Table 1. Current studies and methods to assess human-animal-relationships in various animal groups

Method	Description	Species applied to	Context	Results & method comments	References
Methods of Behavioural Assessment (MBA)	Keepers rate animals on behavioural elements using a questionnaire.	Black rhinoceros *(Diceros bicornis)*	Individual behaviour profiles in relation to breeding success.	Ratings by keepers of behaviour attributes can be used as reliable and valid cross-institutional descriptions of individual differences to correlate with environmental variables.	Carlstead et al., 1999a, 1999b
Behavioural scoring	Scoring specific behaviours during HAI events (e.g interactive behaviours during a cue or command from keeper)	Chimpanzee (*Pan troglodytes)*	Effect of positive HAIs on chimpanzee behaviour	Positive behavioural changes were observed when study chimpanzees were provided additional positive human interaction. Levels of abnormal behaviour fell.	Baker, 2004
		Gorilla (*Gorilla gorilla gorilla*)	Effects of increased social interaction with a human on abnormal behaviours	Reduced abnormal and aggressive behaviours following periods of social interactions with human	Pizzutto et al., 2007
		Lowland gorilla (*Gorilla gorilla gorilla*)	Effects of positive reinforcement training and playing from keepers on gorilla behaviours.	Positive changes found with reduced stereotypies and aggressive behaviours, and increased social play- related behaviours.	Carrasco et al., 2009
		Ungulates (12 species)	Behavioural response of ungulates to keeper presence	Visual orientation was the most frequently scored behaviour, differences found in vigilance between female and male ungulates to keeper and visitor presence. Instance of aggression towards keeper required adjusting procedure of human presence to include a physical barrier.	Thompson V. D. 1989
		Sumatran orangutan (*Pongo abelii*), Western Lowland gorilla (*Gorilla gorilla gorilla*)	The effect of familiar and unfamiliar humans on great ape initiated, human directed behaviours.	Behaviour patterns indicated more negative relationship with unfamiliar humans, and positive with familiar humans. Affiliative behaviours classified as "close" (<3m) or "distant" (>3m), where positive relationship expected to be characterized by high levels of "close" behaviours.	Smith, 2014
Distance parameter	Measure spatial parameters and behavioural scoring during HAI event (e.g. distance of animal from keeper performing a cue or command)	Meerkat (*Suricata suricatta*)	Effect of visitors (unregulated and regulated visitor behaviour)	No effects of reduced intensity of visitor behaviour on meerkat behaviour. Distance measuring apparatus used, enclosure design must be considered. Suggest investigating physiological responses in addition to behavioural.	Sherwen et al., 2014
		Sumatran orangutan (*Pongo abelii*), Western Lowland gorilla (*Gorilla gorilla gorilla*)	The effect of familiar and unfamiliar humans on great ape initiated, human directed behaviours.	Behaviour patterns indicated more negative relationship with unfamiliar humans, and positive with familiar humans. Affiliative behaviours classified as "close" (<3m) or "distant" (>3m), where positive relationship expected to be characterized by high levels of "close" behaviours.	Smith, 2014
Response to cues	Measure latency and distance during HAI event (e.g. animal being asked to perform specific behaviour)_	Black rhinoceros (*Diceros bicornis*), Chapman's zebra (*Equus burchellii*), Sulawesi crested macaques (*Macaca nigra*)	Investigate unique keeper-animal dyads in zoos	Significant difference in the animals' latency to appropriately respond after cues and commands from different keepers, indicating unique keeper-animal dyads were formed.	Ward and Melfi, 2015
		African elephant (*Loxodonta africana*), Rothschild giraffes (*Giraffa camelopardalis rothschildi*), Brazillian tapir	Response to familiar and unfamiliar keepers	Animals found to distinguish between un/familiar keepers, more locomotion towards familiar keepers. Further investigation of behavioural and hormonal responses necessary to fully quantify findings.	Martin and Melfi, 2016

		(*Tapirus terrestris*),			
Qualitative behaviour Assessment (QBA)	QBA uses free-choice profiling in which observers generate their own descriptive vocabularies of how an animal behaves based on observing the whole animal from numerous video clips	Dairy calves (*Bos primigenius)*	Stockperson handling style	Stockpersons who handle calves patiently and calmly during handling have animals with higher levels of friendly and content animals. Suggest QBA valid method to assess handling style.	Ellingsen et al., 2014
		Dairy buffaloes (*Bubalus bubalis*)	Isolation tests with different observers groups	Meaningful association between quantitative and QBA; QBA play valuable role in interpreting animals' state. Good inter-observer agreement between observer groups	Napolitano et al., 2012
		Horses Ponies (*Equus caballus*)	Responsiveness to environmental challenge during an open field test	Appropriate methodology to study horse behavioural responsiveness, provided characterisation of behavioural expression, which were in agreement with quantitative assessments.	Napolitano et al., 2008
Reaction to handling	Behavioural and physiological parameters measured during handling tests. Methods usually involve responses to leading or moving, capture, restraint, and specific handling events such as veterinary procedures.	Rabbits (*Oryctolagus)*	Effect of handling between un/familiar human	Reductions in fearful reactions with increased handling.	Podberscek et al., 1991
		Horses (*Equus caballus),* Donkeys (*Equus asinus*)	Assess the use of HAR methods between horse facilities	Method proved feasible, high observer agreement, good repeatability of tests (at 3-month intervals) in on-farm environment for both species.	Dalla Costa et al., 2015
Voluntary Approach	A test person enters an area and stands stationary, the latency of an animal to approach is recorded (or % for a group of animals within fixed time). An approach behaviour is defined as the animal approaching a stationary human; must be pre-defined.	Dairy goats (*Capra hircus)*	HAR method testing to assess on-farm welfare.	For goats VA test seems to be most suitable option for assessing on-farm welfare. Suggest performing behavioural tests following separation of males and females.	Battini et al., 2016
		Piglets (*Sus domesticus)*	Unfamiliar and familiar human	Suggests early handling changed the way pigs reacted to challenging situations; handled pigs showed less fearful behaviours during handling and novel environment.	De Oliveira et al., 2015
		Horses (*Equus caballus*), Donkeys (*Equus asinus*)	Assess the use of HAR methods between horse facilities	Method proved feasible, high observer agreement, good repeatability of tests (at 3-month intervals) in on-farm environment for both species.	Dalla Costa et al., 2015
Avoidance distance test	The latency of an animal to avoid (e.g. walk away) from an approaching human is recorded in addition to behavioural responses of the animal. The test ends when the animal withdraws and moves away from the human. AD: minimum distance in which an animal will allow moving person to approach.	Horses (*Equus caballus*), Donkeys (*Equus asinus*)	Assess the use of HAR methods between horse facilities	Method proved feasible, high observer agreement, good repeatability of tests (at 3-month intervals) in on-farm environment for both species.	Dalla Costa et al., 2015

Table 3. Evaluation factor scoring for each HAR method evaluated

Evaluation factor	Reliability	Robustness	Practical application	Validity and accuracy	Feasibility (safety, financial, long term study)
Method 1: Latency and distance parameters	Good - observers using distance meters could potentially miss subtle cues from animals. Could be difficult to know specifically whether the animal is responding to the human cue or coincidentally performing the required behaviour by chance or for another reason.	Fair – could be difficult for multi-zoo comparison if different behaviour requests are used from zoo keepers at different HAI events, which may not be directly comparable.	Good – requires little formal training, can last a short time and be recorded from a distance. Physical existing landmarks can be used to measure distance. .	Good – influence of animal sociality must be considered, as differences in behavioural responses to keeper commands have been found between socially and solitary housed species (Ward and Melfi, 2013). Estimations of distance parameters are likely to introduce errors and inconsistencies between or within studies.	Good – performed during routine HAI events (e.g. daily training, movement between enclosures, feeding events) therefore safe for human and animal, suitable for long term study. Distance meters could be used as an alternative to estimations and physical marks in enclosure, at little costs.
Method 2: Avoidance test	Good – inter-observer reliability has been found to be high irrespective of whether person is experimenter or observer. Individual animal reactions to avoidance distance test were shown as moderately repeatable when tested by different experimenters (Windschnurer et al 2009).	Fair – currently no zoo studies using this method. Possibly due to ethical implications of creating a situation to potentially elicit a fear response. Would not be suitable for all zoo species, especially species with protected contact therefore not sufficient to fully test an animal's avoidance response.	Poor – Time consuming on a large fam scale, requires specific training by observer to properly move into area, recognise first avoidance reaction (Battini et al 2016).	Good – has been validated for several agricultural species (Battini et al 2016). Validated by showing its sensitivity to gentle HAIs (Windschnurer et al 2009). Interpretation of animal response can also be difficult if animal did not move and neither approached nor avoided the human (Rousins and Wablinger 2004)	Poor – safety concerns for both human and animal with some zoo species.
Method 3: Voluntary animal approach	Good - easily performed, however, curiosity of a novel event such as a human's presence may increase the motivation to approach. This must be considered for use with animals in a zoo setting which rarely have human contact.	Fair – may be unsuitable for animals which rarely have human contact as it is measuring animal curiosity rather than fear. The safety risks for participants will also prohibit the use of this test for some zoo species.	Fair – may require time to carry out test and train observers to be able to identify approaches, whilst ensuring safety. Test is dependent on animal management and accessibility, i.e. animal species and temperament will dictate whether this test can be performed from inside the animal's enclosure or not.	Good - curiosity of a novel event such as a human's presence may increase the motivation to approach.	Good – minimal financial cost, potential safety implications to both animal and human however this test could be adapted to been used with the presence of a physical barrier.
Method 4: Reaction to handling	Poor – several potential confounding variables which could reduce reliability and repeatability; handlers reacting differently based on animal response, physical and social environment. More testing is required.	Poor – test relies on animal being suitable for handling by humans in a safe manner. Due to the variation in handling of animals in zoos this test would not be suitable for all zoo species.	Poor – this test could be considered invasive and therefore has ethical implications. This test is species dependant meaning t cannot be performed for all species within a zoo.	Poor – has been used in conjunction with physiological measures, such as faecal glucocorticoid metabolites (Baird et al 2016), however these can be influenced by other variables such as feeding habits, diurnal variations and life history. Requires some standardisation in how the animal is handled as the variation between handling styles and skills of handlers could influence reliability.	Poor – this test could be considered invasive and therefore has ethical implications. Safety concerns for both animal and human. Animals which are not handled as part of daily routine would require additional time from keepers, and cause unnecessary stress, therefore not suitable for long-term monitoring.

Method 5: Qualitative behaviour assessment	Excellent - Inter-observer reliability has been tested using a variety of statistical methods to rate zookeeper QBA scoring of animals; overall high levels of agreement have been found for zoo keepers assessing cheetahs (Wielebnowski 1999) and black rhinos (Carlstead et al 1999a).	Excellent – videos of animals can be obtained for all zoo species, dependant on practical application, enclosure design, video recording equipment.	Poor - due to the requirement of multiple observers to analyse clips, the practical application of QBA can be challenging and time consuming.	Good – has been validated in previous studies and used as a cost-effective approach in monitoring farm animal welfare. Free-choice profiling allows observers to integrate subtle movements, posture and aspects of the context in which the behaviour occurs into an animal's overall style of behaviour, evaluating the "animal-as-a-whole" (e.g. bold, shy, hostile) (Wemelsfelder et al 2000, 2001). High levels of observer agreement in scoring found when testing inter-observer reliability.	Poor – requires organising and conducting two phases of focus/observer groups to analyse clips which is time consuming and challenging. Cost of obtaining a video recording device.