Personality in Asian elephants (Elephas maximus): Temporal stability and methods of assessment

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Personality in Asian elephants (*Elephas maximus*): Temporal stability and methods of assessment

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ABSTRACT

Personality is the essence of individuality in animals, affecting individual behaviours, perceptions and lived experiences. Being able to reliably assess personality in animals holds the key to understanding individual differences, and application of this knowledge is paramount in the provision of individual-level management of animals to optimise welfare. A key aspect of the definition of animal personality is 'consistency over time'. Yet, despite the range of studies assessing elephant personality, there is a lack of consistency within methodologies and personality is usually assessed at a single point in time. Here, we examine personality data from adult members of the Asian elephant (*Elephas maximus*) herd at Chester Zoo at five separate time points, across a ten-year period (2013–2023). Data were analysed in terms of the instruments used to measure personality (differences in questions/items across assessments, presentation of the personality assessments, raters), and changes over time in elephant personality assessment scores. Select personality traits were consistent over multiple time points. Inter-rater reliability across personality adjectives is highest when keepers are involved in scale development, reinforcing the importance of collaboration between scientists and animal caregivers in building tools for evidence-based management decisions over the lifetime of animals.

1. Introduction

Historically, there has been reluctance or scepticism towards using the word personality, a term historically reserved for humans, when referring to behavioural variations in animals, due to concerns over anthropomorphism (Gosling, 2001; Tetley & O'Hara, 2012; Watters & Powell, 2012). However, since the early twentieth century, scientists have observed and commented upon the clear differences between individuals of the same species, referring to such differences as personality, with early narratives using terms such as 'Sociable' or 'Fearful' (Crawford, 1938; Whitham & Washburn, 2017). The concept of animal personality as a scientific area of study has progressed rapidly, with an exponential increase over the last two decades (Beekman & Jordan, 2017; McMahon et al., 2022; Roche et al., 2016; Weiss et al., 2011; Whitham & Washburn, 2017). It has since been accepted that there are repeatable and consistent behavioural variations among individuals of the same species, reflective of what we would refer to in humans as 'personality' (Beekman & Jordan, 2017; Harrison et al., 2022; Kaiser &

Müller, 2021; Roche et al., 2016). These individual differences have numerous impacts on animals both in the wild (survival in the wild (Wolf & Weissing, 2012), reintroduction success (Bremner-Harrison et al., 2004; Haage et al., 2017)), and in zoos: responses to other animals and their environment (Watters et al., 2017), development of relationships (Martin-Wintle et al., 2017; Massen & Koski, 2014) and experiences within zoos (Watters & Powell, 2012). In the wild, there are a number of ecological and evolutionary implications of animal personality including resilience and persistence of populations, distribution within habitats, disease transmission and social evolution (Wolf & Weissing, 2012). There is a complex relationship between personality and survival in wild animals (Haage et al., 2017). Animal personality also affects dispersal and colonisation behaviours in wild animals (Wolf & Weissing, 2012) and so ensuring that candidates for release are selected on the basis of this behavioural variation has been advocated as important in animal reintroductions (Bremner-Harrison et al., 2004). Within zoos, its importance has been widely highlighted (e.g. (Martin-Wintle et al., 2017; Massen & Koski, 2014; Watters & Powell, 2012)).

Understanding animal personality and applying it to evidence-based management of zoo animals providing environments which support positive welfare, and successful conservation of animals within in-situ environments, is paramount in species conservation.

Animal social groups may exhibit collective personalities, which is defined as the emergent behavioural phenotype observed at the group level (Bengston & Jandt, 2014). In the same way that animal behaviour develops as animals age, and personality at an individual level evolves, collective group personalities can change over time, as a result of changes in circumstance (Bengston & Jandt, 2014). Whilst the environment within a zoo is typically more static than the wild, zoo animals may still exhibit fluctuations in social dynamics over time (Williams et al., 2020) and so it is possible that individual- and group-level personalities will show variation as a result of this. Furthermore, changes to group structures in terms of births, deaths or animal transfers may also lead to observable phenotypic changes.

There are a number of inconsistent synonyms found within the literature when referring to individual differences among animals, including temperament, coping style, behavioural syndromes, behavioural profile/profiling, behavioural types, character, and individual distinctiveness. Whilst these may vary across disciplines or animal industries, they are often used interchangeably with no explicit explanation as to why one term was preferred over another (MacKinlay & Shaw, 2023; McMahon et al., 2022; Tetley & O'Hara, 2012; Watters & Powell, 2012). MacKay and Haskell (2015) tried to create a framework for applying definitions of personality, based on the information of interest. Table 1 presents a summary of definitions or key components identified from the literature. It may be possible that these variations in terms differ according to the relationship that the researcher (or persons of interest) have with the focal animal. In this paper, we refer to animal 'personality', where we are defining personality as 'consistent individual differences in behaviour over time and contexts'.

1.1. Methods of assessment of animal personality

The acknowledgement of individual differences in any given species has subsequently led to the need for suitable methodologies that can adequately capture a species' idiosyncrasies (Feaver et al., 1986). There

Table 1
Personality definitions present within animal personality literature.

Author(s)	Definition/key components
Beekman and Jordan (2017)	Repeatability of behaviour across time and context
Carter et al. (2013)	Between-individual differences that persist across time
Dingemanse and Wright (2020)	The repeatable part of an individual's behaviour
Freeman and Gosling (2010)	Individual differences in behaviour that are stable across time and situations
Gartland et al. (2022)	Behaviour varying within individuals across the same species over time or contexts regardless of age or sex effects
Gosling (2001)	Characteristics of individuals that describe and account for consistent patterns of feelings, thinking and behaving
Kaiser and Müller (2021)	Consistent behavioural differences across time and contexts
Murray (2011)	Lasting dispositions which lead to characteristic behaviour across situations
Neumann et al. (2013)	Stable over time and/or across contexts
Réale et al. (2007)	Individual behavioural differences that are repeatable over time and across situations
Roche et al. (2016)	Repeatable inter-individual differences in behaviour, consistently different between individuals
Uher (2008)	Internal organisation of behaviour that is stable over time and varies across individuals of the same species
Watters and Powell (2012)	Behavioural expression and individual differences
Wilson et al. (2019)	Consistent individual differences in behaviour and emotion

are three different forms of personality assessment (experimental assessment, behavioural coding, and trait rating) that are used to varying extents and often in different combinations with one another within the research field (Carter et al., 2013).

Behavioural coding involves recording an individual animal's behaviour according to a pre-determined ethogram and then analysing the data in the context of personality (Carter et al., 2013; Freeman & Gosling, 2010; Tetley & O'Hara, 2012). Behavioural coding is widely used; a meta-analysis revealed that 89 % of studies used behavioural coding (Freeman & Gosling, 2010). It is also considered to be more objective than trait ratings as it requires less subjective judgement from the observer/rater and all definitions are operationalised via the ethogram (Freeman et al., 2011; Freeman & Gosling, 2010; Vazire et al., 2007). However, it is more time consuming to complete, and as such, often results in a smaller sample size (Freeman et al., 2011; Freeman & Gosling, 2010; Tetley & O'Hara, 2012), something which is inherent within many zoo studies. Behavioural coding can also be used in the context of an experimental set up. Experimental assessments to understand animal personality often focus on response to novelty, in terms of visual, auditory or olfactory stimuli, or novel environments. e.g. (Bremner-Harrison et al., 2018; Hall et al., 2018; Perals et al., 2017). In these settings an animal will be presented with a stimulus considered to be novel and their responses will be recorded and evaluated. Metrics recorded in this context depend upon the type of stimuli, but typically include: latency to approach or respond to the stimulus, duration of the response to the stimulus, type of interaction with the stimulus, duration of interaction with the stimulus, and time taken to return to normal behaviour following presentation of the stimulus. As with standard behavioural coding, response to novel stimuli assessments are time consuming. Within zoos, it may also be particularly difficult to find stimuli which are truly novel to animals and are safe for the animals to be exposed to (without risk of the animal hurting themselves or someone else). An inherent difficulty of response to novel objects is that what is being measured is a behavioural response to a very specific context; it does not necessarily reflect animal responses to other contexts, of which zoo animals are exposed to many.

Trait ratings, on the other hand, are substantially less time demanding with the capacity to capture a large sample size. Trait ratings involve rating each animal against a list of adjectives or descriptors that is often accompanied with behavioural statements or definitions to improve clarity (Carter et al., 2013; Freeman & Gosling, 2010; Murray, 1998; Tetley & O'Hara, 2012). Those who are asked to rate the animals of interest are individuals who are familiar with the animals, such as researchers, keepers, or, in the case of companion animals, owners, who assess discriminant personality traits by proxy (de Azevedo & Young, 2021; Freeman & Gosling, 2010; Grand et al., 2012; Horback et al., 2014; Kaiser & Müller, 2021; Murray, 1998; Tetley & O'Hara, 2012; Watters & Powell, 2012). Usually, the ratings are completed by more than one observer, which provides an opportunity to calculate inter-observer reliability (a means of quantifying similarity between observers) (Shrout & Fleiss, 1979). They may also, but not always, be completed at multiple points in time, creating an important method for obtaining large quantities of personality data from a number of individuals, across different species and across multiple sites or zoos both nationally and internationally (Gosling, 2001; Kaiser & Müller, 2021; Tetley & O'Hara, 2012; Vazire et al., 2007). Within zoos, animal personality is most frequently assessed using this rating method (Tetley & O'Hara, 2012; Watters & Powell, 2012).

The type of personality assessment used often varies across scientific disciplines. However, when comparing methods of assessing personality, behavioural coding and trait ratings were found to be largely consistent with one another in studies with capuchin monkeys (Fernández-Bolaños et al., 2020) and elephants (Horback et al., 2013; Williams et al., 2019). In zoo-housed Asian and African elephants social interactions significantly correlated with keeper ratings of the trait 'social' and in a group of 12 zoo-housed African elephants, the

behaviourally coded trait Playful significantly correlated with the keeper-rated trait Playful, demonstrating clear construct validity (Horback et al., 2012; Williams et al., 2019). Keeper trait rating scales provide a means of capturing expert knowledge in a standardised and repeatable manner (Gartner & Weiss, 2018).

Most personality studies opting for trait ratings have used one of four main tools: the Hominoid Personality Questionnaire (HPQ), the Emotions Profile Index (EPI), the Madingley questionnaire or variations of the Five Factor Model of personality, traditionally used with humans. Examples of non-human primate research studies which have utilised these methods are included in Table 1 in Supplementary Material. Research with other taxa has used similar methodologies e.g., cetacean personality work using variations of the Five Factor Model (Highfill & Kuczaj Ii, 2007; Úbeda et al., 2019).

These tools predominantly differ in terms of number and types of adjectives included. The HPQ comprises 54 items which include an adjective and an associated primate-specific description. The EPI is a forced choice pairwise scale which is scored in terms of how animals correspond to basic emotional states (anger, fear, joy, sadness, acceptance, disgust, surprise and expectancy). Finally, the Madingley questionnaire is a 28-item inventory which utilises a 1–7 Likert scale. Personality studies may also utilise a modified version of these tools, as has been seen in elephants (Table 2). In personality assessments it is important to utilise adjectives that relate to the animals in question, as some adjectives may be more or less suited to particular species. Independently created personality assessments should show validity (Tetley & O'Hara, 2012), defined as adjectives which show strong levels of inter-observer agreement or those that are able to predict behaviour or real world outcomes (Gosling & Vazire, 2002).

1.2. Assessments of elephant personality

Elephants are long-lived and highly intelligent, and they live in socially complex societies (Archie et al., 2006, 2005; Bonaparte-Saller & Mench, 2018; Doyle, 2018; Harvey et al., 2018; Lee & Moss, 2012; Seltmann et al., 2018; Sukumar, 2006; Wei & Baker, 2020). The success of animal social groups depends on the compatibility of the group (Williams et al., 2018), with animal personalities shaping social interactions within the group (Massen & Koski, 2014). The notion that elephants have distinct personalities is not disputed and is widely documented in papers over the last decade (Barrett & Benson-Amram, 2021; Grand et al., 2012; Highfill et al., 2013; Horback et al., 2013; Lee & Moss, 2012; Rutherford & Murray, 2021; Seltmann et al., 2018; Williams et al., 2015, 2019; Yasui et al., 2013). Indeed, following extensive observations of wild African elephants, Cynthia Moss likened observing elephant behaviour to watching a soap opera or reading "an engrossing, convoluted novel that I cannot put down but also do not want to end" … just like humans, elephants exhibit behaviours and tendencies showcasing their clear individuality (Moss, 2000). This is reflected in the most recent iteration of the EAZA Best Practice Guidelines for Elephants, which includes the need to create elephant behavioural profiles and consider the personality of elephants during introductions and interactions with enrichment and caregivers (for training or other purposes) (EAZA, 2020). Successful management which leads to positive welfare for zoo elephants requires the recognition of these individual differences and the impacts they have on individual experience.

The importance of undertaking welfare assessments which capture individual experiences has been highlighted (Boissy et al., 2007; Finch et al., 2020; Glaeser et al., 2020; Goursot et al., 2021; Wemelsfelder & Mullan, 2014). Incorporating knowledge of an animal's personality into management decisions can help to optimise individual welfare (e.g. identifying socially compatible individuals (Horback et al., 2013), improving mating success (Carlstead et al., 1999; Fox & Millam, 2014; Martin-Wintle et al., 2017), and understanding friendships (Massen & Koski, 2014; Williams et al., 2019). Through identifying preferred social

Table 2
An overview of currently published elephant personality research in Asian elephants (*Elephas maximus*) and African elephants (*Loxodonta Africana*).

Author(s)	Species common name	Wild or zoo housed	Number of individuals	Methodology
Grand et al. (2012)	African	Zoo	5	Trait rating – 23-item Elephant Behaviour Index, based on Madingley scale, rated on a 5-point Likert scale NB: only allowed raters with 1-year experience. Assessed against serum and salivary cortisol Analysed using Spearman's Rho correlation.
Lee and Moss (2012)	African	Wild	11	Trait rating – 28 behavioural descriptors using Murray (1998) adapted Madingley Questionnaire (Stevenson-Hinde & Zunz, 1978) rated on a 7-point Likert Scale. Analysed using PCA both with and without promax rotation.
Highfill et al. (2013)	Asian	Zoo	6	Trait rating – 30 behavioural descriptors based upon the five-factor model (6 descriptors for each of the five-factors), rated on a 7-point Likert Scale. Analysed using a related Wilcoxon signed ranks test.
Horback et al. (2013)	African	Zoo	12	Behavioural coding Item-rated traits – 25-items separated into three sections: interactions with the environment (E) /other elephants (C) /humans (H). Rated on a 7-point Likert Scale. NB: required raters to have a min. of 1 years' experience with the herd.
Yasui et al. (2013)	Asian and African	Zoo	45 Asian 30 African	Trait rating – 30-items, rated on a 4-point Likert scale. Analysed using factor analysis, varimax and promax rotation
Williams et al. (2015)	Asian	Zoo	14	Trait rating – combined the adjectives from Grand et al. (2012) and Yasui et al. (2013) to produce a 22-item scale. Rated on a 10 cm Visual Analogue Scale with anchors Disagree (0 cm) and Strongly Agree (10 cm). Analysed using Principal Components Analysis (PCA), varimax rotation. NB: only 9 items were

Table 2 (*continued*)

Author(s)	Species common name	Wild or zoo housed	Number of individuals	Methodology
Seltmann et al. (2018)	Asian	Semi-captive	257	entered into PCA (ICC >0.6) 28 behavioural descriptors – based upon the Madingley Questionnaire with specific additions of relevant descriptors e. g., 'Moody', 'Quitting', Translated into Burmese. Rated on a 4-point Likert scale. Analysed using Exploratory Factor Analysis (EFA), Oblique geomin rotation used.
Williams et al. (2019)	Asian and African	Zoo	20 Asian 10 African	Trait rating – a modified version of a Williams et al. (2015). 21 behavioural adjectives on a visual analogue scale rated on a 10 cm Visual Analogue Scale with anchors Disagree (0 cm) and Strongly Agree (10 cm). Analysed using PCA, varimax rotation.
Barrett and Benson-Amram (2021)	African and Asian	Zoo	15 Asian 3 African	Behavioural coding Trait ratings – 20-item scale (similar to Seltmann et al. (2018) rated on a 5-point Likert Scale. Trait ratings analysed using Principal Components Analysis (PCA), rotation not specified.
Rutherford and Murray (2021)	Asian	Zoo	9	10 item personality inventory, (TIPI, originally created for human use by Gosling et al. (2003). Represented the Five Factor Model with 2 items per factor. Rated on a 7-point Likert Scale across 4 time points. Analysed using Spearman's correlation for stability over time.

or mating partners it ensures that animals are housed with compatible individuals which provide positive stimuli. Furthermore, an underlying understanding of animal personality can also mean that changes in behaviour are easily recognisable and thus may lead to easy identification of any potential welfare compromise (Cole & Fraser, 2018; Fernández-Lázaro et al., 2019), which is an important consideration in pro-active, evidence-based management.

Despite the range of studies assessing elephant personality, there is a lack of consistency within methodologies applied to the assessment of elephant personality. Numerous approaches have been used to study elephant personality, from an adapted version of the Madingley questionnaire (Lee & Moss, 2012; Seltmann et al., 2018) to behavioural coding (Barrett & Benson-Amram, 2021; Horback et al., 2013), novel personality inventories (Grand et al., 2012; Highfill et al., 2013;

Williams et al., 2015, 2019; Yasui et al., 2013) and traditionally human-centric personality assessments (Rutherford & Murray, 2021). A brief overview of these is included in Table 2, with a more detailed critique of the study included in Table 2 in the supplementary material. There is a clear need for the development of validated, species-specific personality assessments but there should also be consistency across the assessments and terminology used wherever possible (Gosling, 2001; Tetley & O'Hara, 2012; Wilson et al., 2019).

The importance of animal personality is recognised. Whilst there are many definitions, a commonality within them all is the focus on 'consistency over time and situations'. There is a paucity of work which has actually assessed animal personality over a prolonged period. Here we use elephants as a case study, for despite them being a long-lived and well studied species, there has never been an investigation of their personality over time. The current study examined personality data from adult elephants in the Asian elephant (*Elephas* maximums) herd at Chester Zoo, across a ten-year period (2013–2023). Different personality assessment tools were utilised across the study period with raters varying from keepers (with over twenty years of experience working with the Chester elephants) to student observers. Data were analysed in terms of the tools used to measure personality (differences in questions/items across assessments, presentation of the personality assessments, raters), and changes over time in elephant personality assessment scores. These data are explored in terms of the rationale for consistencies and changes seen in elephant personality ratings, how this information can be utilised in zoo management, and indicating how long-term personality data can support and inform the development of an 'optimum' personality assessment.

2. Methods

2.1. Elephant herd and enclosure

The study herd were Asian elephants (*Elephas maximus*) ($n = 8$) housed at Chester Zoo, Cheshire, U.K. (53.2273° N, 2.844° W) over a 10-

Table 3
Study animals.

Elephant ID	Related to others in herd	Sex	Estimated Date of Birth	Wild or Zoo born	Time points personality assessed
E1	Y	F	1982	Wild	2013 2016 2017–2018 2018–2019
E2	Y	F	31-12-1997	Zoo	2013 2016 2017–2018
E3	Y	F	07-03-2004	Zoo	2013 2016 2017–2018 2018–2019 2023
E4	N	F	1966	Wild	2013 2016 2017–2018 2018–2019 2023
E5	N	M	16-07-2001	Zoo	2013 2016 2017–2018 2018–2019 2023
E6	Y	F	20-08-2015	Zoo	2016 2017–2018
E7	Y	F	16-12-2016	Zoo	2017–2018 2018–2019 2023
E8	Y	M	17-05-2018	Zoo	2017–2018 2023

year period (2013–2023). An overview of the study population is included in Table 3.

Elephants were housed in two outdoor paddocks (the main paddock 5490 m² and the male 530 m² paddock, referred to as the bullpen throughout) and two indoor enclosures (the main house 985 m² and the male pen 415 m²). The outdoor paddock was mainly used by the female and sub-adult herd members and the male during periods of mixing. Outside of this time the male had access to the bullpen.

2.2. Data and personality assessments

An overview of the personality assessments undertaken at each time period, the raters and statistical analyses are included in Table 4. Intra-class correlations were undertaken to determine reliability between observers at an individual adjective level. Reliably rated adjectives were then entered into a principal components analysis to determine personality profiles within the study elephants.

2.2.1. 2013–2016

For the first two data collection periods, elephant personality was assessed using a trait rating method by keepers familiar with the elephants. Full details are available in Williams et al. (2019, 2015). In 2013 the personality assessment comprised 14 adjectives with accompanying definitions. Small changes were made to presentation of the adjectives following feedback from keepers (Williams et al., 2019). In 2016 it comprised 21 adjectives. At both times, ratings were made on a 10 cm visual analogue scale with the anchors 'disagree' (0 cm) and 'strongly agree' (10 cm). An exact score was determined by measuring the distance (in centimetres, to 1dp) along the line that the rating was placed. ICCs were undertaken to identify reliably rated adjectives (2013, adjectives with an ICC of 0.6 or above: $n = 9$; 2016, adjectives with an ICC of 0.5 or above: n = 9) and these were entered into a principal components analysis to condense these into personality components. Three personality components were identified in each year, which accounted for 90.1 % and 90.9 % of the total variance in 2013 and 2016 respectively.

2.2.2. 2017–2019

Two trait rating scales were used: the Ten Item Personality Inventory (TIPI), originally developed for human use representing the shortest version of the Big Five or Five Factor Model of personality (Gosling, 2001) and the 28-item measure derived from the Madingley questionnaire used in previous elephant personality research (Lee & Moss, 2012). Personality was measured using the TIPI at four different time points (April 2018; September 2018; November 2018 and May 2019) for the purpose of comparison of personality ratings before and after changes to the herd composition. Personality was measured using the 28-item personality inventory in May 2019. Data from the 28-item personality inventory was assessed for reliability between observers using ICCs. Reliably rated adjectives, with an ICC of 0.5 or above ($n = 26$) were entered into a principal component analysis ($n = 3$ components which accounted for 94.8 % of the total variance).

2.2.3. 2022–2023

The personality assessment used was created alongside elephant keepers at Chester Zoo. Seventy items were generated by keepers and experts in the field with advice sought from Emeritus Professor Phyllis Lee. These were reduced to 35 following keeper feedback and removal of redundant synonyms. Definitions accompanied each item, taken and adapted from pre-existing personality tools (Hopper et al., 2018; Murray, 2011; Robinson et al., 2017; Seltmann et al., 2018; Stevenson-Hinde & Zunz, 1978). Two methods of presentation were compared. Keepers were randomly split and allocated a Likert Scale format of the 35-item assessment (using a Likert Scale adapted from Murray (1998) or a visual analogue scale (VAS) format (an anchored 7 cm line using Murray's Scale as a template) to investigate the reliability of these two methods across the suite of personality adjectives included in the assessment. The personality assessment was further refined based on keeper feedback with 21 adjectives being included in the assessment. In the final iteration of the assessment six of the behaviour adjectives were presented as a VAS and the remaining 15 were presented as a Likert Scale. Keepers ($n = 8$) completed the final 21-item trait rating assessment. Reliably rated adjectives ($n = 20$ items ICC >0.05) were entered into a PCA which yielded 4 components representing 97.3 % variance.

2.3. Data comparison

The first stage in analysis of these multiple personality assessment tools was to descriptively compare the terminology used, to determine the terminology that was being used to assess personality of elephants and whether it differed over time. This analysis was undertaken at an individual adjective level and a personality component level (components from PCAs at each time point). Adjectives were visually compared using definitions which accompanied them by LR and EW to identify where the same personality traits were being assessed. In some instances, these adjectives were used consistently (e.g., aggressive), but in other instances different adjectives were used but the definition was comparable (e.g., dominant 'Asserts authority over conspecifics' and effective 'gets own way, can control others').

2.3.1. Individual adjectives

Only items that were reliably rated at each time point were compared in the assessment of personality adjectives over time. In total, 17 adjectives were the same across all time points where they were used. Five adjectives were identified as comparable synonyms. Sixteen adjectives were non-comparable, and these were removed from subsequent analyses. Once the mapping was completed, intra-class correlation coefficients (ICC two-way, agreement, using average rater scores) were used to assess consistency of personality at different times. Elephants that were present at the relevant time points were included in the analysis (Table 3). As the tools used to measure elephant personality had different scales (maximum 10 in T1 and T2; maximum 7 in T4 and T5) personality adjective scores were calculated as a proportion of the possible maximum, to enable a direct comparison.

Table 4
Data summary.

Time point	Primary researcher	Year of assessment	Personality assessment used	Raters	Analyses
T1	EW	2013	Combination of adjectives used in the literature	Keepers	ICC, PCA
T2	EW	2016	Combination of adjectives used in the literature	Keepers	ICC, PCA
T3	LR	2017–2018	Ten Item Personality Inventory (TIPI)	Student observers	TIPI output (means representing the Big Five), rater agreement
T4	LR	2018–2019	TIPI and Lee & Moss Inventory	Student observers	ICC, PCA Means (TIPI)
T5	LR	2022–2023	Keeper-developed assessment	Keepers	ICC, PCA

Note. ICC: Intra-class correlation coefficients; PCA: Principal Components Analysis; TIPI: Tn Item Personality Inventory.

2.3.2. Personality components

At each time point, a Principal Components Analysis (PCA) was conducted to identify personality components (Rutherford, 2018, 2019; Rutherford & Murray, 2021; Williams et al., 2015, 2019). The personality components were also mapped against each other, in the same way as comparisons of behavioural adjectives, with the personality components being considered similar if they comprised similar personality adjectives.

2.3.3. Comparisons with the TIPI

The Ten Item Personality Inventory (TIPI) (Gosling et al., 2003) comprised 10 brief statements which represent the Five Factor model (two per trait, with one positively and one negatively worded). This has traditionally been used for human personality studies. The traits are Extraversion, Openness to Experience, Emotional Stability, Agreeableness and Conscientiousness. The TIPI was used at two time points (Time 3 and Time 4). The TIPI data was omitted from the main data comparison due to the way in which it was presented (e.g. each item consisting of two corresponding words or phrases and no definitions provided). Instead, a Spearman's correlation was conducted using the TIPI values from T3 and T4 and the reliably rated items from T1, T2, T4 and T5 to visually look for points of similarity.

3. Results

3.1. Consistency at an individual adjective level

3.1.1. Mapping items

Items that were reliably rated at each time point are highlighted in bold (see individual sections for threshold for reliability). Proportion of reliably rated adjectives (out of the whole personality assessment at each time point) is included in Table 5.

There was a variation in how reliably rated these adjectives were at the different time points (i.e. to what extent keepers agreed on scores across all elephants at each time point). Items reliably rated at all of the data collection points (or where present) were Active (including its reverse scored Slow), Aggressive, Calm/Equable, Dominant/Effective,

Playful, Sociable and Solitary. Apprehensive, Confident, Curious/Inquisitive and Subordinate/Submissive were sometimes reliably rated, but not always. Over time, there is also a notable difference in the rate of reliably rated items which increases to 95 % of total items at T5.

3.2. Consistency of items over time (test-retest) within and between measures

Items were considered consistent if they had an ICC of 0.5 or above. An overview of the ICC results is included in Table 6. Full outputs including 95 % confidence limits are included in Supplementary Material 2. T1 and T2 used the same personality assessment (within measures). T4 and T5 used different personality assessments to T1/T2 and to each other (between measures). Items that were consistent over time were (in order of consistency): Aggressive, Active, Confident, Calm, Sociable, Dominant/Effective, Playful, Solitary, Subordinate, Maternal, Apprehensive, Gentle, Excitable, Fearful and Intelligent. Active, Aggressive, Calm, Confident, Sociable and Dominant/Effective were consistent over multiple time comparisons.

3.3. Consistency at a component level

Personality components were visually mapped against one another and are presented in Table 7. This visual comparison led to the identification of four overarching categories which could be used to describe elephant personality: Active/Playful; Dominant/A leader; Social; Gentle/Calm.

3.4. Comparisons with the TIPI

A full overview of the correlations is available in the Supplementary Material. The factors that correlated most frequently with items across the four distinct time points were Agreeableness (at T3 and T4) and Conscientiousness (at T3 and T4). Few correlations were observed between Extraversion, Openness and Emotional Stability over time. Of the reliable items, those that correlated most with the TIPI were (in order of most to least) Active, Calm, Solitary, Sociable, Intelligent, Playful, Slow,

Table 5
Mapping of personality items, (R) denotes reversed scored items, bold denotes items that were reliably rated at each time point.

	T1	T2	T4	T5
	Active	**Active**	**Active**	**Slow (R)**
			Slow (R)	
	Affectionate (elephants)		**Maternal**	**Maternal/paternal**
	Aggressive	**Aggressive**	**Aggressive**	**Aggressive**
	Apprehensive	Apprehensive	**Apprehensive**	**Apprehensive**
	Calm	**Calm (novel situations)**	**Equable**	**Calm**
	Placid	Calm (unfamiliar people)		
	Confident	Confident	**Confident**	**Confident**
	Curious	Curious	**Curious**	**Curious**
	Inquisitive	**Inquisitive**		
	Dominant		**Effective**	**Effective**
	Eccentric		**Eccentric**	
	Fearful	Fearful (conspecifics)	**Fearful**	**Reactive/Anxious**
		Fearful (disturbances)		
		Gentle (keepers)	**Gentle**	**Gentle**
			Excitable	**Enthusiastic**
			Intelligent	**Intelligent**
			Irritable	**Irritable**
	Placid	Placid	**Equable**	Reserved
			Opportunistic	**Opportunistic**
	Playful	**Playful (conspecifics)**	**Playful**	**Playful**
		Playful (objects)		
			Popular	**Popular**
			Predictable	**Predictable**
	Sociable	**Sociable**	**Social**	**Sociable**
	Solitary	**Solitary**	**Solitary**	
	Subordinate		Permissive	**Submissive**
Items Reliably Rated (%)	**59%**	**38%**	**93%**	**95%**

Table 6
ICC values for each personality adjective at the four data collection points.

Adjective	T1 & T2	T1, T2 & T4	T1, T2 & T5	T1, T2, T4 & T5	T1 & T4	T2 & T4	T1 & T5	T2 & T5	T4 & T5	T1, T4 & T5	T2, T4 & T5
Active	**0.89**	**0.84**	**0.72**	**0.80**			**0.56**	**0.49**	**0.81**	**0.74**	**0.70**
Aggressive	**0.80**	**0.69**	**0.97**	**0.89**			**0.97**	**0.97**	**0.54**	**0.73**	**0.86**
Calm	**0.58**	-0.48	**0.82**	0.33			**0.87**	**0.65**	N/A	-0.14	N/A
Playful	**0.85**	**0.80**	-0.06	-0.11			N/A	**0.56**	0.12	-0.87	0.44
Solitary	**0.86**	**0.79**									
Sociable	**0.80**	**0.56**	**0.81**	0.35			0.41	**0.97**	N/A	N/A	0.21
Confident					**0.87**		**0.90**		**0.92**	**0.93**	
Dominant/ Effective					**0.95**		**0.83**		**0.81**	**0.93**	
Subordinate							**1.00**				
Maternal									**0.92**		
Apprehensive									**0.83**		
Gentle									**0.71**		
Excitable									**0.86**		
Eccentric					0.35						
Curious						N/A			N/A		N/A
Fearful									**0.59**		
Intelligent									**0.90**		
Irritable									-0.90		
Popular									N/A		
Predictable									N/A		

Note. N/A: ICCs were larger than absolute agreement (indicating the presence of non-negligible bias) and thus these values were invalid (Liljequist et al., 2019); T3 used the TIPI and is omitted; items in bold are those considered to be 'consistent' (ICC > 0.5) over time.

Opportunistic, Maternal, Curious, Effective (Dominant), Reactive/ Anxious, Popular and Predictable.

3.5. Scales used in the personality assessment

When the use of VAS and Likert scale assessments were compared during the final data period (T5), different levels of reliability were found across the adjectives investigated. Six adjectives were more reliably assessed using a VAS: Submissive, Confident, Maternal/Paternal, Popular, Slow and Playful. The remaining 15 were more reliably rated using a Likert Scale: Reserved, Calm, Apprehensive, Intelligent, Irritable, Enthusiastic, Aggressive, Predictable, Gentle, Curious, Reactive/ Anxious, Disruptive, Sociable, Opportunistic, Effective.

3.6. Impacts of changes in group structure: an individual case study

One adult female elephant, E3, was assessed for personality development over time. She was present at all time points. Owing to a change in herd structure she moved from being a lower-ranking elephant (T1–4) to the herd matriarch (T5). Her scores for personality adjectives that were reliably rated at all time points are included in Table 8.

There was variation in average scores across the time periods. Consistency (assigned here as scores which deviated by 10 % or less between the highest and lowest scores attributed over the time periods) can be seen in the following traits: Irritable, Intelligent, Submissive/Subordinate, Gentle, Maternal and Playful. Of note were changes to the scores attributed to this elephant in Effective/Dominant (116 % increase from T1 to T5 and 180 % increase from T4 to T5) and Popular (95 % increase from T4 to T5). It is believed that changes in these aspects of personality relate predominantly to her change in social status.

4. Discussion

A key aspect of animal personality definitions is the requirement for inter-individual differences to be consistent over time and across contexts. Yet, in practice, personality data are rarely collected over a long period of time. Rather, assessments are made using one or more different methods, often at a single point in time. There is thus rarely the opportunity to look at whether animal personality varies over time and if it may be impacted by environmental changes over a period of time. This data set provided a rare opportunity to look at personality, in a herd of zoo housed Asian elephants over a ten-year period.

4.1. Behavioural adjectives and raters

The types of trait rating scales utilised for this work have been used widely in zoos and wild elephant personality assessments. The exact adjectives used differed across the assessment periods. Of those that were reliably rated at their time point, 17 were repeated at more than one time point and for a further five terms, synonyms were being used. There were 16 additional adjectives that were used at only one time point. Reliably rated adjectives all related to activity/confidence, and engagement (with other elephants, with keepers and with the environment). These are all highly relevant to the social nature of elephants and reflect aspects of behavioural profiles which are most important in terms of elephant care within managed environments. At a component level, the PCA components did also clearly correspond with one another, representing activity components (Playful/Active), leadership (Dominant), Social and Gentleness (Calm/Gentle) components. The components detailed were similar to those reported in other elephant studies, for both in-situ (Lee & Moss, 2012) and ex-situ environments (Grand et al., 2012; Horback et al., 2013; Seltmann et al., 2018; Williams et al., 2015, 2019).

The most important aspect highlighted in trait rating methods in the animal personality literature is the importance of raters knowing the animals and understanding what varying personalities look like. In order to be able to understand animal personality across time and contexts, raters must be both familiar with the animal and across contexts. It is reported that those who know the animal the longest (are most familiar) are more reliable at rating personality (Gosling, 1998, 2001; Grand et al., 2012; Martau et al., 1985; McCrae & Weiss, 2007; Powell & Svoke, 2008). Because of this, it had been predicted that T4 would have lower reliability scores at an individual adjective level because student observers completed the assessments and some of the definitions used were not 'elephant-specific'. This was not the case, the level of familiarity with the individual elephants (student raters vs. keepers) did not influence overall reliability score. Studies on elephants (Webb et al., 2020); dogs (Fratkin et al., 2015), rats (Renner & Renner, 1993) and birds (Sándor et al., 2021) have also demonstrated that students or raters with shorter acquaintanceship can reliably rate behaviour, and thus, especially for adjectives that are accompanied by a description of observable, trait-indicating behaviours (Uher et al., 2008), it is possible for such assessments to be undertaken by observers with varying amounts of familiarity. A key limitation in this piece of work is that different raters were used over the period of this assessment. This made comparison

Table 7
Mapped PCAs from Time 1, 2, 4 and 5.

Playful/Active Component(s)	Dominant Component(s)	Social Component(s)	Calm/Gentleness Component(s)
T1: **Restless** **(54.1%)** Vigilant Eccentric Restless (-) Active (-) Confident (-) Playful	**T1:** **Dominant** **(16.0%)** Dominant Aggressive (-) Subordinate	**T1:** **Social** **(11.5%)** Sociable (-) Solitary	**T1:** **Steady** **(8.5%)** Calm (-) Impulsive
T2: **Playful/Engaged** **(44.7%)** Playful (conspecifics) Playful (objects) Inquisitive Active	**T5: *** **(11.4%)** Intelligent (-) Effective	**T2: Solitary** **(46.1%)** Solitary Aggressive Calm (-) Sociable	**T4: Fearful/confident** **(35.45%)** Fearful Apprehensive Deferential Permissive Insecure Gentle Equable Eccentric (-) Effective (-) Opportunistic (-) Confident
T4: **Deliberate/Excitable** **(42.5%)** Slow Intelligent Predictable Tense Strong Irritable Aggressive (-) Social (-) Excitable (-) Curious (-) Active (-) Playful		**T4:** **Attractive/Unpopular** **(16.82%)** Popular Sensitive Protective (-) Solitary	
		T5: Social Activity **(33.3%)** Playful Enthusiastic Sociable Curious popular (-) slow	**T5: Confidence** **(28.3%)** Apprehensive Reactive/ Anxious (-) Predictable (-) Confident (-) Calm
T5: Social Activity **(33.3%)** Playful Enthusiastic Sociable Curious popular (-) slow			**T5: Gentleness** **(24.3%)** Disruptive Aggressive Opportunistic Irritable (-) Maternal/ Paternal (-) Gentle (-) Submissive

Note: * Component only consisted of 2 items (+) Intelligent and (-) Effective so was not named; the other components within the table are labelled according to the time period they refer to (e.g., T1), and the name that was used to describe the component, based on the adjectives within it.

across the individual studies slightly difficult, with the obvious drawback being that it is unclear if some differences in personality scores were representative of a change in personality, or whether they were a product of altered perceptions across the raters. To minimise the impact of this as much as possible, the study only considered adjectives which were reliably rated at each time point. Average scores at each time point were then used in the comparison. The fact that different assessors were used enabled benefits such as being able to assess the relative efficiency of different types of raters with varying levels of familiarity and of different response formats. The fact that some behavioural adjectives did show consistency over time, and that for the in-depth focal elephant assessment, these changes made biological sense in relation to the environmental changes, lends support for these methods.

Reliability (in terms of proportion of total terms reliably rated) within time points was highest at T5 (95 %). In T5, keepers took an active role in developing the personality assessment (item generation and refinement) - keeper involvement, therefore, may produce assessments of higher reliability. Including raters in personality assessment development will also likely reduce issues that may be encountered in relation to misunderstanding the assessment, particularly if assessments are being translated into multiple languages. It is recommended to test this personality assessment at other collections, to determine whether input from persons who work with the focal species is enough, or whether persons who are rating the animals at that particular facility should be involved in the development of collection-level personality assessment tools. An important aspect to consider is whether consistency comes down to the individual relationships between keepers and animals. That individual connection may impact on how keepers view animals and that could also have implications for individual scoring. Using an average of multiple raters will alleviate this issue but enable

Table 8

E3's personality scores across time points.

Adjective	Time 1	Time 2	Time 4	Time 5
Active	0.68	0.83	0.39	
Aggressive	0.35	0.13	0.24	0.26
Apprehensive			0.86	0.70
Calm/Equable	0.54	0.69	0.76	0.49
Confident	0.34		0.29	0.47
Curious/Inquisitive		0.70	0.29	0.54
Dominant/Effective	0.25		0.19	0.54
Eccentric	0.25		0.76	
Excitable/Enthusiastic			0.81	0.61
Fearful/Reactive/Anxious			0.81	0.66
Gentle			0.61	0.70
Intelligent			0.67	0.71
Irritable			0.43	0.41
Maternal			0.81	0.90
Playful	0.34	0.44	0.43	0.41
Popular			0.39	0.76
Predictable			0.76	0.51
Sociable/Social	0.58	0.70	0.29	0.61
Solitary	0.79	0.29	0.90	
Slow			0.57	0.39
Subordinate/Submissive	0.65			0.70

Note. Standardised values are presented calculated as a proportion of maximum (Score values 0–1).

consideration of elephant personality types in animal management.

The mapping of similar adjectives for comparison attests to the continued need for researchers to use comparable terms when conducting personality assessments and we recommend the development of an elephant-specific personality measure involving input from the keepers who work with the elephants closely and know them best. Items that were most consistent over time, at a group and individual level and following removal of synonyms were, Aggressive, Active, Apprehensive, Calm, Confident, Curious, Dominant/Effective, Gentle, Intelligent, Irritable, Maternal Opportunistic, Playful, Popular, Predictable, Reactive/Anxious, Slow, Sociable, Solitary, Subordinate (see Supplementary Material 4 for corresponding definitions). We thus recommend that these 20 items be considered during development of future personality assessments.

4.2. Types of scales: Visual Analogue (VAS) vs Likert scales

The method of presentation of personality assessments varies within the literature, from what has been referred to as a graphic rating scale and/or a visual analogue scale (VAS) (Crawford, 1938; Williams et al., 2015, 2019) to Likert scales (Murray, 1998; Stevenson-Hinde & Zunz, 1978). When a comparison was made between visual analogue and Likert scales, differences were seen. Adjectives more reliably rated using VAS were identified as clearer items, whereas those identified as being reliably rated on a Likert scale were identified as adjectives that were more ambiguous, and so benefited from a more structured rating opportunity. This finding should be interpreted with caution, as there were technical issues when presenting the VAS using an online survey platform and it is believed some of the VAS outliers were caused by technical error. However, it should be recognised that keepers were identifying some adjectives as clear and others as more ambiguous, so this should be borne in mind with personality assessment development.

Visual analogue scales are something with which zoo personnel are familiar, owing to their increasing use in qualitative behavioural assessment of animals. QBA forms a part of the quarterly BIAZA Elephant Behavioural Welfare Assessment Tool (EBWAT), which is routinely used by elephant-holding collections in the UK and Ireland (Yon et al., 2019). Despite these being a familiar tool, people vary in the way they calibrate scales (Cooper & Wemelsfelder, 2020) and raters interpret and use these scales in different ways, which has ramifications for the reliability of the results. In some instances, adding numerical or

verbal benchmarks has been identified as being positive for consistency between raters, but this is not always the case (Clark & Rooney, 2021). Whilst users may utilise the VAS in different ways (e.g. using a particular section of the scale) it is likely they will be consistent in this across all of the adjectives. Thus, looking at average scores for animals minimises the impact of differences attributed to scale use and individual relationships between keepers and animals.

It is recommended that future personality assessments for elephants should focus on producing adjectives which are clear, pairing these with definitions, to reduce the need for individual interpretation and increase reliability of the assessment. More complex constructs should be considered for presentation in a Likert scale format to increase ease of use, reliability between raters and applicability in animal management.

4.3. Consistency in personality scoring over time

Not all of the personality adjectives were consistently scored across all five time points (or all times they were present) across the whole herd. Those that were consistently rated were Active (including its reverse scored Slow), Aggressive, Calm/Equable, Dominant/Effective, Playful, Sociable and Solitary. Those that showed differences at an individual item level were Apprehensive, Confident, Curious/Inquisitive and Subordinate/Submissive. Some were reliably rated at some time points, but not others e.g., Confident reliable at T1, T4 and T5 but not T2.

A lack of consistency over time could mean one of two things: (i) raters scored the animals differently (i.e. their perceptions of animal personality were different), this is especially possible where raters have changed; (ii) there were genuine changes in elephant personality, and this was being captured by the different instruments. As this was a growing herd with changes to group dynamics, this is also possible. Animal personalities are shaped by those around them and overall group personalities shape survival success in the wild (McDougall et al., 2006). The original proposition that these differences could be caused by raters viewing animals in different ways is unlikely, because at both T1 and T2 all elephants were rated by keepers. Additionally, at both points, definitions were provided, which is believed to aid comprehension and improve clarity (Carter et al., 2013; Freeman & Gosling, 2010; Tetley & O'Hara, 2012). It is thus likely that at least some of the changes in personality in terms of changes in scores on the rated adjectives represent genuine changes within elephant personality, possibly as a result of changes in circumstance. It could also be that elephant personality is made up of different aspects, some of which may be more stable over time (perhaps reflecting a fundamental temperament such as activity or sociability) but others may be more influenced by context, the presence or absence of particular conspecifics, or maturation (e.g. dominance). For example, in the case study of the adult female, E3, changes were seen in adjectives which were likely related to her change in position from a lower-ranking and peripheral member of the herd to the central role of matriarch. Similar findings were reported by Lee and Moss (2012) who recognised that the concept of playfulness was age related in wild elephants.

4.4. Elephant personality in zoo management

This work has highlighted the potential for there to be variation in some aspects of zoo elephant personality over time, particularly when there are structural changes within the herd. This supports findings from the same herd showing changes in both personality and behaviour following the death of herd members (Rutherford & Murray, 2021). However, for other aspects of elephant personality, consistency is seen in ratings over time. It is recommended that future research considers whether the changes in personality scores are representative of personality change or are instead due to observable behavioural changes (e.g., changes in coping style/behavioural adaptations).

Capturing behavioural and personality profiles in any capacity is

important in zoo animal management as it is now widely recognised that animals experience zoo environments in different ways (Watters & Powell, 2012). This therefore has welfare implications. Considering the animal holistically is paramount – acknowledging the interplay between personality, behaviour and welfare. It is logical that any welfare outcomes would be mediated by personality and that personality assessments would be skewed should there be any areas of welfare enhancement or welfare compromise. Information on personality has been utilised in the management of many species, and for elephants, behavioural profiles have to be considered in managerial decisions (Bolechova et al., 2020). When conducting a personality assessment, it is imperative that the adjectives used relate to behaviour in the subjects. The components of playful/active and sociable relate to the core values of this long-lived, social species, who are renowned for their extensive migratory travel in the wild. The fact that reliably rated personality profiles relate to key aspects of elephant life history is highly important.

The results of this study suggest that some aspects of animal personality are more variable than others. This should be considered when creating behavioural profiles for animals. Understanding how personality may develop over time and utilising this knowledge in evidence-based approaches to elephant management is paramount in provision of high welfare environments for elephants. There may be particular relevance when considering elephant similarities and differences. The ability to assess personality traits in zoo elephants enables the tailoring of zoo elephant management at the individual level, and the ability to prepare for, manage and respond to changes. Research in bonobos has indicated that keepers can predict animal responses to animal husbandry changes, and that this links to personality types (Ward, 2024). The focus on the same individuals at multiple time points over a 10-year period allowed us to consider both maturational and situational variances that may have played a part. We recommend that future work undertakes long-term monitoring such as this in a more consistent manner, e.g. utilising the same tools and where possible the same keepers. We also advocate for wider consideration of the potential for personality changes in other species, especially long-lived species.

5. Conclusion

Elephant personality shows consistency over time for some aspects, but not all. The importance of understanding personality and applying it to evidence-based management of zoo animals has been recognised. However, the potential for alterations to personality over time as a result of situational factors must be borne in mind. A gold standard personality rating assessment is one that has clear and concise terminology, and where possible, persons rating the animals should be involved in its development. The twenty items presented can be used to inform the development and application of elephant personality assessments which in turn can aid welfare and management considerations, of particular benefit within zoo settings where elephant welfare remains a high priority.

CRediT authorship contribution statement

Lucy Rutherford: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Lindsay Murray:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Lisa Holmes:** Writing – review & editing, Supervision, Resources. **Ellen Williams:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that there are no conflict of interests.

Appendix A. Supplementary data

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