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Assessing Behavioral Syndromes in Captive Red Pandas (Ailurus fulgens) Using an Ethological Approach

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by

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Abstract

Research on animal personality has revealed that it is stable and contextually consistent, and has a significant impact on an animal's physiology and psychological wellbeing. Personality, sometimes referred to as behavioral syndromes or temperament, impacts health, reproductive success, and survival, and is thus an important factor to consider when assessing the welfare of captive animals. In this study, eight red pandas (*Ailurus fulgens*) were observed from three institutions in the New York City area to determine if behavioral syndromes can be assessed in this species using an ethological approach. Two behavioral syndromes were assessed: 1) "Active/Exploratory" and 2) "Maintenance", which showed no differences between age or sex classes. The "Active/Exploratory" behavioral syndrome is consistent with several personality dimensions found in other mammalian species, while the "Maintenance" behavioral syndrome may be related to a broader personality dimension. Neither behavioral syndrome showed sex differences, but the "Active/Exploratory" dimension was inversely correlated with age. Both behavioral syndromes have ecological and welfare implications. This study can serve as the start of a deeper investigation into behavioral syndromes in red pandas and the impact they have on the welfare of this species in captivity.

Keywords: Behavioral syndromes, red panda, welfare, animal personality

Assessing Behavioral Syndromes in Captive Red Pandas (*Ailurus fulgens*) Using an Ethological Approach

Research on non-human animal personality has historically been sparse. Some work on this topic emerged in the early 20th century from a few researchers, but animal personality remained understudied until recently due to the argument that animal personality is subjective and idiosyncratic (Freeman & Gosling, 2010; Gosling, 2008; Dall, Houston, & McNamara, 2004). This recent resurgence encompasses a variety of fields, and is the result of empirical and conceptual advances that demonstrate that animal personality is in fact stable, quantifiable, and consistent (Gosling, 2008; Sih, Bell, & Johnson, 2004; Pennisi, 2016).

Scientists use several terms to discuss the concept of animal personality, including “personality”, “behavioral syndromes”, and “temperament” (Gosling, 2001). No overarching, comprehensive definition of animal personality exists across disciplines. However for the purpose of this study, “behavioral syndromes” will be used to refer to the dimensions of animal personality, and are defined as suites of correlated behaviors that remain consistent within a given behavioral context and across time and ecological contexts (Sih, Bell, Johnson, & Ziemba 2004). These behavioral syndromes are variable between individuals (Wielebnowski, 1999; Gartner & Powell, 2011; Gosling, 1998), heritable (Sih, Bell, & Johnson, 2004; Dingemanse, Bouwman, van de Pol, van Overveld, Patrick, Matthysen, & Quinn, 2012), and affect survival at both the individual and the group level (Bergvall, Schäpers, Kjellander, & Weiss, 2011; Grinsted, Pruitt, Settepani, & Bilde, 2013), thus making these consistent individual differences an important factor in the evolution of a population. Behavioral syndromes serve an important ecological role, affecting species distributions and response to environmental change by maintaining individual variation in behavior and limiting behavioral plasticity (Sih, Bell, &

Johnson, 2004; Sih, Cote, Evans, Fogarty, & Pruitt, 2012). In the broader context, they have the potential to be a vital core of interdisciplinary studies that connect the ecological impacts of behavior with the developmental bases of behavior and genetics, within an evolutionary overview, due to their nature of variability, heritability, and their impact on survival, reproductive success, and dispersal (Sih, Bell, Johnson, & Ziemba, 2004).

Behavioral syndromes have been studied in many species in disparate taxa. In the social spider *Stegodyphus sarasinorum*, for example, variation in personality within groups was shown to be a main factor in task differentiation, both in a controlled laboratory setting and in a natural social setting (Grinsted, Pruitt, Settepani, & Bilde, 2013). In this species of social spider, the more aggressive individuals hunt prey or protect the web from invaders, while more docile individuals care for young and repair damage to the webs (Grinsted, Pruitt, Settepani, & Bilde, 2013). Pruitt & Goodnight (2014) also demonstrated in another social spider (*Anelosimus studiosus*) that certain ratios of aggressive-to-docile behavioral syndromes within a population yield different levels of survivorship between different sites. This study also revealed that groups of these social spiders adjust the ratio of aggressive-to-docile behavioral syndromes for the population over two generations in response to the risk of extinction, ensuring long-term persistence in their native habitat (Pruitt & Goodnight, 2014). In a similar study, Sih & Watters (2005) looked at group composition of differing behavioral types with a species of water striders (*Aquarius remigis*). They created 12 mixed-sex groups with low variance of behavioral traits, meaning males in one group were the most active and aggressive in the study, and the next group represented the next most active and aggressive, and so on (Sih & Watters, 2005). They found that the most highly active and aggressive groups continued to be active and aggressive, but did not have higher mating success as the hyper-aggressive males would drive females away (Sih &

Watters, 2005). More importantly, they found that a mix of behavioral syndromes within a population is better for the long-term persistence of the population, similar to the findings of the Pruitt & Goodnight (2014) study (Sih & Watters, 2005). Individual variation in average level and behavioral plasticity of exploratory behavior has been shown in wild populations of great tits (*Parus major*) (Dingemanse et al., 2012). Dingemanse et al. (2012) found significant individual differences in exploratory behavior between several populations of great tits and that these individual differences were consistent across populations. More importantly, their findings support the assertion that this exploratory behavior is ubiquitous and heritable (Dingemanse et al., 2012). Thus, accumulating data support the hypothesis that behavioral syndromes are heritable, found in disparate taxa, and allow individuals and populations to adjust to changes in their environment.

Behavioral syndromes have also been studied in domestic species. A variety of behavioral syndromes have been found in domestic cats (*Felis silvestris catus*), but one review paper found the highest validity between 20 personality studies of domestic cats included three dimensions: “Sociable”, “Curious”, and “Dominant” (Gartner & Weiss, 2013). A later study looked at behavioral syndromes across five felid species, and found three behavioral syndromes across 100 domestic cats: “Neuroticism”, “Impulsiveness”, and “Dominance” (Gartner, Powell, & Weiss, 2014). Here, “Neuroticism” is made up of anxious, insecure, tense, and not stable traits; “Impulsiveness” contains excitable, active, playful, and eccentric traits; and “Dominance” is made of dominant, bullying, and aggressive traits (Gartner & Weiss, 2014). In contrast, a large number of behavioral syndromes have been studied in domestic dogs (*Canis familiaris*), with little agreement on terminology and number between studies (Gartner, 2015). One review study focusing on personality in domestic dogs found seven broad behavioral syndromes: “Reactivity”, “Fearfulness”, “Activity”, “Sociability”, “Responsiveness to Training”, “Submissiveness”, and “Aggression” (Jones & Gosling, 2005). Other behavioral syndromes isolated in domestic dogs include “Subordination/Aggressiveness”, “Ambivalence”, “Calmness”, “Neuroticism”, and more (Gartner, 2015). Studies have also found breed differences in behavioral syndromes (Svartberg & Forkman, 2002), and some studies found sex differences while others did not (Gartner, 2015). Consistency of behavioral syndromes over time has also been found in both domestic dogs (Fratkin, Sinn, Patall, & Gosling, 2013) and domestic cats (Raihani, Rodríguez, Saldaña, Guarneros, & Hudson, 2014).

Studies have also found that behavioral syndromes can impact an individual’s health and vulnerability to disease (Cavigelli, 2005; Capitanio et al., 1999). Capitanio, Mendoza, and Baroncelli (1999) discovered that some behavioral syndromes, particularly one labeled “sociability”, were correlated with indicators of health, including hypothalamus-pituitary-adrenal axis (HPA) functioning, measures of viral load, and rhesus cytomegalovirus (CMV)-specific antibody response in rhesus macaques inoculated with simian immunodeficiency virus (SIV). Individuals who were rated as highly sociable showed a significantly more rapid decline in plasma cortisol levels and SIV RNA in response to inoculation (Capitanio et al., 1999). Personality has also been shown to impact health in humans. “Neuroticism”, one of the Big Five personality dimensions in humans (Nettle, 2006), was linked directly to both the risk of psychiatric disorders and chronic somatic diseases in a sample of 5,362 men and women born in 1946 in the UK (Neeleman, Sytema, & Wadsworth, 2002). High neuroticism measured between ages 13 and 26 linked with poor somatic health in 28% of the sample and with poor psychiatric health in 52% of the sample independently of one another (Neeleman, Sytema, & Wadsworth, 2002).

Behavioral syndromes are vital to the field of animal welfare. Consistent individual differences can be used to predict a captive animal's behavior in response to changes in the environment, such as behavior towards keepers and additions of conspecifics or enrichment (Carlstead, 2009; Jones & Gosling, 2005). Several studies suggest that an understanding of behavioral syndromes can help predict individual reproductive success in captivity (Wielebnowski, 1999; Loeffler, 2011). One study focusing on giant pandas (*Ailuropoda melanoleuca*) found a correlation between high scores in a "shyness" dimension and poor sociosexual performance (Powell et al., 2008). Wielebnowski (1999) found that in captive cheetahs (*Acinonyx jubatus*), individuals scoring high in a "Tense-Fearful" dimension had poorer reproductive success. The authors suggest that more areas of seclusion in the cheetahs' environment can help them breed successfully (Wielebnowski, 1999). Another study found a similar relationship between behavioral syndromes and reproductive success in giant pandas (Martin-Wintle, Shepherdson, Zhang, Huang, Luo, & Swaisgood, 2017). The significant findings from this study show that certain combinations of personality traits for giant pandas are beneficial for reproductive performance, and other combinations impair reproductive performance (Martin-Wintle et al., 2017). Based on these results, the authors made several recommendations to improve reproductive performance in this species, including pairing High-Aggressive males with Low-Aggressive females and High-Excitable males with Low-Excitable females, while avoiding pairing Low-Aggressive males with Low-Aggressive females and High-Fearful males with Low- or High-Fearful females (Martin-Wintle et al., 2017). A similar study using cockatiels (*Nymphicus hollandicus*) also found a relationship between behavioral syndrome and reproductive success. When allowed to pair by free choice, those birds that paired disassortatively on a behavioral syndrome of "Agreeableness", which measured individuals' tendency to be aggressive vs. gentle, submissive, or tolerant of other birds' behaviors, had lower rates of aggression towards their mates and were more coordinated during incubation as compared to birds that paired associatively on this dimension (Fox & Millam, 2014). This illustrates that the ability to assess behavioral syndromes in captive individuals can provide key information about the subjects' health or who they may breed most successfully with, and can inform keepers on possible enrichment and enclosure modifications that will benefit the animals' reproductive success. In this way, an understanding of behavioral syndromes is key for any captive species where reproduction is a major focus, such as for example the red panda (*Ailurus fulgens*).

Red pandas are generally solitary, territorial mammals that are endemic to the Himalayan temperate forests in parts of Bhutan, Nepal, India, Myanmar, and China (MacClintock, 1988; Hodgson, 1847). Mature individuals interact only briefly with conspecifics during breeding season (mid-January to March), and at other times inhabit large, overlapping territories of about 2.5 km^2 (females) to twice that size (males). Individuals generally travel about 25% of this range during the day to mark territory (MacClintock, 1988). This species also has very specific requirements for forest type, altitude, proximity to watercourses, and precipitation (Pradhan, Saha, & Khan, 2001). Red pandas are currently listed as endangered by the IUCN Red List. A Red Panda Species Survival Plan exists in AZA-accredited zoos to manage the reproduction of this species to maintain population genetic and demographic health (Glatston, Wei, Than Zaw, & Sherpa, 2015; AZA Small Carnivore TAG, 2012).

Personality is already a consideration in the rearing of captive red pandas, particularly in breeding and maternal care. According to the AZA Red Panda Care Manual (2012), keepers may adjust mother and cub management depending on the personality of the mother. The manual recommends either allowing the mother and cub to access the exhibit before, during, and after parturition, or keep them in the nest area until the cub is 2-3 months old (AZA Small Carnivore TAG, 2012). Red panda mothers may become intolerant of public disturbance when they have young cubs and the management of both mothers and cubs will depend on the personality of the mother. In some cases, red panda mothers may have poor milk production, and personality of the mothers again comes into consideration for management as keepers may choose to hand-rear the cub or supplement feed while the cub remains with the mother (AZA Small Carnivore TAG, 2012). Personality is being used in some considerations for red panda management in captivity, but no work has yet been done to categorize behavioral syndromes in this species or systematically study their impacts on welfare.

There are two main methods for collecting data in personality studies: 1) Behavioral coding and 2) Observer trait ratings (Gosling, 2011). Behavioral assessment is an ethological approach, where animals are observed and their behavior is recorded, typically in terms of frequency or duration. This may be done passively, where only naturalistic behaviors are recorded, or used in a testing context (i.e. novel object tests). In contrast, the second methodology used in animal personality studies involves animal keepers or observers who are familiar with the subjects rating the subjects based a set of predefined traits or adjectives on a scale from strongly characteristic to strongly uncharacteristic of the individual (Gosling, 2011). The trait rating method can be done based on the rater's cumulative experience with the subjects, on natural observations in a set time frame, or in combination with testing methods (Freeman & Gosling, 2010). The first method, employing behavioral observation, is the most often used method for assessing personality in animal studies, though rarely with non-captive animal. In a review of primate personality research, Freeman & Gosling (2010) found that 56% of the studies reviewed used behavioral coding based on natural observation, while the second most used method was behavioral coding in testing contexts, with 28% of reviewed studies using this method. Trait rating based on cumulative experience with an animal was seen in 26% of the studies, while trait rating based on natural observations and trait rating based on testing contexts represented only 17% of the reviewed studies (Freeman & Gosling, 2010). Both methodologies have benefits and drawbacks. The ethological approach is less subjective and allows for easier comparison between animals (Freeman & Gosling, 2010), and the data collected are reusable (in the form of videos) and arises from more natural situations (Watters & Powell, 2011). However, it takes more time and is harder to account for variability, and staff training investment is high (Freeman & Gosling, 2010; Watters & Powell, 2011). Trait rating is a much faster method. It accounts for noise and cross-situational consistency (Freeman & Gosling, 2011) and for behavior across many contexts (Watters & Powell, 2011) but it requires subjective judgments by observers and those observers may disproportionately weight salient events more (Freeman & Gosling, 2010). The trait rating method is also more time intensive in terms of survey design and validation, and variation in experience among raters can add variation to the data (Watters & Powell, 2011).

Little is known about what behavioral syndromes are seen in captive red pandas. No study has attempted to look systematically at behavioral syndromes in this species, and where personality is referenced it is based primarily on informal keeper reports. A more detailed understanding of the specific behavioral dimensions seen in this species may optimize reproductive success. Identifying behaviors that serve as major indicators of behavioral syndromes will aid in the analysis of individual personality, regardless of familiarity with the subject.

The goal of this study is two-fold:

1. Examine if a purely ethological approach can provide clear assessment of behavioral syndromes in a small sample of captive *A. fulgens*.
2. Evaluate behavioral syndrome differences between age and sex classes in this sample of captive *A. fulgens*.

To accomplish this goal, this study will examine inter-animal behavioral differences in red pandas located at the Bronx, Central Park, and Prospect Park zoos operated by the Wildlife Conservation Society in New York City (n = 8). It has been shown in studies with snow leopards and spotted hyenas that certain types of behaviors can be grouped statistically, revealing behavioral dimensions such as “Bold” or “Playful” (Gartner & Powell, 2011; Gosling, 1998). This study will use a similar method to isolate behavioral syndromes based on the ethological data obtained from the videos. Under these conditions, any resulting behavioral syndromes will reflect stable patterns of behavior across time and context, and thus the animals’ personalities. This study will show if this type of analysis can assess behavioral syndromes in captive red pandas and will begin to look at the way personality may impact this species by examining differences in these behavioral syndromes based on age and sex class.

Other studies have found sex and/or age differences related to behavioral syndromes. Powell & Svoke (2008) found significant differences between male and female giant pandas, with females being rated more “Alert”, “Excitable”, “Tense”, and “Innovative”, and less “Eccentric” than males by keepers, which were consistent with results of a novel object test. In another study, five behavioral syndromes were found in snow leopards (*Uncia uncia*) using keeper surveys (Gartner & Powell, 2011). These dimensions were “Active/Vigilant”, “Curious/Playful”, “Calm/Self-assured”, “Timid/Anxious”, and “Friendly to Humans”. This study also found differences in behavioral syndrome based on sex and age. Males were found to be more "Active/Vigilant" than females, and age correlated significantly with all of the assessed behavioral syndromes aside from "Friendly to Humans" (Gartner & Powell, 2011). Finally, a recent study examining personality in captive sea lions (*Zalophus californianus*) uncovered three behavioral syndromes: "Extraversion/Impulsivity", "Dominance/Confidence", and "Reactivity/Undependability" (Ciardelli, Weiss, Powell, & Reiss, 2017). They found that "Extraversion/Impulsivity" showed a significant sex difference, but none of the three dimensions showed a relationship with age class.

Based on natural red panda behavior, the author anticipates isolating behavioral syndromes that pertain to activity or territoriality. As mentioned previously, red pandas are territorial and solitary in the wild, often traveling through much of their territory per day to perform marking behavior (MacClintock, 1988). Additionally, the author expects that a behavioral syndrome denoting activity would have sex and age difference, with younger individuals being more active. Males have larger territories, and other studies that have found sex and/or age differences in behavioral syndromes have found similar results, with males and juveniles more active than females and adults (Gartner & Powell, 2011; Ciardelli et al., 2017).

Methods

Subjects

This study includes eight red pandas (males: n = 4, females: n = 4) from the Bronx (n = 4), Central Park (n = 2), and Prospect Park zoos (n = 2). Ages of subjects ranged from three years to nine years of age at the start of the study. All subjects were born in captivity and were housed with conspecifics. The Bronx Zoo group is comprised of a mated pair, their mature female offspring, and an unrelated male. At the start of this study, the unrelated male was housed individually and the unpaired female was housed with her parents. Through the majority of the study, however, the unpaired female was housed alone and in a holding area adjacent to the unrelated male. The two underwent introductions and were given access to each other's holding areas periodically in the later part of the study. The Prospect Park and Central Park subjects are both mated pairs and were housed together.

Procedure

Video Collection.

This study consisted of 150 10-minute videos from two periods in 2012: spring (April – June) and winter (October – December). Animals were filmed from the zoo visitor viewing areas at each institution using a continuous sampling method for individual subjects in order to capture durations of specific behaviors and interactions with conspecifics and/or the surrounding environment. The number of videos per subject is unevenly distributed, varying from 11 to 28 with an average of 18.75 videos per red panda, and a median value of 19.5 videos. The time of observation was randomized across videos to account for daily and weekly variations in behavior. Videos were taken by Dr. David Powell, then Assistant Curator for Mammals at the Bronx Zoo, and Briana Aguilar-Austin, MA Candidate at Hunter College, using a Kodak PlaySport and an 8 GB Flip UltraHD Video Camera respectively.

Video Coding.

Videos were coded using GriffinVC, a free video coding software created by Shur V. Singh and Sonia Ragir (accessed from: http://svirs.github.io/griffinVC/). The analysis of red panda behaviors in this study is based on a comprehensive ethogram of 74 red panda behaviors compiled from 930 hours of observation (Jule, 2008) (Table 1). In this study, a revised form of this ethogram consisting of 18 behaviors was used in order to focus on “higher-order behaviors” (Watters, Margulis, & Atsalis, 2009) (Table 2).

All videos were coded to determine the durations of each of the target behaviors. In order to test inter-rater reliability, a subset representing 10.67% of the total videos was also coded by a second person. For all videos, data from both observers were ordered chronologically. Behavior codes were considered to be from the same time point if they were reported within one second of each other. If one observer coded a behavior at a time point when the other observer did not, the previous behavior from the other observer was carried over to align with this observation. For example, both Observer A and Observer B coded the subject as performing a “Locomotion/Climbing” behavior at 1:00 minute, and then only Observer A coded the subject switch to an “Exploratory” behavior at 1:30 minutes. In computing for inter-rater reliability, two paired observations are analyzed: one at 1:00 minute where both observers were in agreement on a “Locomotion/Climbing” behavior, and one at 1:30 minutes where Observer A recorded “Exploratory” and Observer B’s previous “Locomotion/Climbing” code was carried over. The resulting paired observations were analyzed using Cohen’s (1960) Kappa. Kappa values are considered good between 0.4 and 0.75, and excellent if greater than 0.75 (Fleiss, 1981). The Kappa value for this study was an acceptable $\kappa = 0.638$.

Statistics

All statistical analyses were performed using IBM SPSS v. 24 for Macintosh.

Assessing Behavioral Consistency and Correlations.

In order to assess behavioral syndromes, the relevant coded behaviors need to be shown to be consistent across context. Consistency was assessed for each behavior using an independent sample *t*-test between the spring and winter periods for each panda. An independent sample *t*-test was used in order to determine if the mean duration of each behavior was significantly different between time periods. Behaviors that were found to be significantly different between periods were considered inconsistent and were thus dropped from the analysis. Behaviors that were consistent in at least six of the eight subjects were used to assess personality.

Correlations between behavioral variables would determine if any rotation is needed for the Principal Component Analysis to assess behavioral syndromes. Therefore, a matrix of Pearson’s correlations coefficients was created among behaviors found to be consistent to determine their relationships.

Assessing Behavioral Syndromes.

Consistent behaviors were then used in a Principal Component Analysis (PCA) to calculate behavioral syndromes (cf. Cote, Fogarty, Weinersmith, Brodin, & Sih, 2010). A PCA uses observed variables to uncover underlying variables that cannot be directly measured, such as behavioral syndromes, while retaining as much variance as possible with the fewest number of components (Pearson, 1901). The PCA was performed within each subject using a varimax rotation because the consistent behaviors were found to be correlated. Two components for each subject were found. For each consistent behavior, the direction and component upon which it loaded was tallied across subjects, and behavioral syndromes were constructed based on highest agreement between the individual subjects’ results. For example, if six subjects had “Locomotion/Climbing” behavior loading positively on Component 1, one subject had “Locomotion/Climbing” behavior loading negatively on Component 1, and the final subject had “Locomotion/Climbing” loading positively on Component 2, agreement among subjects places “Locomotion/Climbing” behavior loading positively on Component 1. Although the data in this study violate the assumption of independence, agreement between the results from the eight subjects would provide an argument that the emergent factors represent behavioral syndromes in this sample.

Age and Sex Class Comparison.

The subjects' ages are represented as the median between the ages they were at the start and the finish of the study based on information from their respective institutions. All subjects are beyond the age of sexual maturity. For analysis, age classes were created based on the average age of all subjects ($\mu = 5.75$). The five subjects below that age were classified as young adults, and the three subjects above that age were classified as older adults.

For all subjects, loadings on each personality component were weighted, where behaviors stronger than 0.32/-0.32 were assigned a weight of +1/-1 respectively, and behaviors between -0.32 and 0.32 were assigned a weight of zero (Ciardelli et al., 2017). Behaviors that cross-loaded between the two components (loading stronger than 0.32/-0.32 on both components) were weighted +1 or -1 based on the loading on Component 1 and weighted zero in Component 2. This is because weighted loadings for cross-loaded behaviors would have loadings of equal strengths for both components, and Component 1 explains more variance as PCA orders components based on the amount of variance explained by each (Pearson, 1901). Once the scores were weighted, they were multiplied by each subject's mean duration of behavior and summed. These scores were normalized by transforming them into *z*-scores and were analyzed for sex and age class differences using Mann-Whitney *U* tests. As age is a continuous variable, Pearson's correlation coefficients were also calculated between age and the component *z*-scores to get a more in depth view of the relationship between age and the personality components.

Results

Behavioral Consistency and Correlations

The results of the independent sample *t*-test for all behaviors between spring and winter periods are shown in Tables 3a and 3b for all subjects. The tables list the *t*-score and degrees of freedom of each behavior per subject. Asterisks (*) denote behaviors that are significantly different across time periods per subject. As a result, eight behaviors were consistent, and thus used in the assessment of behavioral syndromes (Table 4). These behaviors were "Lying sleeping", "Lying or sitting – alert", "Standing", "Locomotion/Climbing", "Grooming/Scratching self", "Eating", "Exploratory", and "Marking". "Grooming/Scratching self", "Standing", and "Eating" behaviors were consistent for all eight subjects, while "Lying sleeping", "Lying or sitting – alert", "Exploratory", and "Marking", and behaviors were consistent for seven of the eight subjects. The "Locomotion/Climbing" behavior was consistent for six of the eight subjects.

In order to explore the relationships between the eight behaviors, a Pearson's correlation was conducted. Seven of the eight consistent behaviors turned out to be correlated with at least one other consistent behavior (Table 5). This supports the use of a varimax rotation during the following Principal Components Analysis, which seeks to find non-correlated latent variables from correlated observed variables (Quinn & Keough, 2002).

Behavioral Syndromes

Principal Component Analysis produced two components for each subject, shown in Tables 6a and 6b. Table 6a lists the varimax rotation factor loadings per panda on the first component, and Table 6b lists the loadings on the second component. A variable is said to load on a component if its loading is greater than 0.32 or less than -0.32 (Tabachnick & Fidell, 1996).

In the event that a variable loads on both components, the variable is said to load on the component where the loading is greater if the loading is above zero, or less if the loading is below zero. Behaviors not exhibited by a subject are denoted by a period. The two components together explained between 50.8% and 67.6% of the variance for each subject (Bamboozle: 50.8%, Elliot: 65.0%, MeiMei: 53.9%, Walter: 62.4%, Amaya: 51.0%, Biru: 54.3%, Beilei: 54.3%, Qin: 67.6%). Component 1 explained between 32.0% and 46.3% of the variance for each subject (Bamboozle: 35.1%, Elliot: 46.3%, MeiMei: 34.2%, Walter: 46.2%, Amaya: 32.0%, Biru: 38.4%, Beilei: 32.5%, Qin: 43.7%), while Component 2 explained between 15.7% and 23.9% of the variance for each subject (Bamboozle: 15.7%, Elliot: 18.7%, MeiMei: 19.7%, Walter: 16.2%, Amaya: 19.0%, Biru: 15.9%, Beilei: 21.8%, Qin: 23.9%).

Seven of the eight consistent behaviors showed agreement among subjects for both components, representing behavioral syndromes. These behavioral syndromes and their associated behaviors are shown in Table 7. “Eating” behavior loaded on Component 2 in three subjects, versus loading on Component 1 in two. Within Component 2, “Eating” behavior loaded positively in one subject, and negatively in two subjects. Based on this lack of agreement, “Eating” was not included on either component. Component 1 is comprised of “Locomotion/Climbing”, “Exploratory”, and “Marking” behaviors loading positively, and “Lying or Sitting – Alert” behavior loading negatively. This appears to define an “Active/Exploratory” behavioral syndrome, wherein an individual scoring high in this dimension is characterized by increased movement or activity, exploration, and territorial marking, while an individual scoring low in this dimension is primarily inactive. The second component is comprised of “Grooming/Scratching self” behaviors loading positively and “Lying sleeping” behavior loading negatively. This component seems to describe a behavioral syndrome of

"Maintenance". Individuals who score highly in this dimension frequently perform maintenance behaviors, such as grooming, scratching, or sleeping, while those who score low in this dimension are inactive.

Age and Sex Class Comparison

Weighted component *z*-scores, as well as age and sex information for each subject, are presented in Table 8. There were no significant sex differences for either behavioral syndrome (Active/Exploratory: $U = 2$, $p = 0.114$; Maintenance: $U = 6$, $p = 0.686$). Age differences were found in the "Active/Exploratory" dimension ($U = 0$, $p = 0.036$), with young adults ($n = 5$, $Mdn = -82.143$) scoring significantly higher than older adults ($n = 3$, $Mdn = -242.608$). This relationship was confirmed by the Pearson's correlation between the "Active/Exploratory" behavioral syndrome and age ($r = -0.717$, $p = 0.045$). The "Maintenance" dimension was not significantly related to age based on either test ($U = 6$, $p = 0.786$; $r = -0.339$, $p = 0.411$).

Discussion

Behavioral syndromes are an important aspect of animal welfare. For red pandas in captivity, they are part of the consideration in mate pairing and are thought to impact maternal care (AZA Small Carnivore TAG, 2012). However, no formal study has focused on examining behavioral syndromes in captive red pandas in depth.

The ethological approach used to identify behavioral syndromes in this study was successful in revealing two behavioral syndromes in a small sample of captive red pandas. These two behavioral syndromes are based on eight consistent behaviors commonly exhibited by red pandas in captivity. These syndromes have been labeled "Active/Exploratory" and "Maintenance" dimensions. These dimensions explained greater than half of the variance in the eight consistent behaviors used to calculate them. A larger sample size might allow for the isolation of additional components. Furthermore, more components may be assessed and more variance may be explained by combining the ethological approach with a test context or a with the trait survey approach. Despite being more objective and allowing for easier inter-subject comparisons, trait ratings based on cumulative experience have been shown to be the most practical and reliable assessment method for behavioral syndromes in primates (Freeman & Gosling, 2010). A combination of techniques would be more powerful and using a test context or a trait rating survey would help support and confirm the results of the ethological approach (Freeman & Gosling, 2010).

The “Active/Exploratory” dimension appears consistent with behavioral syndromes found in other species, such as “Active/Vigilant” in snow leopards (Gartner & Powell, 2011), “Extraversion/Impulsivity” in sea lions (Ciardelli et al., 2017), “Openness” in spotted hyenas (Gosling, 1998), “Curious” in domestic cats (Gartner & Weiss, 2013), “Activity” in domestic dogs (Jones & Gosling, 2005), and “Openness” and “Extraversion” in humans (Nettle, 2005), which are all marked by active, novelty-seeking, and curious traits. Freeman & Gosling (2010) also found both “Active” and “Curious” dimensions in their review of primate personality research, in eleven and nine studies respectively. Those studies classify an “Active” dimension as “moving about a lot” and a “Curious” dimension based on readiness to explore novel situations (Freeman & Gosling, 2010). This matches fairly well with the “Active/Exploratory” behavioral syndrome found in this study. In contrast, the “Maintenance” dimension appears unrelated to other behavioral syndromes found in snow leopards (Gartner & Powell, 2011), giant pandas (Powell & Svoke, 2008), sea lions (Ciardelli et al., 2017), spotted hyenas (Gosling, 1998), or in reviews of primate (Freeman & Gosling, 2010), domestic cat and dog (Gartner, 2015), or human (Nettle, 2005) personality studies. This may be because this dimension is comprised of behaviors involved in maintaining health (“Sleeping” and “Grooming”). These behaviors may be correlated with other traits and thus represent behavioral syndromes found in other species. One example would be a “Timid” or “Anxious” dimension, as grooming behaviors in particular have been shown in some species to be a strategy to mitigate stress (primates: Boccia, Reite, & Laudenslager, 1989; Wittig, Crockford, Lehmann, Whitten, Seyfarth, & Cheney, 2008; rats: Kametani, 1988; Sachs, 1988). Future studies could compare results of behavioral syndrome assessment using both a keeper survey and an ethological approach to confirm this.

These behavioral syndromes have ecological and welfare implications for red pandas. Individuals who are highly “Active/Exploratory” may travel further and explore more of their surroundings, based on the movement and novelty-seeking behaviors that comprise this behavioral syndrome. This could lead to finding more food or being able to mark a larger territory. Increased activity, however, would increase the likelihood of an individual crossing paths with predators. In regards to the “Maintenance” behavioral syndrome, individuals rating highly in this dimension may have better health due to reduced stress and parasite load from higher rates of grooming. Conversely, if the “Maintenance” behavioral syndrome is related to a “Tense” or “Anxious” dimension, individuals rating highly in this dimension may have increased health problems as a result of chronic stress. As for welfare, captive red pandas that are highly “Active/Exploratory” may require larger spaces, more complex climbing structures, or more forms of enrichment to prevent frustration as this dimension is related to an increased frequency of “Locomotion/Climbing” and “Exploratory” behaviors.

The “Maintenance” dimension did not show age differences, but “Active/Exploratory” was inversely related to age. This is consistent with findings in other species that show a decrease in dimensions relating to activity and novelty-seeking with age in domestic cats and snow leopards (Gartner, Powell, & Weiss, 2014), domestic dogs (Starling, Branson, Thomson, & McGreevy, 2013), chimpanzees (Weiss, King, & Hopkins, 2007), and humans (Donnellan & Lucas, 2008). No sex differences were found in this study for either behavioral syndrome. This is consistent with findings in sea lions (Ciardelli et al., 2017), but is different from findings in cheetahs (Wielebnowski, 1999), snow leopards (Gartner & Powell, 2011), and giant pandas (Powell & Svoke, 2008). The difference in relationship between age and both behavioral syndromes could indicate that some behavioral syndromes are under more genetic control than others (Gartner & Powell, 2011), or it may be due to the small sample size. Additionally, lack of sex differences in either behavioral syndrome may be due to minimal physical differences between male and female red pandas. Red pandas are not sexually dimorphic in coloring or size, and both males and females have relatively large territories through which they travel large distances daily to explore and mark (MacClintock, 1988). A larger sample size is needed to confirm these relationships. Guidelines for the multivariate statistics used in this study vary, but most suggest either a large sample size, or a ratio of more subjects than variables (Osborne & Costello, 2004). This study was limited in having a small overall sample and roughly equal number of both subjects and variables used in the Principal Component Analysis.

Understanding the behavioral syndromes present in red pandas is the first step to uncovering how personality impacts their welfare. The sample size in this study was too small to provide an in-depth picture of behavioral syndromes in captive red pandas, but it serves as a basis for analyzing behavioral syndromes ethologically from video data in this species. Understanding personality in a captive species has numerous benefits for animal welfare. It can be used to plan the introduction of a new individual to a potential mate. Current methods involve at least two steps in introduction before proceeding to allowing full physical contact, with first establishing sensory contact and proceeding to limited tactile contact (Powell, 2010). These methods have traditionally relied on the experience and observations of animal husbandry professionals, but identifying clear personality types can help predict more accurately and efficiently how individual animals would interact with each other (Powell, 2010). An understanding of behavioral syndromes can also help keepers speculate as to which individuals would work best as captive breeding pairs and possibly predict reproductive success (Tetley & O'Hara, 2012). In one species of bird (Fox & Millam, 2014) and in giant pandas (Martin-Wintle et al., 2017), it has been shown that an understanding of behavioral syndromes can accurately predict reproductive compatibility and success. In particular, the relationship between personality and reproductive success found by Martin-Wintle et al. (2017) in giant pandas led to specific suggestions that managers of this engendered species could use to improve reproductive performance. If similar comparisons can be drawn between reproductive success in red pandas and intrapair behavioral syndromes, guidance could be provided to help pair individuals for mating in a way that will maximize reproductive success while supplementing current methods to manage genetic diversity. Wielebnowski (1999) found that female captive cheetahs scored higher than males in a "Tense-Fearful" behavioral syndrome. This information led to suggestions for improving reproductive success by increasing areas of seclusion in the cheetahs' exhibits (Wielebnowski, 1999). In giant pandas as well, a "Shyness" dimension has been shown to be correlated with poor sociosexual behavior (Powell et. al, 2008). These authors suggest that reproductive success in this species could be improved by reducing shyness by increasing comfort levels with keepers and altering the enclosures through increasing the number of dens and providing environmental enrichment (Powell et al., 2008). If a similar relationship between personality and breeding success exists in red pandas, keepers can plan the space of an enclosure, provide enrichment, and apply similar management strategies to reduce a behavioral syndrome component that is negatively impacting reproductive success. Eriksson et al. (2010) found that 30% of zoos in their study situate red panda exhibits adjacent to those of large carnivores, which may lead to chronic stress. Chronic stress has been linked to poor reproductive and immune functioning (Mason & Rushen, 2006; Terio, Marker, & Munson, 2004), and understanding personality can help predict how an individual will fare in a particular exhibit location, or provide keepers with solutions to mitigate this problem (Loeffler, 2011). It has been established that in current care practice for red pandas in AZA institutions, judgments are made in how mothers and young cubs are housed, and in how cubs are to be fed and cared for if the mother is a poor milk producer (AZA Small Carnivore TAG, 2012). Behavioral syndrome assessment for the mother could allow keepers to plan ahead for how to care for both mother and cub before the cub is born, thus providing better welfare for both.

Personality is already a consideration in the management of captive red pandas. Knowing what behavioral syndromes are present in this species and knowing which behaviors are representative of those behavioral syndromes can facilitate individual personality assessment, which can inform management and improve welfare. Further research is needed to confirm these behavioral syndromes in a larger sample, and potentially uncover further behavioral syndromes, as well as assess the deeper relationship between personality and welfare in this species.

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Tables

Table 1

Comprehensive ethogram with 74 red panda behaviors adapted from Jule (2008).

Behaviour	Description
Inactive	
Lying-alert	Head up, eyes open, reaction to surroundings in some manner (head or ear movement)
Lying-sleeping	Lying sleeping (either curled in a ball or lying flat out)- unresponsive to noise/activity
Cooling?	Lying flat out, limbs spread- only done in moderate up to very warm temperatures
Out of Sight	Continues stretch of time out of sight (believed to be inactive)
Active	
Locomotive	
Walking	Using all four limbs walking on ground
Jogging	Using all four limbs jogging on ground
Running	Using all four limbs running or bounding on ground
Climbing	Moving along vertical or horizontal plane provided it is off the ground and not wider than one metre
Fast Climbing	Running or bounding on non-horizontal plane or off ground, but no wider than one metre.
Self Play	Purposeless activity with self (i.e. rolling, tail chasing), but not repetitive
Out of sight	Briefly out of sight while moving
Hunt/Stalk	Hunting/stalking of bird or other mammal
Carry object	Carry object (e.g. bamboo, peacock feather) in mouth or hand while traveling (e.g. walking or climbing).
Out of sight	Believed to be active, but out of sight.
Non-locomotive	
Standing	Standing on all fours
Sitting	Sitting with front paws on ground
Sitting – paws up	Sitting with front paws off the ground
Standing	Standing upright on two legs
Scratching self	
Grooming self	
Hanging	Hanging from tree or enclosure furnishing
Vocalization	Usually to conspecific or keeper
Quack-snort	Harsh, broad-band, polysyllabic
Grunt	Short, deep
Territorial	
Vigilance - in	Observation within enclosure (of a non conspecific)
Vigilance – out	Observation outside enclosure
Exploratory	Exploratory/territorial investigation of enclosure, can involve sniffing,

	digging, interaction with furnishings within enclosure
Scenting	Rubbing of genital regions either sideways or front to back
Scratching	Using claws to rake across ground or object
Rubbing-muzzle	Rubbing of muzzle on ground or object
Rubbing	Rubbing of dorsal/lateral sides on ground or object
Sniffing	Olfactory investigation of an object or a non-animal
Licking	Olfactory investigation of an object or a non-animal
Tactile	Tactile investigation using paws to manipulate item
Digging	Extensive digging in ground, can include “rooting” with muzzle in loose soil
Social	
Eye contact	Two individuals making eye contact (stare)
Vigilance – con	One individual watching another (conspecific vigilance)
Physical avoid	Physical avoidance from a “reasonable” distance away
Displace – init.	Initiate physical displacement behaviour
Displaced – recip.	Recipient of displacement behaviour
Displacement – w	Displacement of another with no contact – Win
Displacement – l	Displacement by another with no contact – Lose
Initiate fight	Initiate physical aggression
Recipient fight	Recipient of physical aggression
Phys. fight – w	Winner of physical fight
Physical fight – l	Loser of physical fight
Chase	Chasing a conspecific
Chased	Being chased by a conspecific
Grooming other	Initiate grooming session
Mutual groom	Mutual grooming session
Being groomed	Recipient of groom
Mutual touching	Close proximity or touching (while awake or sleeping)
Touching	Touching another conspecific
Being touched	Being touched by another conspecific
Smelling other	Sniffing another conspecific, note* olfactory examination is amongst the most common type of social behavior.
Being smelled	Being sniffed by another conspecific
Paws up	Standing up on hind paws – initiate
Keeper Interaction	
Vigilant	Vigilance/observation of keeper
Approach – f	Approach keeper – friendly
Approach – a	Approach keeper – aggressive
Take item (food)	Take an item from keeper (most likely food)
Touched	Allow being touched by keeper
Touch – f	Touching keeper friendly/voluntarily
Touch – a	Touching (biting/scratching) keeper aggressively
Climb	Climbing on keeper (friendly) – (not personally observed, but described)
Consumption	
Drinking	
Eating browse	Eating provisioned bamboo or browse in enclosure

Eating provision	Provisioned food – fruits, vegetables, pellets
Food forage	Foraging in enclosure (e.g. permanent trees, grass), can include digging
Digging	Digging with front paws
Stereotypies	
Stereotypy – 1	Purposeless locomotion (including walking and climbing), mostly repetitive, throughout the enclosure often in a figure-8 style, although route can vary to some extent
Stereotypy – 2a	Repetitive in a localized area – facing out towards public
Stereotypy – 2b	Repetitive in a localized area – facing in towards the enclosure
Stereotypy – 3 circle	Repetitive walking/running in a tight circle, can be done on its own or within a pacing/stereotypic routine (Event behavior)
Stereotypy4	Excessive mouth movements i.e. tongue flicking
Stereotypy5	Excessive grooming/licking
Stereotypy6	Repetitive route in enclosure – predictable pattern, limited response/awareness to outside stimuli. In this case, accompanied by scent marking at repetitive locations but with no investigation (e.g. sniffing)

Table 2

Limited ethogram representing "higher-order behaviors" based on Jule's (2008) ethogram of 74 red panda behaviors.

Behavior	Description
Lying-sleeping	Lying down, without reaction to surroundings
Lying or sitting-alert	Lying or sitting, with reaction to surroundings in some manner (head, eye, ear or tail movement)
Standing	Standing on all fours or on back two paws
Locomotion/Climbing	Moving along vertically or horizontally on or off of the ground
Self-play	Purposeless activity with self such as rolling, tail-chasing, but not repetitive
Pro-social interaction	Interaction with conspecific: grooming, social play, courtship, mating
Anti-social interaction	Interaction with conspecific: aggression
Carry object	Carrying an object in mouth or hand while locomoting
Grooming/scratching self	Grooming or scratching own body, not repetitively
Eating	Eating food in enclosure
Drinking	Drinking water in enclosure
Vocalization	Quack-snort or grunt, any noise the animal emits from mouth
Exploratory	Exploratory territorial investigation of enclosure, can involve sniffing, digging, interaction with furnishings within enclosure
Approach-c	Approach keeper or other animal management staff in calm manner
Approach-a	Approach keeper or other animal management staff in aggressive manner
Marking	Rubbing genitals on an object, or frequent urination on objects
Out of sight	Unable to be seen by observer
Stereotypy	Excessive and/or repetitive walking/running/grooming/licking

Table 3a

Results of independent sample t*-test for first four subjects, showing the consistency of each behavior between spring and winter periods.*

Behavior	Bamboozle			Elliot			MeiMei			Walter		
	t	*p*	DF	*t*	*p*	DF	*t*	*p*	DF	*t*	*p*	DF
Lying-sleeping	-1.688	0.112	15	0.823	0.422	16.53	-0.806	0.43	19	-1.708	0.16	4.15
Lying or sitting-alert	-0.436	0.666	25.91	0.702	0.491	20	-0.118	0.907	19	-0.86	0.405	13.78
Standing	2.025	0.062	14.16	0.536	0.598	20	0.695	0.495	19	0.993	0.338	14
Locomotion/Climbing	0.531	0.6	26	-1.336	0.208	11.14	1.914	0.076	14.02	0.795	0.44	14
Self-play	.	.	.	.	.	.	.	.	.	.	.	.
Pro-social interaction	.	.	.	.	.	.	-1.986	0.078	9	0.661	0.519	14
Anti-social interaction	.	.	.	.	.	.	-1	0.343	9	.	.	.
Carry object	.	.	.	-1	0.341	10	.	.	.	.	.	.
Grooming/Scratch self	1.294	0.22	11.75	-1.645	0.131	10.05	1.322	0.202	19	0.722	0.482	14
Eating	0.883	0.385	26	-0.128	0.9	20	-0.056	0.956	19	.	.	.
Drinking	.	.	.	.	.	.	-1	0.343	9	-1	0.374	4
Vocalization	1	0.339	11	.	.	.	.	.	.	.	.	.
Exploratory	0.068	0.946	26	-0.836	0.418	13.43	2.161	0.05	13	1.699	0.12	10
Approach-c	.	.	.	.	.	.	.	.	.	.	.	.
Approach-a	.	.	.	.	.	.	.	.	.	.	.	.
Marking	-0.696	0.493	26	-1.658	0.128	10	1.647	0.127	11.27	1.482	0.169	10
Stereotypy	.	.	.	.	.	.	.	.	.	.	.	.

Notes. "*" denotes significance at the $p < 0.05$ level. Behaviors that were not demonstrated by an individual subject are noted with a period (.).

Table 3b

Results of independent sample t*-test for last four subjects, showing the consistency of each behavior between spring and winter periods.*

Behavior	Amaya			Biru			Beilei			Qin		
	t	*p*	DF	*t*	*p*	DF	*t*	*p*	DF	*t*	*p*	DF
Lying-sleeping	-0.755	0.461	17	-0.9	0.38	18	0.777	0.453	11	.	.	.
Lying or sitting-alert	1.293	0.228	9.05	0.909	0.376	18	2.539*	0.028	11	2.201	0.055	9
Standing	0.455	0.663	7.12	-0.973	0.343	18	-1.26	0.234	11	-0.735	0.481	9
Locomotion/Climbing	-3.147**	0.006	16.90	-2.245*	0.038	18	-1.815	0.139	4.26	-1.397	0.25	3.25
Self-play	.	.	.	0.221	0.827	18	.	.	.	.	.	.
Pro-social interaction	-0.755	0.461	17	-0.9	0.38	18	.	.	.	.	.	.
Anti-social interaction	.	.	.	.	.	.	-1.552	0.196	4	0.484	0.64	9
Carry object	.	.	.	0.023	0.982	18	.	.	.	.	.	.
Grooming/Scratch self	1.53	0.177	6.02	0.859	0.401	18	-1.202	0.291	4.33	-1.006	0.341	9
Eating	0.92	0.371	17	1.143	0.282	9.25	-0.761	0.463	11	-0.913	0.426	3.12
Drinking	1	0.356	6	-0.9	0.38	18	.	.	.	-1	0.391	3
Vocalization	.	.	.	.	.	.	.	.	.	.	.	.
Exploratory	0.023	0.982	17	0.15	0.883	18	0.617	0.55	11	-0.112	0.913	9
Approach-c	.	.	.	.	.	.	.	.	.	.	.	.
Approach-a	.	.	.	.	.	.	.	.	.	.	.	.
Marking	-2.799*	0.016	11.73	-2.013	0.068	11.59	-0.29	0.777	11	-1.57	0.151	9
Stereotypy	-0.755	0.461	17	.	.	.	-1.674	0.17	4	0.739	0.479	9

Notes. "*" denotes significance at the $p < 0.05$ level, while "**" denotes significance at the $p < 0.01$ level. Behaviors that were not demonstrated by an individual subject are noted with a period (.).

Table 4

The proportion of subjects for each behavior which showed non-significant differences between time periods

Behavior	Prop. Of Subjects w/ Non-Sig Results
Standing	1
Grooming/scratching self	1
Eating	1
Exploratory	1
Lying sleeping	0.875
Lying or sitting-alert	0.875
Marking	0.875
Locomotion/Climbing	0.75
Drinking	0.5
Pro-social interaction	0.375
Anti-social interaction	0.375
Stereotypy	0.375
Carry object	0.25
Self-play	0.125
Vocalization	0.125
Approach-c	0
Approach-a	0

Notes. Table is ranked from highest to lowest proportions. Proportions of 0.75 (six out of eight subjects) or higher were considered consistent for behavioral syndrome analysis.

Table 5

Matrix of Pearson's Correlation Coefficients among consistent behaviors.

Behavior	Lying-sleeping	Lying or sitting-alert	Standing	Locomotion /Climbing	Grooming /scratching self	Eating	Exploratory	Marking
Lying-sleeping	1							
Lying or sitting-alert	-0.126	1						
Standing	-0.235**	-0.353**	1					
Locomotion/Climb	-0.238**	-0.640**	0.307**	1				
Grooming/scratching self	-0.1	-0.023	-0.095	-0.138	1			
Eating	-0.142	-0.326**	-0.057	-0.032	-0.093	1		
Exploratory	-0.186*	-0.350**	0.267**	0.123	-0.012	0.052	1	
Marking	-0.144	-0.388**	0.131	0.568**	-0.057	-0.022	0.194*	1

Notes. *"*" denotes significance at the $p < 0.05$ level, while "**" denotes significance at the $p < 0.01$ level.*

Table 6a

Matrix of Principal Component Analysis factor loadings on Component 1 among consistent behaviors using a varimax rotation.

Component 1	Bamboozle	Elliot	MeiMei	Walter	Amaya	Biru	Beilei	Qin
Lying-sleeping	-0.227	-0.264	-0.243	-0.214	0.346	0.068	-0.27	.
Lying or sitting-alert	-0.852*	-0.584	-0.741*	-0.825*	0.864*	-0.875*	-0.439	-0.851*
Standing	0.758*	0.479*	0.188	0.727*	-0.152	0.182	0.819*	0.897*
Locomotion/Climbing	0.894*	0.854*	0.84*	0.874*	-0.907*	0.792*	0.041	0.18
Grooming/scratching	-0.062	-0.113	0.35	-0.136	0.408*	-0.517*	-0.108	0.053
Eating	0.294	0.775*	0.124	.	-0.108	-0.009	-0.519	0.48*
Exploratory	0.519*	0.912*	0.769*	0.571*	0.405	0.797*	0.679*	0.866*
Marking	0.542*	0.913*	0.72*	0.927*	-0.707*	0.687*	0.634*	0.141

Notes. “*” denotes loading. Behaviors not exhibited by a subject are denoted by a “.”

Table 6b

Matrix of Principal Component Analysis factor loadings on Component 2 among consistent behaviors using a varimax rotation.

Component 2	Bamboozle	Elliot	MeiMei	Walter	Amaya	Biru	Beilei	Qin
Lying-sleeping	-0.818*	-0.88*	-0.092	-0.667*	-0.656*	-0.742*	-0.359*	.
Lying or sitting-alert	0.429	0.745*	0.4	-0.099	-0.162	0.062	-0.746*	-0.475
Standing	0.066	0.35	0.563*	0.049	0.69*	0.66*	0.309	0.058
Locomotion/Climbing	-0.013	0.009	0.385	-0.035	0.06	0.529	0.898*	0.978*
Grooming/scratching	0.579*	-0.111	0.393*	0.821*	0.406	0.213	-0.218	-0.227
Eating	-0.193	0.173	-0.901*	.	-0.108	-0.324*	0.779*	-0.015
Exploratory	0.131	0.244	-0.06	0.096	0.638*	0.115	0.004	-0.094
Marking	0.12	0.012	0.33	-0.025	-0.062	0.322	0.135	0.961*

Notes. “*” denotes loading. Behaviors not exhibited by a subject are denoted by a “.”

Table 7

Principal Component Analysis resulted in two components representing behavioral syndromes.

Component 1	**Component 2**
Lying or sitting-alert (-)	Lying-sleeping (-)
Standing (+)	Grooming/Scratching self (+)
Locomotion/Climbing (+)	
Exploratory (+)	
Marking (+)	

Notes. The behaviors associated with each are listed along with the direction of their loading.

Table 8

Demographic information for each subject, as well as each subjects score for both components.

Panda	Sex	Age	Component 1	Component 2
Bamboozle	F	3.5	-0.336	-0.127
Elliot	M	7.5	-0.297	-1.679
MeiMei	F	4.5	0.665	-1.036
Walter	M	9.5	-1.759	0.307
Amaya	F	5.5	1.662	0.830
Biru	M	3.5	0.548	-0.329
Beilei	F	3.5	-0.446	0.762
Qin	M	8.5	-0.038	1.273