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Personality in Free-Ranging Hanuman Langur (*Semnopithecus entellus*) Males: Subjective Ratings and Recorded Behavior

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The authors obtained behavioral observations and personality ratings for 27 free-ranging Hanuman langur males. Subjects were rated using a questionnaire based on the human Five-Factor Model (FFM). Behavioral observations were taken over 5 months using an ethogram that included 50 behaviors. Principal Component Analysis (PCA) of ratings revealed Agreeableness_R, Confidence_R, and Extraversion_R components. Each personality dimension was associated with a unique set of observed behaviors. PCA of 36 behavioral indices revealed Dominance_B, Involvement_B, and Activity_B components. Bivariate correlations showed that Agreeableness_R was negatively correlated with Dominance_B; Confidence_R was positively correlated with Dominance_B and Involvement_B but negatively correlated with Activity_B; and Extraversion_R was positively correlated with Activity_B. Dominance rank was positively correlated with Confidence_R and Dominance_B but negatively correlated with Agreeableness_R and Activity_B. These results highlight the comparability of behavioral coding and personality ratings and suggest that some aspects of personality structure were present in the common ancestor of Old World monkeys.

Keywords: trait rating, questionnaires, behavioral indices, dominance

Animal personality has been examined across a wide range of disciplines. Commonly defined, personality refers to characteristics of individuals that describe and account for consistent patterns of feeling, thinking, and behaving (Pervin & John, 1997). Personality traits, then, represent an economical way to summarize how one individual differs from another and how any given individual will behave across a range of situations and over long periods of time (John & Gosling, 2000).

Two approaches are used to study individual differences in temperament or personality in nonhuman animals. First, behavioral coding methods are based on the classical ethological method, which describes the observed behavior by behavioral categories defined in an ethogram (Gosling, 2001). The coding approach has primarily been used in studies of individual differences in a single behavioral domain, for example, parenting (Maestripieri, 1994, 2001), aggression (Petit, 1999; Petit, Abegg, &

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Thierry, 1997), reconciliation (Petit et al., 1997; Petit & Thierry, 1994a, 1994b), sociability (Shepherd & French, 1999), temperament (Boinski, 1999), or reactions to stressors (Fairbanks, 2001). However, it has also been used to study multiple domains (Chamove, Eyseneck, & Harlow, 1972; Rouff, Sussman, & Strube, 2005; Watson & Ward, 1996).

The second approach involves trait ratings (for a review see Gosling, 2001, or Gosling & John, 1999). This is a more recent approach which is based on commonly used method of studying human personality and should only be used if raters have long term knowledge of and experience with the subjects under study. Here subjects are rated by knowledgeable individuals using rating scales. Data are then analyzed via principal components or principal factors analysis.

Recently, the trait rating approach has been used to study the personality of several nonhuman primate species, including chimpanzees (*Pan troglodytes*; Buirski, Plutchik, & Kellerman, 1978; Dutton, Clark, & Dickins, 1997; King & Figueredo, 1997), gorillas (*Gorilla gorilla*; Gold & Maple, 1994), orangutans (*Pongo pygmaeus* and *Pongo abelii*; Weiss, King, & Perkins, 2006), vervet monkeys (*Cercopithecus aethiops sabaeus*; McGuire, Raleigh, & Pollack, 1994), and rhesus macaques (*Macaca mulatta*; Bolig, Price, O'Neill, & Suomi, 1992; Capitanio, 1999; Stevenson-Hinde, Stillwell-Barnes, & Zunz, 1980). This approach has also been used to study other nonhuman animal species (for a review see Gosling, 2001). Interrater reliabilities have been reported as satisfactory when using this method (Gosling & Vazire, 2002; Tinsley & Weiss, 2000).

If personality explains and predicts behavioral and affective consistencies, then it should be related to personality dimensions based on observed behaviors (Gosling, 2001). In a previous study, Capitanio (1999) found that personality ratings of rhesus macaques were stable across different situations and over time and also correlated with behaviors such as groom, contact, threat, and sexual present. In a study of zoo chimpanzees, Pederson, King, and Landau (2005) reported, along with other findings, that the chimpanzee personality domains of Dominance and Extraversion were correlated with agonistic and submissive behaviors, and affinitive and public orientation behaviors, respectively.

When examining nonhuman animal personality, studies should use as comprehensive a set of items as possible (Gosling & John, 1999). In human personality research, the Five-Factor Model (FFM) is the most widely supported and comprehensive model (Borkenau, 1992; Borkenau & Ostendorf, 1998; John, 1990; McCrae & Costa, 1999). This model postulates that five personality domains, Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness (Goldberg, 1990; John, 1990; McCrae & Costa, 1999), explain most of the variation in human personality differences. These domains have genetic underpinnings (see Bouchard & Loehlin, 2001, for a review), have been identified cross-culturally (McCrae et al., 2000), and homologues or analogues of all five domains as well as a species-specific Dominance dimension have been found in chimpanzees (King & Figueredo, 1997).

Evolutionary continuity among animal species and humans suggests that homologues or analogues of some personality dimensions may be common in a wide range of species. Because of its comprehensiveness, the FFM was been used as a framework to classify personality dimensions found in a wide range of species (Gosling, 2001; Gosling & John, 1999).

In the present study we hope to extend the previous work on nonhuman primate personality by assessing personality in free-ranging Hanuman langurs (*Semnopithecus entellus*) using a modified version of a questionnaire that has been used to assess personality in chimpanzees (King & Figueredo, 1997) and orangutans (Weiss, King, & Perkins, 2006). Our study will thus extend previous findings in several ways. First, this study would be the first in which a species of monkey would be assessed on a FFM-based questionnaire. While we do not expect to find the same structure in Hanuman langurs, we do believe that the use of the most comprehensive range of personality traits would be the best means of revealing the personality structure specific to langurs and showing how it differs from that of other species, including humans.

Second, Hanuman langurs are the first species from the Colobinae subfamily used for any personality study. Apart from apes, other primate species included in previous studies were macaques and vervet monkeys, all members of the Cercopithecinae subfamily. The Colobinae and Cercopithecinae subfamilies belong to the Old World monkeys, but represent two different sister clades (Purvis, 1995). Colobines are clasified as folivores-frugivores (Kirkpatrick, 2007), and this differentiates Hanuman langurs from the previously studied species of monkeys. Studying Hanuman langurs therefore broadens the phylogenetic perspective of comparative studies on personality structure. Hanuman langurs often live in one-male-multifemale groups with surplus males forming separate all-male bands. Vervets and macaques live in multi-male-multifemale groups and are mainly frugivorous (Ménard, 2004). Barton and Dunbar (1997) proposed that diet preference and social organization may be related to behavioral differences, which we suspect may be reflected in personality ratings. Species differences in particular aspects of personality and temperament have been reported in several studies of nonhuman primates involving performance differences in various situations for example, reactions to training tasks, novel objects or environmental stimulation (for a review see Clarke & Boinski, 1995).

Third, if trait ratings of personality are based on informal behavioral observations over long periods of time, personality dimensions derived from trait ratings and behavioral codings should be comparable. To date, there have been few studies examining personality structure derived from behavioral observations (see, however, Chamove et al., 1972; Rouff et al., 2005; Watson & Ward, 1996).

The goal of the present study is to assess personality in Hanuman langurs using a ratings approach and behavioral observations. By comparing these results to those derived in other nonhuman primates we hope to better understand the evolutionary bases of personality dimensions.

Method

Subjects

We observed 27 males (24 adults, 3 subadults) of an all-male band of free-ranging Hanuman langurs. Identification cards were completed for all subjects and those subjects were individually recognized by all observers. Their exact ages were not known, thus we classified them as adults or subadults according to their size.

The study group was regularly provisioned in a Hindu temple complex, Naranimata. Throughout the study period this all-male band intruded and had regular contact with members of a one-male bisexual troop present on the same study site. At the end of our study, one of the males finally took over the one-male bisexual troop. Similar long-lasting takeovers were regularly observed in our as well as some other Hanuman langur populations (Rajpurohit, Sommer, & Mohnot, 1995).

Study Site

The study was carried out at the Bhangarh–Naranimata study site in Rajasthan, India (N 26°50′, E 77°17′). The study site is dominated by a degraded, dry deciduous forest and open shrub with *Anogeisus pendula*, *Holoptelia integrifolia, Acacia* spp., *Prosopis juliflora*, *Ficus* spp., *Phoenix sylvestris, Zizyphus* spp., and *Adhatoda vasica*. A natural water source is available throughout the year.

Raters

Questionnaire ratings and behavioral observations were made by two male and two female students. All four were trained in data collection and the use of a behavioral ethogram with captive Hanuman langurs in zoos and video recordings of their behavior. After this training period, observers reached a high level of agreement for all items of ethogram. During data collection in the field, an effort was made to observe all animals equally by every single observer during their observations. Two to three observers were usually with the troop on a given time. Total duration of focal animal observations recorded by each observer ranged from 45.5 to 156.5 hr ($M = 85.4$; $SD = 50.4$) and time spent with troop from 3 to 5 months, with high overlap in time spent on study site among all. After each observer finished their behavioral data collection, which was with one exception at the end of the study, they rated each monkey using a personality questionnaire in Czech.

Behavioral Observations

Behavioral observations were conducted between October 2002 and February 2003 and took place from 07:00 to 17:00. For each subject, data were collected evenly throughout daytime and during the entire study. Each subject was observed at most once during a given day for a 30-min focal period. There was a mean of 12.5 hr of behavioral data per subject for a total of 341 hr for all subjects combined.

If personality domains in Hanuman langurs are, as in chimpanzees (Pederson, King, & Landau, 2005), related to distinct sets of behaviors, those sets of behaviors would likely be intercorrelated in such a way that they would form factors or components related to the personality domains. As such, in the present study, behaviors were recorded according to an existing ethogram containing 70 predefined behaviors (available from the authors upon request). This ethogram was not focused on any narrow behavioral domain (e.g., aggression), rather the items were selected from a more extensive ethogram to cover a broad range of everyday activities. Of these behavioral categories some were pooled to broader categories and some had to be omitted as they occurred too infrequently. The resulting 50 behavioral categories were used for all subsequent analyses.

Observations were divided into 30-min focal periods. During each focal period, the behavior of a single animal was coded using focal continuous sampling simultaneously with focal instantaneous sampling (Altmann, 1974) on the same animal at 2.5-min intervals. All occurrences of short-duration behaviors were recorded by the focal continuous sampling technique, together with the partner identity in case of social interactions. Focal instantaneous sampling was used to record long-duration behavioral states, including grooming, proximity of social partners, and substrate use. In addition, ad libitum sampling (Altmann, 1974) of opportunistically observed aggressive, sexual, and displacement interactions was used to supplement the focal animal sampling data. As ad libitum data cannot be directly related to the observation time, they were not used for computing those behavioral indices, which related the behavior to time. Behavioral data from all four observers were pooled. If observers agree on behavioral recordings and all raters observed all individuals for equal time periods, then the frequency of particular behaviors should be comparable across raters. Pearson correlation coefficients for frequency of recorded behaviors between each pair of observers ranged between $r = .79$ to $r = .97$.

Behavioral Indices

The behavioral data set included rates of occurrences of short-duration behaviors (e.g., threats received per hour) obtained by focal continuous sampling and the proportions of time spent in long-duration behaviors (e.g., proportion of instantaneous sampling points spent eating) derived from the instantaneous sampling. A pilot study revealed that a principal components analysis (PCA) of the rates and durations of behaviors did not reveal components similar to personality dimensions. Instead, relations among behavior rates were based on their occurrence in specific sequences so that many loaded onto multiple components.

Given the pilot results, we compiled behavioral indices that set behaviors in a variety of specific relations in contrast to ethogram items. These indices were selected, in part, to parallel the questionnaire items. For example, index approach rate (rate of approaches initiated to approaches received) was proposed to be related to the adjective *popular*. While ethogram items (e.g., approach, displacement) provided the raw frequencies of defined behaviors, the proposed indices considered behaviors with respect to either time (e.g., *affiliation time*) or other behaviors ($approach\ rate,\ aggression_{contact\ vs.\ threats}$). Synchronization indices were computed to compare the behavior of individuals to prevalent troop activity. Shannon diversity indices (H′; Magurran, 1988) were used in order to analyze the diversity of individual activities and social partners in various contexts. The resulting 36 indices were used for the subsequent PCA analyses (for the formulas and the full list of behavioral indices with definitions see Appendix Table A1).

Dominance Rank

Dominance rank was determined on the basis of displacements between pairs of group members (Borries, Sommer, & Srivastava, 1991; Hrdy, 1977; Poisbleau, Janouvrier, & Fritz, 2006). Due to the all-male band's attempt to take over the bisexual troop, there

was considerable social instability during the study period. The whole period was thus considered unstable. As such, social position among several males changed. These changes were, however, only in the order of one to three positions. We did not classify males as high, middle, and low ranking as this approach leads to a loss of information and the decision of how to assign individuals to such categories is arbitrary. However, if such categories were used, the observed changes in dominance rank would not lead to changes in whether individuals were high, middle, or low ranking individuals. To address this problem, we divided the entire study period into six periods with "unchanged" hierarchy lasting from 2 to 57 days ($M = 23.5$; $SD = 20.2$), where linear hierarchies were determined and no rank changes took place.

Within each period, subjects were ranked in ascending order with the most dominant assigned a score of 1. Overall, there were 13 (3.7%) dyads in which neither subject was displaced in either period. In such cases, the mean value of relevant rank positions was given to those males of the dyads. The final value of dominance rank was computed for every male as a score equal to the mean of the all period's scores weighted by period duration. This reflected value (multiplied by -1) was used in all analyses. We followed previously published methods for assessing dominance in Hanuman langurs by constructing dominance matrices (Borries et al., 1991; Hrdy, 1977).

Questionnaire Ratings

Observers were instructed not to discuss their ratings with others and to make their judgments according to their own personal experience with each subject. Observers were also instructed to base ratings on overall impressions and not on estimated frequencies of particular behaviors. One of the observers did not rate one individual because the monkey was no longer present in the group after the observer's arrival on the study site.

The questionnaire contained 51 items that could be rated on a 7-point Likert scale, 1 (*trait is not displayed*) to 7 (*extreme amounts of the trait*). Each item included an adjective followed by one to three clarifying sentences that served to help observers understand the trait and its application in free-ranging langurs (e.g., *sociable* was defined as "Subject actively seeks and spent considerable time in company of others"; *lazy* was defined as "Subject is relatively inactive and slow moving with indistinctive reactions"). To maintain behavioral observations and trait ratings as independent as possible, clarifying sentences were modified so that they did not include any behavioral terms defined in the ethogram. The full questionnaire is available from authors upon request.

The rating form was adapted from a 48-item questionnaire that was previously used to rate orangutan personality (Weiss et al., 2006), which, in turn, was based on a 43-item questionnaire used to rate chimpanzees (King & Figueredo, 1997). This questionnaire was made up of adjectives used by Goldberg to measure the Big Five model of human personality (Table 3 in Goldberg, 1990).

For the present study six items (*imitative, clumsy, autistic, anxious, cool*, and *apprehensive*) were excluded because they were too close in meaning to other adjectives or because, in previous studies, they had low interrater reliabilities (King & Figueredo, 1997). In addition, nine new items were included so as to allow comparisons with studies that used other personality questionnaires. These items included five (*eccentric, opportunistic*, *permissive*, *popular*, and *tense*) from the Stevenson-Hinde-Zunz (1980) questionnaire and one item, *alert*, from a questionnaire created and used by McGuire et al. (1994).

To date, domains similar to human Conscientiousness have only been found in chimpanzees (King & Figueredo, 1997). This may indicate that similar domains evolved only recently or that markers of similar traits are seldom used in studies of nonhuman animals. In animals, conscientiousness is defined more narrowly than in humans and has slightly different connotations (King & Figueredo, 1997). Therefore, in the present study, we included two additional items (*selective* and *patient*), which were possible markers of conscientiousness in this species.

Finally, one item, *playful*, was divided into two traits (*playful* and *social in play*), one for overall playfulness and the other for preference of social play. To maintain consistency with previous questionnaires, we followed the Czech translation of items used in the Czech translation of Costa and McCrae's (1992) Revised NEO Personality Inventory (Hěbíčková, Urbánek, & Čermák, 2000).

Data Analysis

Interrater reliability. Interrater reliabilities of questionnaire items were computed using intraclass correlation coefficients. The first, *ICC* (3, 1), represents the reliability of individual ratings and can be used to compare reliabilities across different studies. The second, *ICC* (3, *k*), indicates the reliability of the mean of *k* ratings (Shrout & Fleiss, 1979). Given that all analyses were based on the mean personality ratings provided by the four raters, *ICC* (3, *k*) is an indication of the reliability of personality dimensions in the remaining analyses.

Principal components analysis. We used parallel analysis (Horn, 1965; O'Connor, 2000) to determine the number of components from the questionnaire and the behavioral data set. In parallel analysis, eigenvalues derived from the data are compared to eigenvalues derived from random matrices of a similar size to the data set. Only components which exceed the 95th percentile of values derived from random matrices are extracted.

After determining the number of components to extract, these components were extracted using PCA in Statistica 7.1. The components were then subjected to varimax rotation so as to obtain an interpretable orthogonal structure.

Given the small sample size, for the questionnaire data we compared the structure derived from the mean ratings of the 27 subjects to a PCA of data from all 107 individual ratings (4 ratings on 26 monkeys and 3 ratings on 1 monkey) treated as independent measures via an orthogonal targeted Procrustes rotation (McCrae, Zonderman, Costa, Bond, & Paunonen, 1996). Because the number of individual ratings is closer to 150, that is, the sample size which has been identified as sufficient to ensure component structure stability (Guadagnoli & Velicer, 1988), comparable structures would suggest that the structure identified with the 27 mean ratings would be similar to the more stable structure found in a larger sample.

After these analyses, weighted scores based on the PCA of the 27 mean ratings were obtained with Statistica 7.1. To examine possible influence of subadults in our sample, we ran the PCA also without these three subjects. The results did not change and thus the subadults were retained in all analyses.

Behavior and Personality Assessment Relationship. We used Pearson product–moment correlations to examine whether dominance rank was correlated with personality dimensions assessed by questionnaire or behavioral observations. We also used Pearson product–moment correlations to compare personality domains revealed by the questionnaire and those obtained via behavioral measures.

Results

Interrater Reliability of Item Ratings

One item (*persistent*) was clearly unreliable ($ICC[3, 1] = -0.030$; $ICC[3, k] = -0.128$) and excluded from further analyses. While the interrater reliabilities as assessed by ICC (3, *k*) of three additional items (*protective*, *predictable*, and *selective*) were below .100, we retained these as doing so would only possibly lead to their loadings being conservative and would likely not influence structure.

The remaining reliabilities of individual ratings *ICC* (3, 1) ranged from 0.05 (*unemotional*) to 0.77 (*dominant*) with a mean reliability of 0.31. The mean reliability ratings ICC (3, *k*) ranged from 0.17 (*unemotional*) to 0.93 (*dominant*) with a mean reliability of 0.58.

Principal Components Analysis of Questionnaire Items

For the PCA analysis of the 27 mean ratings, visual inspection of the scree plot suggested the presence of four components, but parallel analysis (Horn, 1965; O'Connor, 2000) suggested that only the first three components had eigenvalues exceeding what would be expected by chance. PCA was then used to extract these three components, which accounted for 36.8% of the total variance.

Rotating the three components based on the 27 mean ratings to the three components based on the 107 individual ratings via orthogonal targeted Procrustes rotation (McCrae et al., 1996) indicated that the structures replicated: Congruence coefficients for all three components exceeded .95 and the congruence of the entire structure was .97. Moreover, the item congruences were all greater than .90.

Table 1 shows the structure derived from the 27 mean ratings. For the purpose of interpreting the components absolute loadings ≥0.40 were considered salient. There were 25 cases in which items had two salient loadings. In these cases, as in prior studies (see, e.g., Weiss et al., 2006), the item was interpreted as belonging to the component with the highest loading.

The highest loadings on the first component included traits such as *affectionate*, *gentle*, and (not) *irritable*. It was labeled as Agreeableness$_R$ because it resembles the human and chimpanzee Agreeableness dimensions and was based on ratings. The second component can best be described as negative Confidence, as the item *confident* from the Stevenson-Hinde inventory was one of the items with the highest loading, with an absolute value exceeding 0.90. Other items that had loadings greater than or equal to an absolute value of 0.90 included (not) *independent* and *timid*. The resulting individual scores were reflected, and this component was labeled Confidence$_R$. Items that had the highest loadings on the third component included *sociable*, (not) *lazy*, and (not) *depressed*, and it was thus labeled Extraversion$_R$.

Table 1
Principal Components Structure of Questionnaire Items

Item	Component		
	Agreeableness$_R$	Confidence^a_R	Extraversion$_R$
Affectionate	**.87**	−.31	.06
Gentle	**.82**	**−.46**	−.10
Stingy	**−.78**	.31	−.12
Helpful	**.77**	**−.41**	−.02
Tense	**−.75**	−.17	−.08
Irritable	**−.74**	**.44**	.23
Friendly	**.73**	**−.55**	−.04
Eccentric	**−.72**	−.10	.12
Sensitive	**.71**	−.21	.27
Excitable	**−.71**	.13	.39
Impulsive	**−.69**	−.34	**.45**
Permissive	**.69**	**−.49**	−.33
Aggressive	**−.68**	**.61**	.08
Bullying	**−.66**	**.64**	.10
Conventional	**.66**	**−.47**	−.19
Sympathetic	**.64**	**−.51**	−.14
Patient	**.63**	.16	**−.61**
Erratic	**−.61**	**−.57**	.20
Cautious	**.56**	−.32	**−.55**
Predictable	**.51**	−.18	−.04
Timid	.23	**−.92**	−.13
Dependent	.26	**−.92**	.11
Confident	−.27	**.92**	−.01
Independent	−.33	**.90**	−.10
Dominant	**−.40**	**.90**	−.08
Submissive	.39	**−.89**	.00
Fearful	.35	**−.89**	−.01
Defiant	**−.40**	**.88**	−.03
Intelligent	−.07	**.87**	.11
Playful	.15	**−.86**	.32
Playful (Soc)	.12	**−.82**	.35
Reckless	.04	**−.76**	.17
Disorganized	−.17	**−.76**	.13
Alert	−.34	**.72**	.05
Curious	−.06	**−.66**	**.56**
Manipulative	.00	**.65**	**.45**
Selective	**−.49**	**.64**	.17
Exploratory	.15	**−.60**	**.49**
Popular	.38	**.58**	**.49**
Opportunistic	−.36	**.58**	**.52**
Protective	**.51**	**.56**	−.35
Stable	**.47**	**.50**	**−.40**
Lazy	.29	−.08	**−.84**
Sociable	.36	−.03	**.83**
Solitary	−.18	.25	**−.79**
Depressed	.37	−.32	**−.73**
Unemotional	.27	**.47**	**−.71**
Active	**−.43**	−.04	**.64**
Inventive	.03	−.27	**.49**
Jealous	**−.43**	.24	**.45**

Note. Loadings in bold-face were salient.
[a] Loading on this component were reflected.

Correlations of Components and Behavioral Indices

We then examined the correlations between the Agreeableness$_R$, Confidence$_R$, and Extraversion$_R$ dimensions and behavioral indices (see Table 2). Of the 36 behavioral measures, 15 were correlated to a single personality dimension and only 2 were correlated with more than a single dimension (*terminate groom* and d*isplacement rate*). Subjects who were high in Agreeableness$_R$ had lower

Table 2
Correlations Between Behavioral Indices and Personality Components

Behavioral index	Components		
	$Agreeableness_R$	$Confidence_R$	$Extraversion_R$
Grunt and grimace	−.32	**.75**	.09
Display	−.11	**.53**	.27
$Aggression_{close\ vs.\ distant}$	−.19	**−.64**	.31
Terminate groom	−.01	**−.57**	**.44**
Displacement rate	**−.48**	**.57**	.13
Copulation	−.37	**.48**	.23
Passive affiliation time	−.11	**.42**	−.37
$Locomotion_{demanding\ substrate}$	−.36	**−.41**	.13
Approach rate	−.38	**.39**	.30
$Aggression_{contact\ vs.\ threats}$	**−.59**	.24	.29
Touch penis	**.48**	−.01	.12
Aggression	**−.44**	.35	.37
Grooming time	**.41**	−.35	.38
$H'_{partners\ approaching}$	**.41**	−.36	−.18
$Synchronization_{rest}$	−.25	.16	**−.52**
Resting time	.01	.33	**−.44**

Note. Only indices with significant correlation with at least one component are shown. Correlations significant at $p < .05$ are in bold. H′ = Shannon index.

rates of *aggression*, contact aggression to distant threats ($aggression_{contact\ vs.\ threats}$), and *displacements rate*. Also consistent with the definition of Agreeableness, individuals high in $Agreeableness_R$ spent more time grooming (*grooming time*), had higher scores on the Shannon diversity index for partners who were approaching an individual ($H'_{partners\ approaching}$), and had a higher frequency of penis touching (*touch penis*). Monkeys high in $Agreeableness_R$ were also lower in terms of dominance rank, suggesting that these individuals were more compliant and submissive.

Individuals ranking high in the second component, $Confidence_R$, engaged in more displays than low ranking ones. As such, they engaged in more frequent grunt vocalizations and grimaces (*grunt and grimace*), jump displays, and whoop vocalizations (*display*). Individuals with high $Confidence_R$ scores were also more often dominant in displacements (*displacement rate*), had lower rates of contact aggression relative to distant aggression and power demonstrations ($aggression_{close\ vs.\ distant}$), and copulated more often with females (*copulation*). Individuals who had higher $Confidence_R$ scores also tended to approach others more than they were approached (*approach rate*). Also, when they were in others' company, they engaged less in grooming (high value of *passive affiliation time*), and, consequently, termination of grooming (*terminate groom*) occurred less frequently. They also spent more time on the ground (low value of $locomotion_{demanding\ substrate}$), where most interactions in troop life occur.

$Extraversion_R$ was correlated with indices related to social behavior and locomotion. Thus, $Extraversion_R$ was positively correlated with termination of grooming (*terminate groom*), which may be related to longer time spent in grooming or proximity to others (correlations of corresponding indices were however not significant); and negatively with the activity index of time spent in resting activities (*resting time*) and the synchronization index for resting ($synchronization_{rest}$).

Principal Component Analyses of Behavioral Indices

We used principal components analysis of the 36 behavioral indices to assess whether the correlations among behavioral indices suggested one or more underlying components. The scree plot results were ambiguous; however, based on parallel analysis, we decided to extract three components, which explained 14.4% of the total variance.

Of the behavioral indices, 10 did not have salient loading on any of the components. The first component, labeled as $Dominance_B$ is related to social dominance behavior in everyday situations as assessed by behavioral coding. Monkeys with high scores on this component had a higher frequency of contact aggression (*aggression*) and copulation (*copulation*), were more likely to displace other individuals rather than being displaced themselves (*displacement rate*), approached other individuals more than they were approached (*approach rate*), and had lower variability of social partners who approach them ($H'_{partners\ approaching}$).

The second component is related to individual involvement in troop life. Individuals with high scores spent more time on the ground (low)

Table 3
Principal Components Structure of Behavioral Indices

Behavioral index	Component		
	$Dominance_B$	$Involvement_B$	$Activity_B$
Approach rate	**.83**	.06	.07
Aggression	**.82**	−.00	.12
$Aggression_{contact\ vs.\ threats}$	**.77**	−.07	.01
Displacement rate	**.75**	.23	−.05
$H'_{partners\ approaching}$	**−.65**	.13	.10
Copulation	**.61**	.04	−.34
Grunt and grimace	**.57**	.36	−.33
Touch penis	**−.50**	.39	.16
$H'_{activity\ substrates}$	**−.44**	−.27	**−.43**
$Synchronization_{progression}$	**−.43**	−.27	.01
$Resting_{demanding\ substrate}$	.07	**−.81**	−.10
$H'_{affiliation\ partners}$	.07	**.66**	−.10
$Aggression_{close\ vs.\ distant}$	.10	**−.62**	**.45**
Provisioning	−.09	**.61**	**.40**
Affiliation time	.05	**.60**	.30
Yawn	.04	**.59**	−.02
$Locomotion_{demanding\ substrate}$	−.00	**−.52**	.34
$H'_{partners\ approached}$	**.40**	**.50**	−.02
Grooming time	−.33	.23	**.74**
Passive affiliation time	.23	.08	**−.72**
Resting time	−.04	.25	**−.66**
Terminate groom	.05	−.20	**.63**
Reciprocate groom	−.28	−.05	**.58**
$Synchronization_{rest}$	.01	.02	**−.49**
Scratch	−.31	.38	**.48**
$H'_{activities}$	−.18	.32	**.43**
Search	−.36	.09	.30
Harassment	.27	−.29	−.11
Embrace	.28	−.01	.34
Display	.31	.35	−.20
Threats	−.01	.15	.32
$Provisioning_{near\ partner}$	.14	.05	−.29
Monitoring	.22	.06	.28
$H'_{partners\ groomed}$	.04	**.40**	−.08
$H'_{eating\ substrates}$	−.34	.21	.06
$Synchronization_{stress}$	−.12	.14	−.21

Note. H′ = Shannon index. Extraction method: Principal component analysis with varimax rotation. Salient loadings in bold.

locomotion$_{demanding\ substrate}$ and *resting*$_{demanding\ substrate}$, where there was a higher possibility of social interactions. They frequently ate food provided by people (*provisioning*) and spent relatively more time in proximity of or contact with social partners (*affiliation time*), who were more variable ($H'_{affiliation\ partners}$ and $H'_{partners\ approached}$). It was labeled as Involvement$_B$.

The third component, Activity$_B$, links together indices related to overall activity including positive social and locomotory activities. Animals scoring high on this component spent more time grooming (*grooming time*, *reciprocate groom*, low *passive affiliation time*), had a higher variability of general activities ($H'_{activities}$), and were active even while others were resting (low *synchronization*$_{rest}$).

Correlations Between Personality Components and Between Personality Components and Dominance Rank

We examined the relationship between personality dimensions derived from behaviors and those derived from the questionnaire (see Table 4). Dominance$_B$ was negatively correlated with Agreeableness$_R$, and positively correlated with Confidence$_R$ and dominance rank. Involvement$_B$ was positively correlated with Confidence$_R$, and finally, Activity$_B$ and Extraversion$_R$ were positively correlated.

The relationship between personality components from both methods to dominance rank indicated that Agreeableness$_R$, $r = -.39$, $p < .05$, and Activity$_B$, $r = -.49$, $p < .05$, were negatively correlated with position in the dominance hierarchy. On the other hand, Confidence$_R$, $r = .82$, $p < .05$, and Dominance$_B$, $r = .61$, $p < .05$, were positively correlated with position in the dominance hierarchy.

Discussion

The main aim of this study was to assess the personality structure in free-ranging Hanuman langurs using two different assessment approaches: trait ratings by observers and coding the observed behaviors. Questionnaire ratings were consistent across raters. PCA of personality ratings revealed three personality components or dimensions in Hanuman langurs. We found evidence for convergent and divergent validity of these dimensions; each was uniquely correlated with several behavioral indices in a way consistent with the definition of the dimension. On the basis of item loadings and correlations with behaviors, we labeled the components Agreeableness$_R$, Confidence$_R$, and Extraversion$_R$. Similar personality dimensions were previously identified in a wide range of species, including nonhuman primates (Gosling, 2001). Furthermore, all three dimensions derived from the questionnaire-based method were correlated with the dimensions derived from the principal components analysis of the behavioral indices: Dominance$_B$, Involvement$_B$, and Activity$_B$. Specifically, Agreeableness$_R$ was negatively related to Dominance$_B$; Confidence$_R$ was positively related to Dominance$_B$ and Involvement$_B$ but negatively related to Activity$_B$, and Extraversion$_R$ was positively related to Activity$_B$.

Table 4
Correlations Between Behavioral and Personality Components

	Questionnaire component		
Behavioral component	Agreeableness$_R$	Confidence$_R$	Extraversion$_R$
Dominance$_B$	**−.58**	**.46**	.32
Involvement$_B$	.20	**.46**	.12
Activity$_B$	.08	**−.50**	**.60**

Note. $p < .05$ in bold.

Dimensions similar to the Agreeableness$_R$ component have been previously identified in chimpanzees (Agreeableness; King & Figueredo, 1997), orangutans (Agreeableness; Weiss et al., 2006), and gorillas (Understanding; Gold & Maple, 1994). Moreover, in vervets, a dimension reflecting the inverse of Agreeableness, labeled Opportunistic, was found (McGuire et al., 1994). The negative correlation between Agreeableness and dominance rank and the Dominance$_B$ dimension may have resulted from the unstable social situation in the troop when aggressive interactions were more frequently observed among dominant individuals. In a more stable social situation, the correlation with dominance rank may be attenuated. However, a study on pigtail macaques (Caine, Earle, & Reite, 1983) revealed that the dominance rank correlated negatively with observers' impressions of popularity. Thus, in addition to being positively related to affiliative behaviors, Agreeableness$_B$ is generally rated lower among individuals who behaviorally appear to be more dominant.

Confidence$_R$ was strongly correlated with the dominance rank and other behaviors. Similar dimensions in other studies have included the Confidence dimension in rhesus macaques (Capitanio, 1999; Stevenson-Hinde et al., 1980), Socially Competent dimension in vervets (McGuire et al., 1994), and Dominance dimension in chimpanzees (King & Figueredo, 1997) and orangutans (Weiss et al., 2006). Confidence$_R$ is also significantly correlated with all three behavior-based dimensions, suggesting that there is a wide range of behaviors reflected in this component and, therefore, that Confidence$_R$ is a crucial predictor of langur behavior. This also suggests that assessment of dominance by observers was based on a broader array of behaviors than those formally associated with dominance, for example, aggressive acts and displacements. The negative correlation between Confidence$_R$ and a behavior-based dimension, Activity$_B$, reflecting activity and sociability is surprising. This counterintuitive finding may reflect the fact that the highest loadings on this behavioral component were indices related to acting as a groomer (total grooming time, reciprocate groom), which is less characteristic for high-ranking individuals. None of the other behaviors that loaded on Activity$_B$ were significantly correlated with Confidence$_R$.

The Extraversion$_R$ dimension combines interpersonal and temperamental aspects of human Extraversion and is comparable to Extraversion dimensions in other species, including chimpanzees (King & Figueredo, 1997), orangutans (Weiss et al., 2006), and gorillas (Gold & Maple, 1994). This dimension is also similar to the Sociability (Capitanio, 1999; Stevenson-Hinde et al., 1980) dimensions in rhesus macaques as well as the Playful-Curious dimension in vervets (McGuire et al., 1994). In addition, Extraversion$_R$ is positively related to Activity$_B$, and both are positively related to social and locomotory activity.

The Involvement$_B$ dimension does not have any equivalent in the questionnaire-based model. It is related to the individual's involvement in the troop social life. In other words, individuals with high scores on Involvement$_B$ pay attention to and participate

in what is happening in the troop. The Involvement_B component is significantly correlated with Confidence_R; however, it is not correlated with dominance rank. We believe that this indicates that Involvement_B reflects aspects of Confidence_R related to the number and nature of social interactions.

Some dimensions of the human FFM were not found in Hanuman langur personality structure. Absence of some personality factors in a particular species may have two explanations. The first possibility is that, within the species, the correlations among these traits do not give rise to that particular personality dimension. The second possibility is that it is not assessed by the questionnaire used in the study (Gosling & John, 1999).

Species-specific absence of a trait is a commonly offered explanation for why Conscientiousness has only been detected in humans and chimpanzees (Gosling & John, 1999). The fact that a dimension similar to human or chimpanzee Conscientiousness was not revealed in Hanuman langurs need not mean that behaviors relevant for Conscientiousness are not present; instead, the nature of intercorrelations of corresponding personality characteristics likely differ. Human as well as chimpanzee Conscientiousness includes the items *disorganized*, *reckless*, *erratic*, and *predictable*. These items loaded onto Confidence_R or Agreeableness_R in langurs. Other items characteristic for chimpanzee Conscientiousness are *aggressive* and *irritable*, which load onto the Agreeableness dimensions in humans and langurs. On the other hand, items related to human Conscientiousness, namely *decisive* and *cautious*, load onto Dominance in chimpanzees and onto Confidence_R and Agreeableness_R, respectively, in langurs. Moreover, items included in chimpanzee Conscientiousness load mostly onto the Dominance factor in orangutans (Weiss et al., 2006). In a study on gorillas (Gold & Maple, 1994), the Dominance dimension included two items: *irritable* and *aggressive*, which are both present in chimpanzee Conscientiousness. Based on these comparisons, one can hypothesize that the human and chimpanzee Conscientiousness dimensions have their roots in Dominance and Agreeableness dimensions of other primates.

The present study did not identify any distinct dimension similar to Openness. In langurs, items relevant to Openness to Experience loaded on Extraversion_R and, less frequently, Confidence_R. Dimensions that combine items relevant to both Extraversion and Openness were present in other studies (Capitanio, 1999; Gold & Maple, 1994; McGuire et al., 1994; Weiss et al., 2006). Additional relevant questionnaire items were included in the present study; thus, the absence of the Openness dimension may reflect a species-specific personality structure difference rather than a problem with the questionnaire (see, e.g., King, Weiss, & Farmer, 2005; Weiss, King, & Hopkins, 2007).

The absence of Openness may be related to the feeding ecology of Hanuman langurs. In contrast with macaques or vervets, langurs usually do not employ extractive foraging for invertebrates. Feeding on invertebrates is a rather opportunistic event in Hanuman langurs (Winkler, 1988) and has only been reported sporadically (Srivastava, 1991) and only in a few isolated observations since 1994 at the field site of the present study (Lhota, personal observation). Furthermore, langurs have never been reported to search for invertebrates hidden in a substrate such as a leaf litter. On the other hand, macaques and vervets are extractive foragers which search for food in substrate (Cords, 1986; King, 1986). These different feeding strategies may require different demands on innovative behaviors and exploratory tendencies. The lack of extractive foraging and related foraging skills in Hanuman langurs may relax the selective pressure for shaping Openness to Experience as a separate personality dimension.

The importance of diet preferences and foraging techniques was also pointed out by Clarke and Linderburg (1993) when reporting the differences in responsivity to environmental stimulation and a novel training task in their study of male cynomolgus and lion-tailed macaques. Personality studies of macaques and vervets have yielded mixed results with some finding no Openness to Experience dimension (Stevenson-Hinde et al., 1980), combined Openness-Extraversion dimension (Capitanio, 1999; McGuire et al., 1994), and others identifying analogous dimensions (Bolig et al., 1992; Rouff et al., 2005). These conflicting findings may have resulted from the fact that these studies used different sets of questionnaire items and were conducted on captive animals.

Many previous nonhuman animal personality studies identified dimensions related to Neuroticism or Emotional Stability (Gosling, 2001). We did not find a similar dimension in langurs. As with the lack of an Openness dimension, this may reflect a problem with the questionnaire. However, given that the present study included additional Neuroticism markers, we think it is more likely that this reflects a species difference. Items associated with these factors in previous studies load mostly on Confidence_R, and, to a lesser extent, Agreeableness_R. This is consistent with some previous studies which have found that items related to Neuroticism can load on dimensions similar to Confidence (Capitanio, 1999; King & Figueredo, 1997; McGuire et al., 1994; Stevenson-Hinde, Stillwell-Barnes, & Zunz, 1980). Our results indicate that most of the Neuroticism-like traits are included in the Confidence_R factor in Hanuman langurs. In this way this Confidence_R resembles the Social Competence dimension in vervets (McGuire et al., 1994). This may arise from the fact that langurs and vervets show lower levels of aggressive behavior or fewer escalated conflicts than rhesus macaques with less common severe aggressive conflicts. Sommer, Denham, and Little (2002) also showed that compared to macaques, Hanuman langurs males tend to solve conflicts by avoidance rather than by reconciliation. Lower levels of escalated conflicts and postconflict reconciliation in Hanuman langurs may relax selection pressures for fine shaping and divergence of Confidence- and Neuroticism-like traits. However, there are no comparative data to support further discussion.

Correlations between personality dimensions and behaviors were found in previous studies of captive animals (e.g., Capitanio, 1999; Pederson et al., 2005). These findings suggest that personality reflects a suite of behavioral strategies for dealing with everyday situations. Our findings that a wide range of behavior are correlated with personality ratings and describe related dimensions in free-living subjects strengthen this hypothesis.

One shortcoming of the present study is that, as ratings and behavioral observations were made by the same observers, they were not strictly independent. However, we attempted to maximize the independence of these approaches by instructions in the questionnaire and by avoiding using behaviors in item definitions. In addition, the raters in the present study indicated that, as instructed by the questionnaire, their ratings were based on their overall impressions rather than on connecting particular items to recorded behaviors. Moreover, observers spent a considerable time with the langur group when behaviors were not recorded.

Another shortcoming of the present study is that, as in Capitanio's (1999) study, there were no females. However, this shortcoming may be outweighed by the fact that, in a short-term study such as the present one, the females' actual reproductive state could lead to inaccurate impressions of female personality traits.

Even given these limitations, our study has demonstrated that in male Hanuman langurs, dominance rank and dominance-related behaviors are correlated with an individual's personality profile. $\text{Confidence}_{\text{R}}$ was defined by a broad set of items combining traits of human Neuroticism, Conscientiousness, Agreeableness, and Openness, and was correlated with a wide range of behaviors. Apart from $\text{Confidence}_{\text{R}}$, individual variability is related to the nature of social interactions ($\text{Agreeableness}_{\text{R}}$, $\text{Involvement}_{\text{B}}$) and overall activity ($\text{Extraversion}_{\text{R}}$, $\text{Activity}_{\text{B}}$). Our findings demonstrate compatibility of both approaches used to assess animal personality. Subjective assessment can be used to obtain reliable data on animal personality when rater with long term knowledge is available, which may be helpful in captive management. On the other hand, if there is no such opportunity behavioral data can serve to provide information on each individual's personality profile.

Assessing personality structure in primate species with different social structures or diet preferences can lead to new insights concerning the evolutionary bases of personality structure. To these ends the present study highlights the structure of individual differences in behavior, affect, and character that would likely have been present in the common ancestor of Old World Monkeys.

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Appendix

Table A1. Behavioral Indices

Common name	Data source	Index structure, high index value
Search	F	search/hour
Harassment	F	harassment(in)/hour
Scratch	F	scratch/hour
Embrace	F	embrace/hour
Yawn	F	yawn/hour
Grunt and grimace	F	(grunt + grimace)/hour
Touch penis	F	touch penis/hour
Display	F	(jump display + whoop)/hour
Threats	F	[hand threat(in) + face threat(in) + noncontact threats(in)]/hour
Aggression	F	[hand threat(in) + hand attack(in) + contact aggression(in)]/hour
Copulation	F	[copulation + present(rec)]/hour (interactions with females only)
Provisioning	F	provisioning/(eat + provisioning) high = high proportion of provisioning on total food intake
Terminate groom	F	terminate groom(in)/groom high = high proportion of initiated terminating groom at all grooming interactions
Reciprocate groom	F	reciprocate groom(in)/groom(rec) high = higher probability of reciprocation of groom in relation to all grooming received
Displacement rate	F	displacement(in)/displacement(rec) high = higher proportion of initiated displacements then received displacement
Approach rate	F	approach(in)/approach(rec) high = higher proportion of initiated approaches then received approaches
$\text{Aggression}_{\text{contact vs. threats}}$	F	[chase + hand attack + contact aggression(in)]/[face threat + hand threat + noncontact threats(in)] high = higher proportion of contact aggression to noncontact aggression
Affiliation time	I	groom + contact + proximity high = higher proportion of time spent in company of a social partner
Passive affiliation time	I	proximity + contact/(groom + proximity + contact) high = higher proportion of time spent in company of a social partner in passive way
$\text{Provisioning}_{\text{near partner}}$	I	provisioning proximity/(provisioning proximity + provisioning) high = higher proportion of time spent during provisioning in proximity of a social partner then without partner
$\text{Locomotion}_{\text{demanding substrate}}$	I	locomotion(tree,wall)/locomotion(ground) high = higher proportion of locomotion on more demanding substrate as trees or walls
$\text{Resting}_{\text{demanding substrate}}$	I	[eat + watch + look + rest(tree,wall)]/[eat + watch + look + rest(ground)] high = higher proportion of resting activities on more demanding substrate as trees or walls
Resting time	I	(rest + look + watch)/(locomotion + groom) high = higher proportion of time spent by resting activities than by active behaviors
Monitoring	I	(look + watch)/(rest + look + watch) high = higher proportion of time spent by monitoring of surroundings from total time spent by resting activities
Grooming time	F	duration of total grooming initiated/hour high = longer time spent by active grooming
$\text{Aggression}_{\text{close vs. distant}}$	F	[hand threat + hand attack + contact aggression + noncontact aggression(in)]/ [chase + grunt + grimace + face threat + power demonstration(in)] high = higher proportion of close and/or contact threats to more distant displays of aggression
$H'_{\text{affiliation partners}}$	I	Shannon index of partners in contact + proximity + groom
$H'_{\text{partners approached}}$	F	Shannon index of partners approach(in)
$H'_{\text{partners approaching}}$	F	Shannon index of partners approach(rec)
$H'_{\text{partners groomed}}$	F	Shannon index of partners grooming(rec)
$H'_{\text{activity substrates}}$	I	Shannon index of places (tree, bush, ground, rock, wall) for locomotion + watch + look + rest
$H'_{\text{eating substrates}}$	I	Shannon index of places (tree, bush, ground, rock, wall) where eating
$H'_{\text{activities}}$	I	Shannon index of activity types (eat, groom, groom self, locomotion, look, watch, rest, provisioning) for all Shannon indices: high = higher variability of particular variable (activities, partners) $_s$Shannon index formula $H' = -\Sigma\, P_{i.} \ln P_i^{i=1}$
$\text{Synchronization}_{\text{rest}}$	I	[eat + sun bask + rest + groom + groom self(rest troop)]*[locomotion + provisioning(not rest troop)] /[eat + sun bask + rest + groom + groom self(not rest troop)]*[locomotion + provisioning(rest troop)]
$\text{Synchronization}_{\text{stress}}$	I	[locomotion + provisioning (stress troop)]*[rest + sun bask + groom(not stress troop)]/ [rest + sun bask + groom(stress troop)]*[locomotion + provisioning(not stress troop)]
$\text{Synchronization}_{\text{progression}}$	I	[locootion + provisioning(progression troop)]*[rest + groom + groom self(not progression troop)]/ [rest + groom + groom self(progression troop)]*[locomotion + provisioning(not progression troop)] for all synchronization indices: high = behavior of an individual was synchronized with the troop activity while the troop was resting, stressed or in progression

Note. High index value (high) is presented to make the index meaning more obvious in cases where they are more complicated then simple rates. F = data from focal sampling. I = data from instantaneous samples. in = initiated. rec = received.

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