to be adopted by Polish horse breeding authorities (Aleksandra

Table 1 Overview of different models used to describe animal personality including a brief, subjective evaluation of strengths and weaknesses of different models

Name/definition of personality	Traits/categories	Categories mutually exclusive?	Limitations	Advantages	References	
					Key[1]	Sample[2]
Coping strategies/styles	Active Passive	Yes	Usually continuous rather than binary/bimodal distribution of behaviour profiles	Simple classification	[46]	[47]
Five factor model	Openness to experience Conscientiousness, Extraversion Agreeableness, Neuroticism	No	Some traits anthropomorphic and/or may be difficult to judge when assessing animals – e.g. conscientiousness	Widespread use in studies on humans	[48, 49]	[50, 51]
Temperament-character inventory	Harm avoidance Novelty seeking Reward dependence, Persistence Self-directedness Cooperativeness Self-transcendence	No	Traits important to practice seem to be missing	Widespread use; genetic basis partly in several species confirmed	[52, 53]	[54–56]
Four common aspects of different temperament definitions	Activity Reactivity Emotionality Sociability	No	Limited set of traits, other relevant traits missing	Straightforward definitions; traits highly relevant to practice	[26]	[57–59]
Using multivariate statistics to define traits	E.g. Gregariousness Reactivity	Partly	Limited consistency and agreement across studies	Optimal model for individual situation		[29, 47, 51, 60–69]
Behaviour traits evaluated in horse breeding programmes	E.g. Temperament, Character Willingness to work Ability to work Trainability Ride-/driveability Intelligence(see also Table 4b)	No	Poor definitions of traits, overlap, relevant traits missing, limited agreement between judges and breeding associations	Most traits highly relevant to practice	[70, 71]	see Table 4b
Form versus content; inherited versus acquired	Temperament (form of reaction, inherited) character (content of reaction, environmentally shaped)	No	Difficulties to distinguish between acquired and inherited components	Distinction highly relevant to animal breeding	*	
Four 'humours'	Sanguinic Phlegmatic Melancholic Choleric	Yes	Unclear which specific behaviour patterns are indicative of which 'humour'	Parallels to human behaviour may make concepts easily understood	[72]	[73]

*Personal communication: Aleksandra, Gorecka-Bruzda, 2012.
1=key references; 2=sample studies.

Górecka-Bruzda, 2012, personal communication). Similar trait distinctions are made by a few practitioners in other countries, too [88]. Therefore, based on the different strengths and weaknesses of different models, it is argued that it may actually be beneficial to maintain a variety of approaches until a universally valid model has been constructed. However, the parallel use of one common model and the subsequent development of a universally applicable model would be highly desirable.

Personality Traits in Livestock and Companion Animals

Of the different personality dimensions, temperament traits play a key role as functional traits in livestock. With particularly fearful and highly reactive animals, handling procedures may be slowed down [89], safety for both handler and animal decreases [90], and meat quality may be negatively affected e.g. in pigs [91], cattle [92] and poultry [93]. Aggressiveness and behaviour patterns leading to cannibalism are likewise traits of major importance to animal welfare and the livestock industry as they lead to stress, severe injuries and production losses and/or necessitate the routine introduction of painful procedures such as dehorning [94], castration [95, 96], tail-docking [97] and beak-trimming [98]. Maternal abilities [99] are of particular importance in animals managed under extensive husbandry conditions such as commonly the case with sheep and beef cattle. Depending on the intended use e.g. as a pet, guide dog, herd dog, hunting dog or a search dog, various personality traits beyond those related to temperament are of importance in dogs. They may include traits related to cognitive abilities [100], obedience [101] or protectiveness [102]. In horses, there are likewise a number of additional personality traits that are highly relevant to the animal's welfare and its suitability for different riding and work purposes. Unlike with other livestock species, behaviour traits can be considered to be performance traits, rather than functional traits, because of their direct relationship with the horses' suitability for different types of tasks [103]. Thus, it is for good reason that a large number of sport horse breeding associations (e.g. 11 out of 19 surveyed European breeding associations [70] or four out of five surveyed breeding associations from Europe and the USA [104] plus many additional breeding associations [105–108] not included in these surveys) evaluate personality traits along with the typical performance traits, i.e. the basic gaits and jumping ability. Evaluated personality traits include traits labelled character, temperament, willingness to work, ability to work, attitude to work, trainability, rideability/drivability and handleability [71, 80, 107, 109, 110]. Table 1 gives an overview of the different behaviour traits included in the breeding goals and/or evaluated by breeding associations. Notably the trait temperament is almost universally included in the evaluation. Some associations such as the Swedish Warmblood breeding association even distinguish between temperament during dressage and showjumping [111]. Both of the above facts point to the importance of this trait, which is, in spite of great differences between breeding associations, usually defined based on aspects of fear reactivity.

Validation of Personality Assessment Methods

Two major purposes may be distinguished for personality, or in particular temperament assessment: (a) the assessment of animals' suitability for a specific environment, i.e. how well a horse's personality suits to the specific task and (b) the assessment of animals' personality traits in breeding programmes, i.e. the use of individual animals' phenotypes to infer genotypes of their relatives. In any case, valid assessment methods are required. One problem in the validation of personality traits is that behaviour is, per definition, plastic. Therefore, traits defined on the basis of behavioural attitudes can be expected to have incomplete repeatabilities, thwarting attempts to validate assessment methods. For example, horses' reaction to novel stimuli is subject to habituation during repeated exposure [112–117], while generalization is limited to objects that are very similar in characteristics such as colour [118]. These facts imply that horses' reaction to one novel stimulus is not highly predictable of that horses' reaction to another novel stimulus. Nevertheless, three major prerequisites need to be fulfilled in order to ascertain validity of a particular method: reliability, repeatability and validity. Table 2 gives an overview of different measures undertaken to validate various methods for assessment of equine personality. Personality assessment methods most commonly include behaviour tests with or without measurements of physiological parameters, non-context specific ratings by owners or caretakers, and behaviour ratings by external observers during everyday situations. Just two studies focused on intra-observer reliability of equine behaviour traits [121, 137] although research in cattle suggests that high intra-observer reliability cannot be taken for granted, even if apparently objective measurements such as behaviour counts are taken [142]. In the majority of validation studies inter-observer reliabilities or repeatabilities across time are assessed. These figures are usually, though not always [47] high (Table 2), indicating that the horses' reactions can be assessed by independent observers with reasonable reliability and that they are consistent over time. However, publication bias may be present, such that studies yielding poor values may not have reported these values. Repeatability across situations tends to be considerably lower than across time [47, 57, 80]. Similarly, construct validity, such as e.g. correlation between different behavioural and physiological parameters used to measure the same trait is generally also rather weak (Table 2). Also correlations to real-life outcomes are

rarely assessed, except where owner ratings are considered real-life outcomes and subsequently used as a basis for comparison with results from behaviour tests [64]. Such mixed findings are also found in studies validating personality assessment methods in other livestock and companion species [18, 79, 143–150] as well as primates [4]. In addition to the above-mentioned validation steps, many authors argue that discriminant ability should also be fulfilled in order to consider a trait to be validated. However, the genetic architecture of most complex traits [151] is of a quantitative nature, implying that several thousand genes influence the trait in question as well as other traits simultaneously via genetic linkage or pleiotropy. For this reason, it appears unreasonable to insist on the absence of correlations of one trait with other traits. It is thus also not surprising that many personality studies [4] fail to show complete independence of different personality traits.

Assessment of Individual Horses' Personality to Infer Suitability for Specific Tasks

Personality tests are commonly suggested for use in matching animals with suitable owners [152] or for assessment of animals' suitability for specific tasks [145, 146, 153, 154]. In practice, for example specific 'calmness-tests' consisting of novel and startling stimuli are used to assess a horse's suitability as a leisure horse [155, 156], based on its level of fear reactivity. Although assessment is typically not based on such standardized tests, riding school [157], vaulting [158], mounted police [157] and therapy horses [125] are likewise usually assessed by the potential buyers for their fear reactivity. However, besides temperament, other personality traits play important roles in these tasks, too. For example, it has been suggested that one of the most important characteristics for a horse to be considered suitable for therapeutic riding would be the ability to form a positive relationship with humans along with an appropriate level of reactivity to environmental stimuli [159]. In vaulting horses, a high degree of sensitivity to tactile stimuli is undesirable as these horses have to cope with various, changing pressures exerted by the vaulters as they perform their exercises. Individual differences in tactile sensitivity exist [135], and more sensitive horses are likely to experience more pain or discomfort in this type of work. More recently, increasing attention has been diverted to tests allowing for optimization of the horse-rider match [160–162]. It is well known that the quality of human–animal interaction impacts both productivity and welfare of livestock [163], and there is some evidence that similar relationships exits with regard to human–horse interactions [164–166], as reviewed by Hausberger *et al.* [167]. Rider personality has been suggested to impact welfare and performance of the ridden horse, although this relationship does not exist universally but may only apply to more emotionally reactive horses [162]. There is also some indication that with horse-rider dyads that are rated as a good match, horses perceive less stress during novel object tests [168], although in this case horses' level of reactivity and familiarity with the rider seem to play a role, too [157]. Links between pets' and their owners' personalities have been suggested for dogs [169] and horses [160] although the observed correlations between personality traits were rather weak. However, analyses of co-variation in personality traits of human couples likewise revealed only weak associations between partners' personalities, including those couples that declared to be happy with their relationship [170]. These findings may indicate that a complete match of personality traits in a given dyad is not necessary for satisfaction with the relationship and perhaps even counteracts contentment. Potentially, an optimum level of agreement rather than complete agreement yields highest satisfaction, allowing for some room to complement each other with different personality traits.

Assessment and Selection for Personality Traits in Equine Breeding

Breeding strategies may be used in many different ways to impact animal welfare [171]. Personality traits are commonly evaluated in horse breeding programmes. However, just a few breeding associations (e.g. some draft-horse breeds [172]) use the obtained information to derive breeding values for personality traits that could be used in sophisticated selection decisions. Also, a review of studies dealing with health disorders leading to death or euthanization in horses (Table 3) revealed that only in three out of nine studied populations horses were indeed retired or culled because of temperamental disorders. These three populations included a population of Icelandic horses [174], coldblood draft horses [179] and thoroughbred race horses [178]. Interestingly the former two breeds are known for their calm temperament. Therefore, results seem to reflect the rigorous selection strategies that in part may have resulted in the calm temperaments of these breeds, rather than the high prevalence of temperamental problems in these breeds. From an ethics point of view, such selection decisions have to be seen critically, as appropriate training and management methods are likely to prevent or alleviate existing problems. In contrast from a breeding point of view, the culling of horses with undesirable behaviour that in part may be based on a 'difficult' personality is an appropriate step towards a sustained progress in personality traits. However, the reluctance to base selection decisions solely on personality scores assigned during performance tests seems justified. The subjectivity of the evaluation systems and the lack of variance in personality scores have long been criticized [180, 181]. Our recent work revealed that these problems persist [71, 80, 182, 183] in spite of

Table 2 Overview of results from studies undertaken to validate different aspects of equine personality assessment

References[1]	Parameter	Test situation	Method[2]	*n*	Repeated time	R. sit[3]	Intra-obs. reliability[4]	Inter-obs. reliability[5]	Repeatability	Construct/content/ criterion validity	Discriminant validity
[119]	Rideability	PT[6] rider	VC	435	6.5, 8, 11 m				0.58–0.70		
[120]	Stereotypic behaviour	Rearing, training, competition	VC	278	Pre-/post weaning, 12, 18, 24 m	x			0.41		
[39]	Reactive behaviour	NOT[7]	*r*	32						Tranquilizer lowered HR[8] during NOT	
[121]	Sexual behaviour	Video versus life recordings	r_p; % agree.	12	1 w		0.47–1.0 60–100%	0.67–1.0			
[122]	Behaviour in barn	PT	VC		25, 50, 80, 100 days				0.71–0.89		
	Character			206							
[45]	Temperament	PT	ICC		< 100 days				0.73–0.80		
	Character								0.61–0.83		
	Rideability			247					0.52–0.63		
[41]	Fearfulness	NOT	r_s	42		x				Arena-handling *r*=n.s.	
	Fearfulness	Handling								Handling-NOT *r*=0.48	
	Gregariousness	Arena test									
[31]	Fearfulness Gregariousness	Arena test, NOT, handling, instrumental task, memorization, detour, rating by rider	r_s	72		x				rs=0.24–0.44 between tests and rider rating	
[123]	Response time behaviour score	Optical/acoustic stimuli	VC	155	1, 1.5, 2, 2.5 y				0.3–0.61 0.32–0.68	Fillies higher *r* than colts	
[124]	Affectionate	Subjective ratings by familiar (>7 months) observer	r_s	20				0.25			
	Alert							0.37			
	Bold							0.00			
	Confident							0.29			
	Enthusiastic							0.40			
	Fizzy							0.42			
	Flighty							0.70			
	Honest							0.22			
	Intelligent							0.30			
	Laid Back							0.40			
	Lazy							−0.11			
	Moddy							0.45			
	Sensitive							0.12			
	Sharp							0.66			
[125]		Survey, NOT, cortisol (nor-)epi-nephrine	*r*, R^2	103				0.01–0.52 in 37% of horses		R^2=0.07–0.11 for ability to predict personality score by hormone concentrations	
[126]	HR	Novel environment and NOT	ANOVA	8						Increase after exposure	
	(Nor-)adrenaline									Increase after exposure	
	Cortisol									Increase after exposure	
	Vasopressin										
	Oxytocin									No increase	
										No increase	

[61]	Temperament	NOT handling	r_s, PCA	41	9, 10, 21, 22 m		0.36–0.81	Only within years; limited *r* across years	
[127]	HR, HR variability, activity	NOT, trained or untrained horses		41	9, 10, 21, 22 m		HR consistent between years	Exposure to NOT leads to decrease in HR variability, effect stronger in untrained horses	
[50]	Big five, confidence in rating	Familiar (Ø 2.8 years) rater	PCA	210				Neuroticism + extraversion rated with most confidence, openness with least	
[51]	Neuroticism Extraversion Openness Agreeableness Conscientiousness	Rater familiar (Ø 2.8 years) with horse	r_s	10		0.62 0.45 0.26 0.49 0.36		*r*=0.0–0.66 for individual traits; not all judges and all traits equally good	*r*=n.s. between five traits
[47]	Temperament, active/passive coping	Arena test, object test, human test, startle test questionnaire	r_s, PCA	33	3× after 9 days		only for arena significant *r* over time	Categorization in active/passive coping not possible; *r*=n.s. between test + questionnaire	
[62]	Personality	NOT, handling, avoidance/reward learning	PCA	41				Personality traits predict show-jumping performance	No correlations between tests
[63]	Temperament	NOT, handling, unfamiliar rider assessment	*r*, PCA	18				HR in test correlates with rating by riders	Handling, but not NOT correlate with rider rating
[128]	Learning ability	Avoidance learning, reward learning	r_s, PCA	39	2× at 14–15 m, 2×16–20 m later		*r* significant short term + for avoidance also long-term		No *r* between avoidance and reward learning
[28]	Temperament	Comparing survey and NOT + HR	r_s, r_p, PCA	86				Good agreement, e.g. horses rated more anxious had higher HR in test	Three independent traits: anxiety, novelty-seeking under-standing
[129]	Temperament	Comparing a survey of caretakers in two groups of horses	FA Cron-bach's α	69 and 70				Internal consistency (α=0.69–0.94) for anxiety, trainability and affability	Four factors common to both groups: anxiety, trainability, affability, gate entrance
[130]	E.g. locomotion, vigilance, time eating, HR	Novel visual, auditory, olfactory objects	ANOVA	24				Time spent eating correlated with all other variables, HR from auditory test correlated with other tests	Behavioural response linked to type of stimulus
[131]	Reactivity	Social isolation (Passing) novel object	Control with tranquilizer					No difference in HR between tranquilized/untranquilized horses *r*>0.33 with HR	
		Emotionality rating		40					
[64]	Behaviourally defined adjectives	Questionnaire + behaviour observations	*r*, PCA	61		Agreement in 72% of the horses		Significant correlation between behaviour test and rating	Six components identified, e.g. dominance

Table 2 (Continued)

References[1]	Parameter	Test situation	Method[2]	*n*	Repeated time	R. sit[3]	Intra-obs. reliability[4]	Inter-obs. reliability[5]	Repeatability	Construct/content/ criterion validity	Discriminant validity
[66]	Personality descriptive adjectives	Owner and trainer supplied information;	PCA	100							Agreement with five-factor model
		Agreeableness	ICC3,1					0.72			
		Extraversion						0.52			
		Neuroticism						0.45			
[132]	Behavioural reactivity	Veterinary examination	VC	4452					0.97–0.98	rg=0.9 between behaviour traits at different veterinary procedures	
[133]	Reactivity to humans	Familiar passive, familiar active, unfamiliar active human	r_s	110	8, 18, 30 m				For example time to touch: 0.40–0.67		
[134]	Reactivity to separation, isolation, attraction to, passing of/from conspecifics	Frequency of neighing, defecation, locomotion, etc.)	r_p	110	8, 18, 30 m	x			Time: $0.41 < r < 0.61$	Medium *r* between situations	
[135]	Behaviour during visual, auditory, olfactory, gustatory, tactile stimulation	Novel stimuli challenging different senses	r_s	26	5 m	x			Generally within one sense: 0.27–0.59		No correlation between reactions to different senses
[136]	Fearfulness	NOT passing novel object startling test	*r*	66	0.6, 1.5, 2.5 years	x			Many parameters with medium correlation across times fewer correlations over time, but HR was correlated		*r*=n.s. to NOT
[67]	Responsiveness	Open field, 12 observers	GPA, PCA	20					Semantically consistent word charts		2 axes: tractable, attentive
[137]	Temperament	NOT, handling	Cohen's Kappa	56	Video recording		0.14–0.92	0.09–0.85		Significant correlations between tests	
[138]	Reactivity to humans, Fearfulness	NOT, handling, human, startling, questionnaire familiar rater	r_s, FA	53						Medium correlation between questionnaire, and both tests	*r*=0.36 human test – fear measures
[80]	Temperament, Reactivity	Ridden NOT	VC	224	2–3 or 18 w			0.89–0.95	0.69–0.75	Medium correlation between reactions to different stimuli	n.s. correlateion to performance traits
[57]	Activity, reactivity, emotionality	NOT ridden, led, free-running	VC	65	3× in <10 min	x			0.10–0.45	Medium correlation between different measurements. No correlations to conventional personality traits from PT	
	HR, HR variability								0.57 0.23–0.25		
[139]	Behaviour counts during riding	Dressage training	r_p, R^2, VC	36	4× in 4 w					R^2=0.26–0.46 for behaviour to explain PT personality scores	

[140]	Behaviour counts + evaluations,	PT riding training dressage, cross-country,	VC, R^2	16		0.05–0.28	R^2=51.5 for behaviour (refusal jump, jumping manner, intensity of rider's aids) to explain 'willingness to work' score
	HR variability	NOT			4× in 70 days	0.75	
[141]	Social rank, fearfulness, learning, fecal cortisol, HR	NOT, negative/positive reinforcement, (un)familiar environment	r_s	25			$r=-0.66$ between HR in novel environment and performance in negative reinforcement task; $r=-0.43$ between fecal cortisol from familiar environment and social rank; r=n.s. between performance in negative and positive reinforcement

1=References; 2: r_p=Pearson correlation, r_S=Spearman correlation; agree.=agreement, VC=calculations based on variance components from analysis of variance, ANOVA=analysis of variance, ICC=Intraclass correlation coefficient, R^2=coefficient of determination from regression analysis, FA=factor analysis, PCA=principal component analysis; 3=repeated over altered test situations (x=yes; situations listed under methods); 4=intra-observer reliability; 5=inter-observer reliability; 6=performance test on station; 7=novel object test; 8=heart rate.

several attempts by breeding organizations to improve the situation [172]. In fact, the observed grade inflation [183] that can in part be attributed to economic competition between testing stations [71] suggests that problems continue to worsen. The lack of appropriate guidelines, the lack of reliance on existing guidelines and severe problems with the trait definitions in the existing guidelines [71, 182] allow for misuse of scores, e.g. to promote specific horses or to increase attractiveness of a testing station to breeders [71, 172]. However, judges and breeding authorities are aware of the problems [71, 182] and many attempts have been undertaken to develop assessment procedures that allow for a more objective assessment of personality traits [57, 58, 80, 137–139, 184–188]. Such a better consideration of personality traits in breeding programmes seems imperative, given the strong link between animal behaviour and rider and animal safety [189]. The importance of personality is further underlined by the value breeders [106, 190] and potential buyers both from the leisure riding sector [190–195] as well as from the professional or competition riding sector [190, 196, 197] assign to personality traits. At present a mismatch between purchasers' expectations and vendors breeding and sales strategies seems to exist [195, 198, 199], indicating that a greater emphasis of personality characteristics by vendors may be needed to align their and the customers' wishes. Although some differences in the relative importance of different personality characteristics exist between riders of different disciplines [200], groups or proficiency levels [190], remarkably, almost all of the above studies [106, 190–194, 196] invariably and independently from each other detected that personality traits were rated by the horse enthusiasts as more important than any of the conventional performance traits such as the gaits or jumping ability.

Genetics of Personality Traits

Domestication is known to be based largely on selection for tameness as impressively shown by selection experiments in foxes [201, 202], and there is thus little doubt that behaviour traits possess some genetic background. Breed [65, 80, 107, 203–205] and genetic-line [206, 207] or sire-line [41, 203, 208–211] differences in personality traits have frequently been reported in equine studies. Also, the level of inbreeding may [38] or may not [212] influence personality traits, depending on the breed and the traits in focus during (in)breeding. Yet, relatively few studies were specifically designed to estimate genetic parameters for equine behaviour traits (Table 4a). In comparison, various studies report genetic parameters for personality traits evaluated in horse breeding programmes (Table 4b). Heritability estimates for these personality scores from performance tests range from values not significantly different from 0 to 0.40. However, all values suggesting a low heritability are estimated based

Table 3 Prevalence of temperamental disorders leading to termination of functional and/or biological life in relation to other groups of health disorders in different riding, breeding or racing horse populations

Reference	[173]	[174]	[175]	[176]	[177]	[177]	[178]	[179]	[179]
Data:									
Type of horses	WB[1]	IC[2]	WB	MI[3]	WB	WB	TB[4]	CB[5]	WB
Gender of horses[6]	♂	all	♀g (♂)	♀g	all	All	all	♀g	♀g
Use of horses[7]	Breed	Ride	Ride	Ride	Ride Breed	Ride School	Race Breed	Work	Ride
Functional longevity?[13]	✓	✓	✓	✓	–	✓	✓	✓	✓
Biological longevity?	✓	–	–	–	✓	–	–	–	–
Data source	Studbook	Survey	Insurance	Insurance	Insurance	Insurance	Survey	Survey	Survey
Time frame	1975 2010	ca. 1997 2002	1977 1987	1997 2002	1984 1994	1984 1994	2002 2003	1970 1975	1968 1982
Group of health disorder/ affected system	Frequencies of disorders (%)								
				[8]		[10]	[11]		[12]
Respiratory	10.3	0	16.3	4.1	7.8	10	< 31	2.1	8.9
Reproductive/urinary	0.8	0	1.2	–	7.8	< 5	< 31	–	0.4
Cardiovascular	6.4	0	4.6	–	13.9	< 5	< 31	0	2.6
Infectious/nervous	1.6	1.0	2.8	–	2.3	5	< 31	3.7	5.6[12]
Musculoskeletal	4.8	54.1	61.2	76.0	32.7	83	< 31	13.4	55.5
Other/unknown	35.0	2.0	–	10.2	5.2[9]	< 5[9]	16.8	15.5	4.2
Trauma/accident	4.0	12.2	–	17.7			< 31	3.1	9.1
Gastrointestinal	7.9	3.1	9.8	10.1	35.5	< 5	< 31	6.2	5.6
Performance	29.4	11.2	–	–	–	–	36.5	–	–
Temperament	0.0	16.3	–	–	–	–	6.4	20.0	< 5.6[12]

[1]=Warmblood; [2]=Icelandic horse; [3]=mixed breeds; [4]=thoroughbred; [5]=coldblood; [6]: ♂=stallions, ♀=mares, g=geldings; [7]breed=breeding, ride=riding, school=riding school horses, work=draft and/or cavalry work; [8]categories not mutually exclusive; [9]respective category included with 'other'; [10]approximate values; [11]detailed health disorders not further specified; illness and injury accounts together for a total of 31% of losses; [12]temperament included with disorders of the nervous system; [13]✓=yes, –=not recorded.

on data collected in the field. Unfortunately, individual variance components are not always given, but based on the differences between field and station data it could be speculated that the low values in the studies based on field records are mainly based on large phenotypic variances, which in turn are based on strong environmental influences, rather than a complete lack of additive genetic variance. However, as indicated above, and also highlighted earlier [172, 180] the present evaluation system for personality traits in horse breeding is flawed, so statistical properties of the scores are suboptimal and the corresponding genetic parameters have to be seen with great caution.

Based on specifically designed personality tests, horses' reactions to novel objects (h^2=0.17–0.90) during handling situations (h^2=0.23–0.28) or in learning tests (h^2=0.15–0.89) seem to be moderately to highly heritable (Table 4a). Similar to the estimates based on conventional personality scores, some restrictions apply such as low sample sizes and violation of parametric assumptions. However, the majority of estimates, including those from studies based on large sample sizes [132], are in a moderate range (h^2=0.15–0.40). These values support the view that selection schemes focusing on these traits could be successfully implemented into breeding programmes, as already the case with a number of breeding organizations [187, 237, 238]. Furthermore, genetic correlations to other relevant performance traits appear to be generally low, and mostly of a synergistic nature. For example, according to our recent work [59], scores for reactivity in a novel object test show a genetic correlation of r_g=0.41 ± 0.33 to the scores for the quality of the gait trot and of r_g=0.69 ± 0.26 to scores for rideability, indicating that genetic selection for calm reactions in a novel object test will entail genetic improvement of the trot and rideability. Nevertheless, some consideration should be given to both ethical and economical aspects before setting up a rigorous selection scheme focusing on personality traits. For example, physical problems should be ruled out before attributing unwanted behaviour such as head-tossing during riding to poor personality characteristics of the horse [139].

Possibilities of Selection for Personality Traits other than Temperament-Related Traits

Compared with aspects of temperament, and in particular fear reactivity, little research has focused on other personality traits. However, some of these other personality

traits seem to be just as important to the riders [106, 190, 239], and at least indirectly also to equine welfare. Tables 1 and 4b list different personality traits currently considered in various breeding programmes, implying that they are considered to be highly relevant traits by practitioners. Surveys among riders [190, 194] and breeders [106, 190] revealed that traits such as rideability, willingness to work and sensitivity are just as important as temperament-related traits. Furthermore, a tight link between personality and performance seems to exist, at least based on the scores from conventional performance tests [80, 240]. Recent attempts of moving towards a more objective assessment of these additional personality traits include the assessment of rein-tension as an objective indicator of the intensity and quality of rein contact as an important component of rideability [241]. Considerable attention has also been paid to direct behavioural observations during different situations important to practitioners such as behaviour during ridden dressage training [139, 242], cross-country training [140], or during handling and leading [243] and veterinary inspections [30, 132]. Some of these studies detected links between specific behaviour patterns such as head-tossing [139, 242] and refusal to jump with the traits rideability and willingness to work, respectively, as assessed during conventional performance tests. Based on these links it is suggested that some of these detailed behaviour patterns should be specifically considered in personality evaluation as they would make the assessment more objective. At present, the situation is further complicated by traits bearing the same label, but which may be defined quite differently in different breeding organizations. For example, in Dutch warmblood breeding, the trait character is defined as a 'score for behaviour during the training of all traits. Character is clarified by concepts such as pleasant companionship, intelligence, courage and willingness to perform', while behaviour in the stable is defined as a separate trait [122]. In contrast, in German warmblood breeding, the trait character focuses on behaviour during handling and in the barn only, and is defined as the 'handleability and behaviour towards humans, the time taken to accustom to the testing station, the overall body posture and behaviour, and in particular behaviour during grooming and tacking' [244].

One of the major areas in which selective breeding on personality traits could help to improve equine welfare is the selection of animals better adapted to confined housing, as suggested also for zoo animals [245], and in particular to individual housing. Rebound effects in exercise after box housing [246] increases risks for injuries, and social separation is stressful to horses even if they are familiar with the surroundings [247]. Breed differences in responsiveness to arena tests involving social separation are present [203, 215], demonstrating that horses of some breeds may be better able to cope with the situation and thus experience less stress when isolated from conspecifics. Similarly, low levels of agonistic interactions in specific groups of horses have been attributed in part to the temperament of that breed [248]. Although little is known about the within-breed additive genetic variance for these traits, it therefore seems likely that such aspects of social behaviour could be changed by selective breeding, and consequently could be used to positively influence animal welfare. In pigs, selection for social behaviour and in particular low aggressiveness has long been in the focus of research [148, 249]. Heritability estimates for aggressiveness and related indicator traits [249, 250], suggest that a selection on these traits may, in theory, be possible in pigs. However, as pointed out by Muir [251], traits related to establishing of dominance hierarchies may be difficult to change when focusing on selection based on individual's performance. Therefore strategies based on group selection, considering the performance of the entire group rather than just individuals within groups [251] may be a more successful strategy for changing traits related to social behaviour. In fact, other personality traits unrelated to social behaviour may also develop differently depending on the personalities of surrounding individuals. Personalities may best function, e.g. based on conflict avoidance [1], if there are large individual differences within an existing group, and thus personalities may form in dependence of personalities of group members to fill in free niches. These theories are supported by recent findings in pigs that genetic clones differed insignificantly less from each other in personality traits compared with a group of distantly related pigs reared and kept under the same husbandry conditions [252]. Likely, the same principles apply to horses, too, making selection for traits related to social behaviour difficult. Moreover, the standardized collection of data related to social behaviour is time-consuming, and costs in relation to profits may be prohibitive for inclusion in horse breeding goals. Even in a fairly long-term perspective it appears to be more economical to fit the environment to the animal rather than taking the opposite approach.

Personality traits related to intelligence and learning ability are likewise expected to impact equine welfare as slow learners will experience repeated negative reinforcement or punishment, while exceptionally intelligent or fast learning horses might likewise experience undue amounts of punishment as they might make undesired associations between unintentional cues and events. A large number of studies focused on various aspects of equine learning behaviour, although most commonly, studies on equine learning are based on positive reinforcement [253–259] rather than negative reinforcement [211, 260, 261], which is the most commonly used method in practical horse training [262, 263]. Since learning based on rewards via food or pleasurable tactile stimuli likely relies on fundamentally different underlying motivations compared to learning based on negative reinforcement via tactile stimuli, it is uncertain in how far results from the former studies are transferable to most practical settings. However, connections may nevertheless exist between

different types of learning as the same anatomical structure seems to be involved in processing of reward and unpleasant touch as occurs in negative reinforcement [264]. Either way, traits related to learning would deserve in future more attention in both research and practice. Some recent attempts to consider learning in breeding programmes include the assessment of speed of habituation in repeated novel object tests [80].

Potential Constraints in Selection for Personality Traits – Relationship between Personality, Performance and Welfare

A review of primate literature also suggests that individual differences in personality may impact welfare or call for individual adaptation of management and training strategies to secure a certain level of welfare [265]. Riders commonly believe that breeding for calm, less reactive horses will result in dull, less sensitive and low-performing horses. However, personality traits assessed during conventional performance tests almost invariably show desirable phenotypic and genetic correlations with performance traits (Table 4a, b [80, 266]). Equally, a number of studies using behaviour tests or ratings during working situations [58, 80, 267–269] found few antagonistic correlations and in many instances the presence of desirable correlations between aspects of temperament and performance in basic gaits, jumping or racing. In contrast, highly reactive horses may be more prone to injury: Lam *et al*. [270] suggested that higher tendon injury rates in stallions might be a result of a more difficult temperament caused by higher levels of male hormones. However, no such relationship was observed between temperament and susceptibility to colic [271], although stress is thought to be a predisposing factor for colic [272]. Therefore, overall a more rigorous selection for behaviour traits seems to be plausible. However, before specific traits are implemented into selection schemes of breeding programmes, these traits need to be validated, and genetic parameters estimated to assess the potential for a successful selection on these traits. Furthermore, economic weights would be necessary for reasonable weighing of the different breeding goal traits, but are notoriously difficult to obtain in horse breeding and for behaviour-related traits [106, 196, 273]. Although for a number of traits and testing regimens these prerequisites are fulfilled (see above and below chapters), and costs for assessment can be kept below the level, owners would be willing to pay additionally for an objective assessment [186], some breeding organizations remain reluctant to introduce new traits into their selection schemes as it would entail relaxing selection on the performance traits. Furthermore, breeders fear that deliberate manipulation may be an issue, in particular, with specific behaviour tests [71, 80]. Although specific training of behaviour traits is possible, the same applies to performance traits [274], and may be used to indirectly assess horses' trainability. In the distant future, genomic selection might help to overcome trait manipulation. Provided that conventional breeding values with sufficient accuracies can be obtained, considerable gain in breeding value accuracies can be expected especially for lowly heritable traits [275].

Influencing Personality by Interventions during Ontogeny of Personality Traits

The influence of early experiences on cognitive development and on later expression of personality traits has long been known from laboratory animals [276], and some results from livestock species are also available. For example, in pigs, marginal differences in housing during rearing resulted in differences in pigs' subsequent reactions to novelty and handling [277]. Perhaps because of the requirement of long-term studies and their limited feasibility in equine research, comparably little research has been conducted regarding possibilities to take influence on the ontogeny of equine personality traits. Temporary effects on horses' fear reactions or learning performances regarding the influence of e.g. diet [278], specific calmatives [279, 280], predator odour [281], restriction of the visual field [282], the presence of other horses [283], or the possibility to observe another horse in a given situation [284], the presence or actions of humans [57, 115, 285–289] and the rider's riding style [290, 291] or training method [292] are well documented, but comparably little is known about possibilities to permanently influence equine behaviour traits. Nevertheless, some interesting results are available on how handling or housing regimens [293, 294] earlier in a horse's life can influence later behavioural attitudes or stress responses ([295–297], reviewed in [298]). Considerable research efforts have been undertaken to assess the impact of various foal or weanling handling regimens (including e.g. habituation to human contact and handling procedures such as haltering or picking up feet) on their handleability and trainability later in life [68, 73, 299–306] (Table 5). Somewhat disappointingly, most studies failed to reveal positive, long-lasting effects of these handling regimens [308], although in a few studies positive effects such as improved handleability and trainability were evident after periods of as much as 1.5 years [304] (Table 5). Positive effects were also transferred to the foals' reactions to unfamiliar humans [68]. On the other hand, negative effects of neonatal handling on social behaviour are also described. In the absence of additional experiences with humans that might overshadow past experiences, positive [309] or even one single negative experience with humans, such as a veterinary treatment [310], appears to have lasting effects on horses' reactions to humans. Similarly, positive handling of the mare rather than the foal appeared to have lasting (1 year) effects on a foal's behaviour towards humans [311]. Differences in juvenile

Table 4a Genetic parameters for equine behaviour assessed via specific behaviour observations taken during tests or everyday situations

Reference	Trait	Assessment/situation	Scale	Breed	n[10]	h^2	Correlated to trait	r_g
[213]	Trainability	Owner rated	Score 1–5	SB[1]	159 (31 sires)	0.10 ± 0.32	n.c.[11]	n.c.
[120]	Stereotypic behaviour	Rearing + training	?	TB[2]	278 (6 sires)	0.13–0.79	n.c.	n.c.
[214]	Timidity	Novel objects	Scores	MA[3]	593, 424, 127	0.39–0.90	n.c.	
	Memorizing ability	Labyrinth	?	WI[4] SI[5]		0.15–0.89		n.c.
[215]	Emotionality	Arena test	Index-scores	SF/16 dif.[6]	246/703 (5583)	0.39 ± 0.26/0.42 ± 0.11	n.c.	n.c.
	Reactivity	Novel object				0.40 ± 0.24/0.29 ± 0.12		
	Reactivity	Bridge	Sec.			0.81 ± 0.17/0.24 ± 0.10		
	Intelligence	Chest opening	Sec.			0.48 ± 0.20/0.36 ± 0.13		
	Memorizing ability	Memorization chest opening	Sec.			0.28 ± 0.21/0.17 ± 0.14		
[132]	Reaction to: Inspection of conjunctiva	Routine veterinary examination	Score 0–3	TB[2]	4452 (10 590)	0.25–0.26	Auscultation	0.81–0.91
	Auscultation					0.23–0.26	Blood sampling	0.85–0.88
	Blood sampling					0.27–0.28	Conjunctiva	0.88–0.99
[187]	Emotionality	Bridge – driving	Score/linear 1–9	FM[7]	520	0.26	n.c.	n.c.
	Emotionality	Bridge – riding				0.17		
	Emotionality	Novel object – riding				0.23		
[58, 59]	Reactivity	Novel object test	Score 1–10	WB[8], PO[9]	575 (10 970)	0.27 ± 0.08	Reactivity – basic gaits	0.28–0.72
	Activity		−5–5			0.40 ± 0.22		
	Emotionality		−5–5			0.26 ± 0.21		
	Time to calm down		Sec.			0.32 ± 0.21	Reactivity – rideability	0.67 ± 0.69
	Intensity of rider's aids		1–10			0.17 ± 0.29	Reactivity – free jumping	
	Attention to environment		%			0.21 ± 0.13		−0.04 ± 0.15
	Attention to rider		%			0.18 ± 0.11		
	Attention to stimulus		%			0.00 ± 0.01		

1=Standardbred; 2=Thoroughbred; 3=Malopolski; 4=Wielkopolski; 5=Silesian; 6=Selle Français (first values for heritability) and 16 different breeds, including the 246 Selle Français (second values); 7=Franches Montagnes; 8=German Warmbloods; 9=mixed breeds of ponies; 10=values represent number of tested animals (and number of animals/sires in the pedigree); 11=not calculated.

Table 4b Genetic parameters for equine personality traits assessed during performance tests

Reference	Trait	Assessment/ type of PT	Scale	Breed	n[13]	h^2	Correlated to trait	r_g
[216]	Temperament	Field	Score 5–10	IC[1]	1171	0.14	Performance, personality	Low but positive
	Character					0.20		
[180]	Temperament	?		HB[2]	284, 295 (31 sires)	0.03–0.11		
	Character					0.07–0.38		
	Obedience					0.12–0.09		
[217]	Temperament	Field	Score 5–10	IC[1]	3975	$0.13 < h^2 < 0.53$		
	Character							
[218]	Temperament	Station	Score 1–10	HA[3], WB[4]	730	ca. 0.10		
	Character							
[219]	Temperament	Station	Score 1–10	HO[5]	286	0.76	Influence of training status prior PT	
[220]	Character	Field	Score 1–10	KW[6]	2023	0.06 ± 0.04	Gaits dressage in competition	0.42–0.87
	Rideability					0.03		0.83
[122]	Character	Station, 3 judges	Score 1–10	KW[6]	206	0.24–0.52		
	Behaviour in stable					0.31–0.65		
[111]	Riding temperament		Score 1–10	SW[7] WB[4]	3601	0.27	Jumping ability external conformation	0.42
	Jumping temperament					0.14		0.74
[221]	Character	Station	Score 1–10	HA[3]	994	0.27		
	Temperament					0.30		
	Willingness to work					0.24		
[222]	Character	Station	Score 1–10	WB[4]	2207	0.18		
	Temperament					0.26		
	Willingness to work					0.14		
	Constitution					0.10		
[223]	Temperament	9 judges	Linear 0–10	HF[8]	3902	0.06	Docility	-0.84
	Docility					0.02		
[224]	Character	Station	Score 1–10	WB[4]	2815	0.21		
	Temperament					0.26		
	Willingness to work					0.29		
	Constitution					0.35		
[225]	Temperament		Score 1–10	PR[9]	1273	0.08 ± 0.04	Performance traits	Not converged
[226]	Temperament	Field/station		HF[8]	660	$0.2 < h^2 < 0.7$	No antagonistic correlations	
[227]	Temperament	Station	Score 1–10	SW[7]	359 (8918)	0.23 ± 0.14	Jumping	0.79 ± 0.19
	Free-jumping					0.33 ± 0.23	Jumping; n.s. to gaits	0.90 ± 0.06
	Temperament							
	Jumping							
[228]	Handleability			HF[8]		0.09		
	Willingness to work					0.10		

[229]	Nerve strength	Field	Score 1–10	SG[10]		0.14		
	Willingness to work					0.14		
	Concentration					0.17		
	Handleability					0.22		
[230]	Riding temperament	Field	Score 1–10	SW[7]	801	0.38 ± 0.11		
	Jumping temperament					0.51 ± 0.12		
[231]	Riding temperament	Field	Score 1–10	SW[7]	70 896 (2 25 921)	0.29	Gaits and conformation	0.34–0.85
	Jumping temperament					0.21	Jumping traits	0.70–0.90
[232]	Temperament	21 judges	Linear	IH[11]	7004	0.26 ± 0.03	Meat/muscularity characteristics	Mean: 0.12 ± 0.07
[233]	Spirit	Field	Score 5–10	IC[1]	39 443	0.29 ± 0.05 – 0.63 ± 0.02		
[234]	Character	Studbook inspection	Score 4–10	FI[12]	6596 (876 sires)	0.12 ± 0.02		
				SB[13]	2112 (551 sires)	0.17 ± 0.06		
[235, 236]	Cow sense/cutting ability	Competition	Score	QH[14]	92 (34 sires)	0.04		

1=Icelandic horses; 2=Halfbred; 3=Hanoverian; 4=Warmbloods; 5=Holstein; 6=Dutch Warmblood; 7=Swedish Warmblood; 8=Haflinger; 9=Spanish Pure Bred; 10=Southern German Draught Horse; 11=Italian Heavy Draught; 12=Finnhorse trotter; 13=Standardbred trotter; 14=values represent number of tested animals (and number of animals/sires in the pedigree).

or adult horses' behaviour during and following different training regimens generally revealed advantages of more sympathetic or positive reinforcement approaches [312–316], but again, studies on long-term effects are missing. Nonetheless, since horses seem to be capable of learning to learn [317], such training strategies might result in a permanent improvement of learning abilities.

Personality traits of dams may also impact welfare of their offspring. For example, less fearful mares showed higher levels of agitation during separation from their foals [318], perhaps indicating that these mares had better maternal abilities and better offspring survival, as shown e.g. in sheep [319]. More importantly, the weaning time and method [320–324] is another crucial management procedure that may have lasting effects on the animal [325–327]. Complete maternal deprivation impacts personality [328], though appropriate management may result in most behaviour traits not being affected [329]. However, orphan foals appeared to learn slower [330] and show more stress during social separation [331]. Weaning is considered to be one of the most stressful events in a horses' life as it generally entails the simultaneous break of the nutritional and social bond between foal and mare [323]. A large proportion of stereotypies in horses develop just after weaning. Although the true function of stereotypies is still unknown it has been suggested that they may act as a coping mechanism during stressful situations [332] including in particular the frustration of behavioural needs [333, 334]. As the predisposition to develop stereotypies seems to be heritable [120, 335, 336] and not all horses develop stereotypies under the same management conditions, and because there are links between the expression of stereotypic behaviour and personality characteristics such as learning [337] and perseveration, the expression of stereotypic behaviour might provide important information on equine personality. Interestingly, the prevalence of stereotypies in formerly feral horses was surprisingly low [338], possibly indicating that a stimulus-rich environment during rearing enables neural circuits to form that later help the individual to cope with the various stressful situations during confined housing and managed feeding. Links between type of work and personality [339] or stereotypies [340] have also been described, although the causal relationship is not always clear. Potentially, horses with certain personality characteristics are more likely to be selected for certain types of work rather than that factors such as work-specific handling or 'learning to learn' have a large effect. The type of housing is likewise suggested to influence handleability and trainability, although less is known about long-term effects. For example, group-housed horses seem to experience less stress during weaning [341], show improved social behaviour [342], are easier to handle [343], and are more efficiently trained [307, 344]. The general importance of the animal's social group to expression of individual personality has been reviewed for different species [345]. Obviously,

Table 5 Duration of effects of different handling/management regimens on personality-related parameters

Reference	Handling/management regimen[1]	Age[2]	Parameter[3]	No effect[4] (time)	Effect[5] (max. time)
[68]	1 m 45 min/day handling	ca. 16 m	Behaviour before/after handling		End
[73]	14 d daily handling	foals	Proportion of time resistant	1 y	6 m
[294]	Forest or stable reared; handled or non-handled	2 w–24 m	Behaviour score for various handling procedures		End End
[297]	3 m single versus paired housing	2 y	Stereotypies, HPA-function[6]		End
			Reaction to novel object	3 m	–
[302]	14 d (un-)forced contact	Weaning	Reaction to human, haltering	>4 m	4 m
[303]	1 h separation from dam	0 d	Mare-foal-bonding, social behaviour		1 y
[304]	0–1 y handling	2 y	Learning ability		End
[305]	0–120 d, different intensities	0 d	Learning ability, manageability	16 d	0
[306]	0 versus 5 d daily handling	0 d	Calmness, friendly, handling		4 m
[307]	6–24 m single versus group housing	6 m	Handling, aggression towards humans		End
[308]	(Un-)forced contact	0 d	Human approach		2 w
[309]	pos./neg. reinforcement	1 y	Human-animal relationship		8 m
[310]	12 d daily handling	Weaning	Fitting halter, picking up feet, being led	18 m	18 m
[311]	5 d human-mare contact	0 d	Human approach, handling		1 y

[1]m=month; d=days; y=years; pos.=positive; neg=negative.
[2]Age at which handling/management regimen started; w=weeks.
[3]Parameters assessed during later tests.
[4]Period of time after which no effect of handling/management regimen could be detected.
[5]Maximum period of time after which an effect in at least one of the measured variables could be detected; end=there was an effect immediately at the end of the treatment regimen, but no tests were conducted at a later time.
[6]HPA=hypothalamus-pituitary-axis.

behavioural expression of personality traits is also influenced by health and physical conditions [346]. For example, if a horse's vision is impaired it will have greater difficulties in learning tasks based on visual stimuli, and depending on the type of impairment, reactions to novel visual stimuli may be enhanced or lowered. Links between visual ability and general personality have also been suggested in humans [347], highlighting the importance of prior experiences on personality.

Conclusions

Some reliable and valid personality assessment methods are available, and an accurate assessment of animal personality could contribute to improvement of animal welfare, and equine welfare in particular, by better matching horses to certain tasks and owners, as well as by use as a selection tool in animal breeding. By these means, equine welfare can either on an individual level or in the long term on a population level be enhanced, as horses will be better suited to their training and husbandry regimens and thus experience less stress. Possibilities to influence personality via early handling or management interference also seem to exist, although little is known about long-term effects. A variety of different personality classification models exist, and there is no consensus on which model is best suited to describe equine personality. The majority of models entail specific advantages that may be missing in other models and it is therefore argued that the frequent call for more standardized methods may be too early. However, it is suggested that the term personality is the most suitable descriptor of all traits relating to animal behaviour. To avoid confusion with existing personality traits in equine breeding, the term temperament should be reserved for a sub-trait of personality including but not limited to aspects of fear-reactivity.

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