THE UNIVERSITY of EDINBURGH

Edinburgh Research Explorer

Personality in bonobos

Citation for published version:
Weiss, A, Staes, N, Pereboom, JJM, Inoue-Murayama, M, Stevens, JMG & Eens, M 2015, 'Personality in bonobos', *Psychological Science*, vol. 26, no. 9, pp. 1430-1439. https://doi.org/10.1177/0956797615589933

Digital Object Identifier (DOI):
10.1177/0956797615589933

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Psychological Science

Publisher Rights Statement:
© Weiss, A., Staes, N., Pereboom, J. J. M., Inoue-Murayama, M., Stevens, J. M. G., & Eens, M. (2015). Personality in bonobos. Psychological Science.

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

OPEN ACCESS

Download date: 12. Oct. 2024

Personality in Bonobos

Alexander Weiss*

The University of Edinburgh and The Scottish Primate Research Group

Nicky Staes*

Royal Zoological Society of Antwerp and The University of Antwerp

Jeffrey J. M. Pereboom

Royal Zoological Society of Antwerp

Miho Inoue-Murayama

Wildlife Research Center of Kyoto University

Jeroen M. G. Stevens

Royal Zoological Society of Antwerp and The University of Antwerp

Marcel Eens

The University of Antwerp

Author Note

Alexander Weiss, School of Philosophy, Psychology and Language Sciences, The University of Edinburgh, Edinburgh, United Kingdom; Nicky Staes, Centre for Research and Conservation, Royal Zoological Society of Antwerp, Antwerp, Belgium and Ethology Research Group, Department of Biology, University of Antwerp, Antwerp, Belgium; Jeffrey J. M. Pereboom, Centre for Research and Conservation, Royal Zoological Society of Antwerp, Antwerp, Belgium; Miho Inoue-Murayama, Wildlife Genome Collaborative Research Group, National Institute for Environmental Studies, Wildlife Research Center of Kyoto University, Kyoto, Japan; Jeroen M. G. Stevens, Centre for Research and

Conservation, Royal Zoological Society of Antwerp, Antwerp, Belgium and Ethology Research Group, Department of Biology, University of Antwerp, Antwerp, Belgium; Marcel Eens, Ethology Research Group, Department of Biology, University of Antwerp, Antwerp, Belgium.

Correspondence concerning this article should be addressed to Alexander Weiss, School of Philosophy, Psychology and Language Sciences, The University of Edinburgh, Edinburgh, United Kingdom EH8 9JZ. E-mail: alex.weiss@ed.ac.uk.

*These authors contributed equally to this paper and share first authorship.

Keywords: Behavior, Chimpanzee, Evolution, *Pan paniscus*, *Pan troglodytes*, Primate

Abstract

To better understand the personality of humans and chimpanzees, we obtained trait ratings of 154 captive bonobos (~80% of the population). We found factors labeled Assertiveness, Conscientiousness, Openness, Agreeableness, Attentiveness, and Extraversion. The factor inter-rater reliabilities and repeatabilities were comparable to those found in humans and other species. Using orthogonal targeted Procrustes rotations we compared the bonobo dimensions to those of three captive chimpanzee samples. Overall congruences indicated a fair degree of similarity and, at the factor level, there was good evidence for Assertiveness, Conscientiousness, Openness, and Agreeableness factors in the chimpanzee samples; evidence for the Attentiveness and Extraversion factors was poor. These findings suggest that, as expected given their close phylogenetic relationship, bonobo personality structure resembles chimpanzee personality structure in some respects. However, divergent evolution, perhaps due to socioecological differences between bonobos and chimpanzees, also appears to have shaped personality structure in these species.

Introduction

Studying our closely-related nonhuman relatives --- the great apes --- helps us to understand the evolution of complex behavioral phenomena. One recent application of this approach has been to study the organization of personality traits into dimensions so as to identify which personality dimensions are ancestral (descended from a common ancestor species) and which are derived (evolved recently in response to ecological or social challenges faced by individuals of a given species) (Gosling & Graybeal, 2007).

A study of chimpanzees, a species we shared a common ancestor with six million years ago (Glazko & Nei, 2003), rated by zoo keepers and volunteer research assistants found six personality dimensions (King & Figueredo, 1997). Dominance, the first dimension identified in this study, consisted of traits related to competitive prowess; the remaining five dimensions identified in this study resembled the human Big Five or Five-Factor Model --- Extraversion, Conscientiousness, Agreeableness, Neuroticism, and Openness (Goldberg, 1990; McCrae & Costa, 1999). Broadly speaking, most or all of these dimensions have been identified in studies of chimpanzees living in environments other than zoos (King, Weiss, & Farmer, 2005; Weiss, King, & Hopkins, 2007) and in studies using different rating forms (Dutton, 2008; Freeman et al., 2013).

We sought to better understand chimpanzee and human personality evolution by assessing personality in bonobos. Bonobos share a common ancestor with chimpanzees about one million years ago, and thus share the same common ancestor as humans and chimpanzees (Glazko & Nei, 2003). Nonetheless, although bonobos are closely related to chimpanzees and, like chimpanzees, live in fission-fusion societies where females are the dispersing sex (Furuichi, 2011), bonobos differ from chimpanzees in several key respects. First, compared to chimpanzees, bonobos live in more stable and predictable environments with low seasonality and more stable food availability (Furuichi, 2011). This is believed to have led bonobos to

have lower degree of fission-fusion and lower rates of inter- and intra-group competition than chimpanzees (Furuichi, 2011). Second, unlike chimpanzees, there is non-exclusive female dominance in bonobos (Furuichi, 2011; Vervaecke, De Vries, & Van Elsacker, 2000) with bonobo females forming stable and valuable social relationships (Stevens, de Groot, & Staes, 2015). Third, compared to chimpanzees, bonobos are more risk-averse, better at socio-cognitive than instrumental tasks, and less bold (see Hare, Wobber, & Wrangham, 2012 for a review).

For the present study we investigated the personality structure of captive bonobos and compared it to personality structures previously identified in three samples of chimpanzees (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007). Personality dimensions shared by these species are likely ancestral and reflect the close phylogenetic relatedness between these species (Glazko & Nei, 2003) and the similarities in their social structures (Furuichi, 2011). Personality dimensions that are not shared are likely derived, having recently evolved in chimpanzees and/or in bonobos. These derived characteristics could reflect genetic drift or differences between the two species, specifically the lower rates of inter- and intra-group competition, and differences in how dominance is expressed (Furuichi, 2011; Vervaecke et al., 2000).

Methods

Subjects

The subjects were all non-infant bonobos from 16 facilities that participated in the study (seven zoological parks and one research institute in the United States, five zoological parks in Germany, one zoological park in Belgium, one zoological park in the United Kingdom, and one zoological park in the Netherlands). Comprising about 80% of the current captive population in Europe and the United States, subjects were 71 males and 83 females. Male subjects ranged in age from 1.6 to 43.9 years (M = 16.2, SD = 10.8) and female subjects

ranged in age from 2.2 to 61.5 years (*M* = 16.6, *SD* = 12.7). This population originated from 36 wild-caught bonobos that belonged to at least four populations spread across the bonobo's range (Reinartz, 1997). As such, it is likely that we captured a minimum estimate of total variation in the wild.

Personality Assessment

Questionnaire. Personality was assessed via ratings on the Hominoid Personality Questionnaire (HPQ; Weiss et al., 2009).[1] This questionnaire is an expanded version of a questionnaire developed to assess chimpanzee personality (King & Figueredo, 1997) and consists of 54 personality descriptive adjectives, each paired with one to three behaviorally descriptive sentences that set the adjective in the context of behavior. The HPQ instructs raters to make ratings on a seven-point scale (1 = "*displays total absence or negligible amounts of the trait*", 7 = "*displays extremely large amounts of the trait*") and to not discuss their ratings.

Of the 54 items, 43 were originally used in a study of chimpanzee personality (King & Figueredo, 1997). Of these items, 41 were derived from a taxonomy of the Big Five (Goldberg, 1990) and 2 were devised for rating chimpanzees The remaining items included five that represented Openness and Neuroticism, added as part of a study of orangutan personality (Weiss, King, & Perkins, 2006), and six that represented Openness and Conscientiousness, added as part of a second study on chimpanzees (Weiss et al., 2009).

Raters at the German and Dutch facilities completed a version of the HPQ in their native language. After the data had been collected, a researcher not involved in this study found a minor error in the German translation of the HPQ: the behavioral descriptive sentence of 'autistic' refers to "rocking" in the English version and "stone throwing" in the German version. Because the behavioral descriptive sentences are offered as a guide and not

as definitive descriptions of the traits, and because this difference would lead our results to be more conservative, we did not exclude this item.

Raters and ratings. Caretakers and staff at zoological parks, researchers, and others who knew the individual subjects made the ratings. Seven ratings at one zoo and six ratings at another did not include information on rater identity and thus these ratings were considered as coming from a single rater. Furthermore, at one zoo, one rater assessed a single subject with another rater. These two raters and a third worked together to rate two additional subjects. In these cases, joint ratings were considered as coming from a single rater.

Of the sample, 112 subjects were rated on only one occasion, 47 of whom were rated by 1 rater and 65 of whom were rated by 2 to 5 raters. The remaining 42 subjects were rated on a second occasion, on average, 5.6 years (*SD* = 0.4) later, consisted of 2 subjects rated by 1 rater and 40 subjects rated by 2, 3, or 5 raters. The same rater or raters rated 17 of the 42 subjects rated on both periods of data collection. There were 25 and 29 raters in the first and second period of data collection, respectively. Five raters rated subjects in both periods.

The duration that raters knew the subjects was available for 222 of the 291 ratings in the first wave of ratings and for 103 out of 117 ratings in the second wave of ratings. Raters in the first wave knew the subjects for an average of 5.8 years (*SD* = 5.3). Raters in the second wave knew the subjects for an average of 5.6 years (*SD* = 6.5).

Analyses

Item reliabilities. Inter-rater reliabilities of the HPQ items were calculated using intraclass correlations (*ICC*s). *ICC*(3,1) indicates the reliability of single ratings, *ICC*(3,*k*) indicates the reliability of the mean scores of an average of *k* raters (Shrout & Fleiss, 1979).

Data reduction. We used an unweighted least squares factor analysis by means of the 'fa' function of the psych package in R (Revelle, 2015) to determine the structure of all items with reliabilities greater than zero to As in previous studies (e.g., Weiss, Adams, Widdig, &

Gerald, 2011), we used the wave of data with the most responses and, in cases where subjects were rated by multiple raters, we took the mean rating across raters. We determined the number of factors to extract by examining the scree plot and by conducting a parallel analysis via the 'fa.parallel' function of the psych package in R (Revelle, 2015). Next, we determined whether to use an orthogonal or oblique rotation. This involved conducting an orthogonal (varimax) and oblique (promax) rotation. If the intercorrelations between promax-rotated factors were high and the structure differed from the varimax-rotated factors, we retained the promax-rotated factors. If the factor intercorrelations were not high and the structure did not differ, we retained the varimax-rotated factors. As in previous studies (e.g., Weiss et al., 2006), for the purpose of labeling factors and creating unit-weighted factor scores, we defined salient loadings as being equal to or greater than |.4|. In the event of multiple salient loadings, we interpreted an item as belonging to the factor with the highest loading.

Inter-rater reliabilities, internal consistencies, and repeatabilities of factors

We computed the inter-rater reliabilities of factors using *ICC*(3,1) and *ICC*(3,*k*) (Shrout & Fleiss, 1979). We determined the internal consistency reliabilities (Cronbach's alphas) of the mean item scores across raters using the 'alpha' function of the psych package in R (Revelle, 2015). For subjects who were rated twice, we computed the repeatabilities (re-test reliabilities) of factors using the rpt.aov function in R (Nakagawa & Schielzeth, 2010).

Cross-species comparisons. As we noted in the Introduction, prior studies using the HPQ or its predecessor, the Chimpanzee Personality Questionnaire, revealed that chimpanzee personality traits define six dimensions (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007). We will compare structures derived from three chimpanzee samples to the bonobo personality structure. The first chimpanzee sample, the ChimpanZoo sample, comprised 100 individuals housed in U.S. zoos and was described in a previous study (King & Figueredo, 1997). The second chimpanzee sample, the Yerkes sample, comprised 175

chimpanzees housed in Yerkes National Primate Research Center and was described in a previous study (Weiss et al., 2007). Ratings of the individuals in both samples were made using the original 43 adjective questionnaire (King & Figueredo, 1997). The third chimpanzee sample, the Japanese sample, comprised 157 individuals housed in zoos, research centers, and a sanctuary, all located in Japan. Of these subjects, 146 were described in a previous study (Weiss et al., 2009). The 11 additional subjects included 4 who were housed in the Fukuoka Zoo, 5 who were housed in the Higashiyama Zoo, and 2 who were housed in the Hirakawa Zoo. All chimpanzees in the third sample were rated using a Japanese translation of the HPQ (Weiss et al., 2009).

The approach we will use to compare bonobos and chimpanzees will depend on whether bonobos, like chimpanzees, have six personality dimensions (King & Figueredo, 1997). If bonobos have six personality dimensions we will compare the chimpanzee and bonobo structures using targeted orthogonal Procrustes rotations (McCrae, Zonderman, Bond, Costa, & Paunonen, 1996). Each rotation will compare a structure derived from one of the three chimpanzee samples to a structure derived from the present bonobo sample. The chimpanzee studies differed with respect to whether factors or components were extracted and in the number of items subjected to data reduction. We therefore made sure that, for each targeted rotation, the extraction method and the set of items used to derive the bonobo target matrix matched that of the chimpanzee sample. We will interpret congruence coefficients using guidelines derived from a study that asked experts to judge the similarity between structures with different levels of congruence. This study found that congruences below .85 were not indicative of factor similarity, that congruences ranging from .85 to .94 were indicative of a “fair” degree of similarity, and that congruences greater than .95 were indicative of equality and thus a “good” degree of similarity (Lorenzo-Seva & ten Berge, 2006, p. 61).

If bonobos have a different number of personality dimensions than do chimpanzees, we will use a method described in previous studies (e.g., Weiss et al., 2011). In this approach, we would first compute unit-weighted scores based on the bonobo and chimpanzee structures and then obtain correlations between these scores.

Results

Inter-Rater Reliabilities of Items

Inter-rater reliabilities for the 54 adjectives for each rating period are presented in Table S1. In the first period the reliabilities of individual ratings, *ICC*(3,1)s, ranged from .04 for 'sensitive' to .70 for 'submissive' (*M* = .34, *SD* = .16), and reliabilities of mean ratings, *ICC*(3,*k*)s, ranged from .11 for 'sensitive' to .86 for 'submissive' (*M* = .55, *SD* = .18). For the second period *ICC*(3,1)s ranged from .09 for 'erratic' to .82 for 'dominant' (*M* = .45, *SD* = .13) and *ICC*(3,*k*)s ranged from .21 for 'erratic' to .93 for 'dominant' (*M* = .69, *SD* = .12). As all items had reliabilities greater than zero for both periods we did not exclude items.

Personality structure

The scree plot and the parallel analysis indicated that there were six factors. The varimax- and promax-rotated factors did not appreciably differ and the absolute factor inter-correlations were modest (*M* = .14, *SD* = .12). We therefore interpreted varimax-rotated factors (see Tables S2 and S3 for the promax-rotated structure and factor inter-correlations). These six factors explained 56% of the variance.

For ease of interpretability and to maintain consistency with previous studies in how dimensions are labeled, prior to interpreting factors we reflected (multiplied by -1) the loadings of four factors. Based on factor loadings, we labeled the factors Assertiveness, Conscientiousness, Openness, Attentiveness, Agreeableness, and Extraversion (see Table 1).

Table 1
Varimax-Rotated Factor Loadings

	Factor						
Adjective	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Anxious	**-.81**	-.04	-.16	-.07	-.03	-.17	.71
Timid	**-.76**	.27	-.12	-.07	-.05	-.12	.69
Fearful	**-.75**	.06	-.17	-.16	-.10	-.12	.64
Independent	**.71**	-.20	-.02	.13	.04	-.30	.66
Dominant	**.68**	**-.52**	-.26	.07	.11	.07	.82
Vulnerable	**-.66**	.22	.10	.00	-.19	-.37	.67
Submissive	**-.64**	**.43**	.18	-.08	.04	-.17	.66
Cool	**.63**	.13	-.04	.08	.26	-.05	.50
Stable	**.62**	.24	.13	.11	.20	.03	.52
Dependent	**-.61**	.12	.17	-.37	.20	.35	.71
Decisive	**.54**	-.07	.09	**.40**	.15	.00	.49
Persistent	**.52**	**-.40**	.15	.14	.13	.05	.49
Excitable	**-.52**	-.30	-.05	-.12	.00	-.01	.39
Cautious	-.36	.31	-.10	.20	.35	-.08	.41
Quitting	-.20	.08	-.19	-.20	.12	.00	.14
Bullying	.27	**-.76**	.01	.08	-.16	.06	.68
Aggressive	.15	**-.75**	.10	.08	-.14	.05	.63
Stingy	.20	**-.72**	.02	-.14	-.03	-.05	.58
Irritable	-.12	**-.70**	-.17	-.09	-.14	-.21	.60
Jealous	-.04	**-.68**	.18	-.15	-.07	-.08	.53
Gentle	-.02	**.67**	-.02	.04	**.53**	-.06	.73
Erratic	-.29	**-.60**	-.02	-.29	-.06	-.18	.57
Defiant	.11	**-.59**	.23	-.11	-.19	-.05	.46
Reckless	.07	**-.58**	.19	-.38	-.21	-.05	.57
Manipulative	.21	**-.55**	.05	.17	.14	.14	.42
Impulsive	-.29	**-.48**	.28	-.15	-.14	-.06	.45
Predictable	.21	**.41**	-.23	.00	.26	-.05	.33
Active	-.13	-.12	**.77**	-.08	.09	.21	.68
Playful	-.08	-.05	**.73**	-.04	.10	.20	.59
Inquisitive	.22	-.01	**.68**	.21	.11	.03	.57
Inventive	.34	-.05	**.64**	.20	.03	-.24	.62
Imitative	-.08	.04	**.63**	-.22	.17	.13	.50
Innovative	.33	.01	**.63**	.07	.05	-.21	.56
Conventional	-.08	.16	**-.61**	.09	.31	-.01	.51
Curious	.15	-.14	**.58**	.23	.17	-.07	.46
Lazy	.12	.03	**-.54**	-.37	.06	-.30	.54
Unemotional	.15	.15	-.25	-.11	.12	-.01	.14
Disorganized	-.18	-.15	-.03	**-.71**	-.16	-.20	.63
Intelligent	.18	-.07	.15	**.68**	.34	.06	.65
Clumsy	.04	.00	-.04	**-.68**	-.06	-.15	.50

	Factor						
Adjective	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Thoughtless	-.18	-.17	-.09	**-.68**	-.18	-.03	.56
Distractible	-.22	-.11	.06	**-.59**	-.05	.12	.42
Unperceptive	-.33	-.15	-.16	**-.50**	.09	-.24	.47
Friendly	-.01	**.40**	.18	-.12	**.71**	.24	.77
Affectionate	.21	.28	.18	.08	**.71**	.32	.76
Protective	.30	-.04	-.13	.27	**.70**	-.02	.66
Sympathetic	.07	.36	.00	.17	**.62**	-.13	.56
Helpful	.07	.15	.17	.31	**.59**	.04	.51
Sociable	.15	-.06	.34	-.01	**.56**	.34	.57
Sensitive	.25	.15	-.15	.48	**.53**	-.03	.62
Solitary	-.17	.17	-.26	-.09	-.14	**-.67**	.61
Depressed	**-.42**	-.13	-.18	-.21	-.07	**-.67**	.72
Autistic	**-.43**	-.23	-.08	-.34	-.06	**-.43**	.55
Individualistic	.14	-.19	.23	-.18	-.04	**-.43**	.33
Proportion of variance	.14	.12	.09	.08	.08	.05	

Note. [a]Factor was reflected. Ast = Assertiveness, Con = Conscientiousness, Opn = Openness, Att = Attentiveness, Agr = Agreeableness, Ext = Extraversion. Loadings ≥ |.4| in boldface. Principal-components analyses yielded highly similar results (see Tables S4 and S5).

Assertiveness resembled the chimpanzee (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007), orangutan (Weiss et al., 2006), rhesus macaque (Weiss et al., 2011), and gorilla (Eckardt et al., 2014; Gold & Maple, 1994; Schaefer & Steklis, 2014) Dominance dimension. It also resembled the Hanuman langur (Konečná et al., 2008) and Barbary macaque (Konečná, Weiss, Lhota, & Wallner, 2012) Confidence dimension and the brown capuchin monkeys (Morton et al., 2013) Assertiveness dimension. With respect to the Five-Factor Model, this dimension resembled the Assertiveness facet of human Extraversion (Costa & McCrae, 1992). Bonobos high on this factor tend to be independent and confident, and more eager to displace, threaten, or take food from other bonobos. On the other hand, bonobos low on this factor tend to be less confident, more anxious, and more prone to getting displaced and physically hurt or emotionally upset as a result of agonistic interactions.

Conscientiousness resembled the identically named chimpanzee dimension (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007) in that it was made up of two clusters

(King, Weiss, & Sisco, 2008). It also partly overlapped with the mountain gorilla Proto-Agreeableness dimension (Eckardt et al., 2014) and was similar to the Five-Factor Model Conscientiousness facet of Deliberation (Costa & McCrae, 1992). Bonobos high on this factor thus tend to be kind, considerate, and predictable in their relationships with others while bonobos low on this factor tend to be impulsive, unpredictable, and aggressive.

Openness resembled its human (Costa & McCrae, 1992), chimpanzee (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007), rhesus macaque (Weiss et al., 2011), brown capuchin monkey (Morton et al., 2013), and mountain gorilla (Eckardt et al., 2014) counterparts. However, similar to mountain gorillas (Eckardt et al., 2014) and brown capuchin monkeys (Morton et al., 2013), traits such as 'active' and 'playful' had positive loadings on bonobo Openness. These traits are associated with the Activity facet of human Extraversion (Costa & McCrae, 1992), the orangutan Extraversion dimension (Weiss et al., 2006), and the rhesus macaque Activity dimension (Weiss et al., 2011). Bonobos high on this factor thus tend to be playful and engage actively in exploring novel social and physical environments. On the other hand, bonobos low on this factor, tend to be indolent, inactive, and disinclined to explore novel individuals or environments.

Attentiveness resembled an identically named component identified in brown capuchin monkeys (Morton et al., 2013). The items loadings on this factor overlapped some with the items loading on the orangutan Intellect dimension (Weiss et al., 2006). In chimpanzees (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007) these item loadings were associated with high Dominance and high Conscientiousness. In gorillas similar item loadings were associated with high Dominance (Eckardt et al., 2014; Schaefer & Steklis, 2014). In rhesus macaques similar item loadings were associated with high Confidence, Friendliness, and Activity (Weiss et al., 2011). This factor was also similar to the Five-Factor Model Conscientiousness facets of Order and Self-Discipline (Costa & McCrae,

1992). Bonobos high on this factor thus tend to be more focused and perhaps better at solving problems. On the other hand, bonobos scoring low on this factor tend to be easily distracted and uncoordinated.

Agreeableness resembled its orangutan (Weiss et al., 2006) and chimpanzee (King & Figueredo, 1997) counterparts. It also included loadings associated with high gorilla Sociability (Eckardt et al., 2014), all of which were also associated with high human Agreeableness (Costa & McCrae, 1992). Some item loadings also resembled those associated with high Hanuman langur Agreeableness (Konečná et al., 2008) and high human (Costa & McCrae, 1992) and chimpanzee (King & Figueredo, 1997) Extraversion. Bonobos high on this factor thus tend to empathize with and help their conspecifics whereas bonobos who are low on this factor do not display such tendencies when engaging with conspecifics.

Extraversion differed from the Extraversion dimensions in other species (King & Figueredo, 1997; Morton et al., 2013; Weiss et al., 2007; Weiss et al., 2006). The items ‘solitary’, ‘depressed’, ‘autistic’, and ‘individualistic’ all had negative loadings on this factor. Traits such as ‘solitary’ and ‘depressed’ are associated with low Extraversion in humans (Costa & McCrae, 1992) and chimpanzees (King & Figueredo, 1997), low Sociability in brown capuchin monkeys (Morton et al., 2013), and low Friendliness in rhesus macaques (Weiss et al., 2011). The item ‘autistic’ is associated with high Neuroticism in chimpanzees (Weiss et al., 2009) and low Sociability in brown capuchin monkeys (Morton et al., 2013). The item ‘individualistic’ is associated with Extraversion in chimpanzees (Weiss et al., 2009) and gorillas (Eckardt et al., 2014; Schaefer & Steklis, 2014). Thus, in contrast to bonobos scoring low in this factor, bonobos scoring high tend to be well-integrated in their social environment.

We also tested the extent to which these dimensions were dependent on the use of exploratory factor analysis. We therefore extracted six components using principal

components analysis. The varimax- and promax-rotated structures derived via principal components analysis were nearly identical to the present results (see Tables S4 and S5).

Factor reliabilities

Factor inter-rater reliabilities, internal consistencies, and repeatabilities are shown in Table 2. Inter-rater reliability in the first period was fair for Attentiveness and Agreeableness and excellent for the remaining factors. Inter-rater reliabilities of these factors in the second period were all excellent. Internal consistencies were excellent with the exception of Extraversion in the first period. All factors were repeatable except for Agreeableness.

Table 2
Reliabilities and Repeatabilities of Factors

	Period 1 reliabilities			Period 2 reliabilities			Repeatability	
	ICC(3,1)	*ICC*(3,*k*)	α	*ICC*(3,1)	*ICC*(3,k)	α	*R*	*p*
Assertiveness	0.64	0.83	0.92	0.72	0.88	0.95	0.62	< .0001
Conscientiousness	0.61	0.81	0.90	0.59	0.81	0.94	0.61	< .0001
Openness	0.60	0.80	0.87	0.65	0.84	0.91	0.37	< .01
Attentiveness	0.23	0.45	0.84	0.52	0.76	0.90	0.41	< .01
Agreeableness	0.32	0.55	0.87	0.54	0.77	0.92	0.17	> .05
Extraversion	0.61	0.81	0.69	0.67	0.86	0.83	0.28	< .05

Note. *ICC*(3,1) = Reliability of individual ratings of factor scores. *ICC*(3,k) = Reliability of mean ratings of factor scores. α = Cronbach's alpha. Significant repeatabilities were still significant if using permutation tests.

Interspecies comparisons

We used targeted orthogonal Procrustes rotations (McCrae et al., 1996) to compare the personality structures of bonobos and chimpanzees (see Table 3). For all three comparisons the total congruences, which are based on all of the factor or component loadings (McCrae et al., 1996, p. 559), indicated that, overall, the factor or component structures for all three chimpanzee samples exhibited a fair degree of similarity with the bonobo structure. The pattern of congruences for the factors or components was consistent across comparisons of the structures derived from the three chimpanzee samples to the structure derived from the bonobo sample: the highest congruences were found for Assertiveness, Conscientiousness, Openness, and Agreeableness, and the lowest congruences were found for Attentiveness and Extraversion. Specifically, Assertiveness, Conscientiousness, and Agreeableness exhibited fair to good similarities in the ChimpanZoo, Yerkes and Japanese chimpanzee samples. Also, while Openness in the Yerkes sample was not similar to bonobos Openness, in the ChimpanZoo sample and in the Japanese sample the congruences were indicative of fair and good similarity, respectively, to bonobo Openness. Extraversion in the ChimpanZoo sample exhibited a fair degree of similarity to bonobo Extraversion; the congruences for this factor in the Yerkes sample and Japanese sample were not indicative of similarity. Finally, factors or components similar to Attentiveness were not found in any of the chimpanzee samples.

Table 3
Congruence Coefficients from Rotating Chimpanzee Structures Towards the Bonobo Structure

Chimpanzee Sample	Ast	Con	Opn	Att	Agr	Ext	Total
ChimpanZoo	.95	.95	.95	.66	.91	.85	.91
Yerkes	.85	.96	.81	.79	.91	.69	.85
Japan	.90	.92	.91	.78	.93	.78	.87

Note. Before rounding to two digits the congruence coefficients reported as .85 ranged from .852 to .855. Ast = Assertiveness, Con = Conscientiousness, Opn = Openness, Att = Attentiveness, Agr = Agreeableness, Ext = Extraversion.

Discussion

We found that 54 personality traits in bonobos were defined by the factors Assertiveness, Conscientiousness, Openness, Attentiveness, Agreeableness, and Extraversion. These factors showed inter-rater reliabilities and repeatabilities comparable to those of human personality factors (e.g., Costa & McCrae, 1992) and personality traits and dimensions in other species (Bell, Hankison, & Laskowski, 2009; Gosling, 2001). Of these factors, Assertiveness, Conscientiousness, Agreeableness, and possibly Openness had chimpanzee analogues. On the other hand, the evidence for chimpanzee analogues of the Extraversion and Attentiveness dimensions was weak. This pattern of results suggests that four bonobo factors (Assertiveness, Conscientiousness, Agreeableness, and Openness) were ancestral and present in the common ancestor of chimpanzees and bonobos and that two bonobo factors (Extraversion and Attentiveness) were derived, possibly as a function of differences in bonobo and chimpanzee socioecology and bonobo social behavior (Furuichi, 2011; Hare et al., 2012; Vervaecke et al., 2000).

Bonobo Assertiveness was similar to the chimpanzee Dominance dimension (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007) and to dimensions identified in other primate species (Eckardt et al., 2014; Konečná et al., 2008; Konečná et al., 2012; Morton et al., 2013; Schaefer & Steklis, 2014; Weiss et al., 2011; Weiss et al., 2006). This is contrary to perception that bonobos are more egalitarian (de Waal, 1995) and to predictions made by some that bonobos should not have a Dominance or Assertiveness dimension (Eckardt et al., 2014). However, it is consistent with behavioral observations, which reveal strong dominance hierarchies in captive bonobos (Stevens, Vervaecke, de Vries, & van Elsacker, 2007; Vervaecke et al., 2000).

Items defining chimpanzee and human Conscientiousness (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007) loaded on two bonobo factors. The first factor,

Conscientiousness, was characterized by high levels of predictability and low levels of impulsive aggression. It thus Deliberation facet of human Conscientiousness (Costa & McCrae, 1992) and the gorilla Proto-Agreeableness dimension (Eckardt et al., 2014). The second factor, Attentiveness, was characterized by the ability to focus on and do well in carrying out tasks. It thus resembled the Order and Self-Discipline facets of human Conscientiousness (Costa & McCrae, 1992) and the Attentiveness dimension in brown capuchin monkeys (Morton et al., 2013). This split of Conscientiousness traits into two factors may explain bonobos' superior performance compared to chimpanzees on tests related to social causality (Herrmann et al., 2010). Further testing should reveal the degree to which this factor reflects cognitive skills in bonobos.

Bonobo Openness resembles that of chimpanzees, except that items related to activity and playfulness, which load on Extraversion in chimpanzees (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007), load on bonobo Openness. A similar pattern has been found in gorillas (Eckardt et al., 2014) and capuchin monkeys (Morton et al., 2013). This difference between bonobos and chimpanzees may reflect the fact that, in bonobos, play is used to reduce tension (Palagi, 2006) and plays an important role in trust building (Behncke, 2015).

Bonobo Agreeableness resembled that of chimpanzees (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007), humans (Costa & McCrae, 1992), orangutans (Weiss et al., 2006), western gorillas (Gold & Maple, 1994), and Hanuman langurs (Konečná et al., 2008). On the other hand, bonobo Extraversion was dissimilar to chimpanzee Extraversion, namely as it characterized individuals who were not withdrawn and depressed. A similar pattern was found for wild mountain gorilla Extraversion (Eckardt et al., 2014).

In trying to explain the evolutionary bases for differences between the personalities of wild mountain gorillas and chimpanzees that were similar to those we found, Eckardt et al. (2014) hypothesized that distinct Extraversion, Openness, and Agreeableness dimensions

would benefit primate species characterized by fission-fusion social structures, namely as they would offer individuals more flexibility to cope with constantly changing social environments. The presence of separate Openness, Agreeableness, and Extraversion factors in bonobos is consistent with this hypothesis as bonobo social structure is considerably more flexible than that of gorillas (Robbins, 2011). Although direct comparisons of degree of fission-fusion between ape species have been hindered by differences in methodology and study duration (Aureli et al., 2008), future comparative studies may wish to test whether differences across species in social structure stability is associated with the structure of traits related to Extraversion, Openness, and Agreeableness.

This study is not without limitations. One limitation is that the sample size was relatively small for factor analysis and translation issues may have affected ratings of bonobos housed in German zoos. As such, the differences between bonobos and chimpanzees may not be species differences but reflect, instead, sampling variability. However, the pattern of congruences between this sample and chimpanzees was highly consistent across three samples. A second limitation is that this study is limited to captive as opposed to wild bonobos whose personality structures may differ. However, this feature of our study ruled out the possibility that differences between bonobos and chimpanzees could reflect differences in how they were kept. Nonetheless, these limitations suggest there would be much value in collecting additional data, both via questionnaires and by behavioral observations and tests, on bonobos and chimpanzees, housed in zoos, sanctuaries, and in the wild.

While there was considerable overlap between the personalities of bonobos and chimpanzees, most probably reflecting their recent common ancestor, there were differences, too, that may be the signals of more recent selection. Although more work needs to be done in this area, we expect that it is bound to reveal an even more complete picture of the evolution of personality in Hominidae.

Author Contributions

A. Weiss, J. J. M. Pereboom, and J. M. G. Stevens developed the study concept. All authors contributed to the study design. N. Staes, J. J. M. Pereboom, and J. M. G. Stevens collected the data on bonobos and A. Weiss and N. Staes analyzed all the data. A. Weiss and M. Inoue-Murayama collected data on chimpanzees in Japan and A. Weiss contributed data from the ChimpanZoo and Yerkes samples. A. Weiss and N. Staes drafted the manuscript and remaining authors provided suggestions and critical revisions. A. Weiss and N. Staes contributed equally to the manuscript it was decided that they should share first authorship. All authors approved the final version of the manuscript for submission.

Acknowledgements

Data collection would not have been possible without the participation of the zoological institutions, sanctuaries, and research institutes. We also thank Jim King, Virginia Landau, Bill Hopkins, and Testsuro Matsuzawa for their help in obtaining chimpanzee ratings and Sara Van Coillie for translating the questionnaire and for her assistance in collecting and entering data. We also thank Jeff McCrae for answering a question about Procrustes rotation.

We thank the Flemish Government for structural support of the Center for Research and Conservation of the Royal Zoological Society of Antwerp and to the University of Antwerp for funding provided to ME. Collection of chimpanzee data in Japan was supported by grants to AW from The University of Edinburgh Development Trust (#2828) and The Daiwa Foundation (Small Grant #6515/6818), and, in part, by grants to MI-M, including the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Grant-in-Aid for Science Research (#25290082 and #25118005) and the Cooperation Research Program of the Primate Research Institute, Kyoto University. The collection of chimpanzee data at Yerkes National Primate Research Center was supported by NIH grants NS-36605, NS-42867, and RR 00165 to the Yerkes National Primate Research Center. The content of this publication is solely the responsibility of all of the authors and does not necessarily represent the official views NIH or the United States Government.

References

Aureli, F., Schaffner, C. M., Boesch, C., Bearder, S. K., Call, J., Chapman, C. A., . . . van Schaick, C. P. (2008). Fission-fusion dynamics new research frameworks. *Current Anthropology, 49*, 627-654. doi: 10.1086/586708

Behncke, I. (2015). Play in the Peter Pan ape. *Current Biology, 25*, R24–R27. doi: 10.1016/j.cub.2014.11.020

Bell, A. M., Hankison, S. J., & Laskowski, K. L. (2009). The repeatability of behaviour: a meta-analysis. *Animal Behaviour, 77*, 771-783. doi: 10.1016/j.anbehav.2008.12.022

Costa, P. T., Jr., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual*. Odessa, FL: Psychological Assessment Resources.

de Waal, F. B. M. (1995). Bonobo sex and society. *Scientific American, 272*, 58-64.

Dutton, D. M. (2008). Subjective assessment of chimpanzee (*Pan troglodytes*) personality: Reliability and stability of trait ratings. *Primates, 49*, 253-259. doi: 10.1007/s10329-008-0094-1

Eckardt, W., Steklis, H. D., Steklis, N. G., Fletcher, A. W., Stoinski, T. S., & Weiss, A. (2014). Personality dimensions and their behavioral correlates in wild Virunga mountain gorillas (*Gorilla Beringei Beringei*). *Journal of Comparative Psychology*. doi: http://dx.doi.org/10.1037/a0038370

Freeman, H. D., Brosnan, S. F., Hopper, L. M., Lambeth, S. P., Schapiro, S. J., & Gosling, S. D. (2013). Developing a comprehensive and comparative questionnaire for measuring personality in chimpanzees using a simultaneous top-down/bottom-up design. *American Journal of Primatology, 75*, 1042-1053. doi: 10.1002/ajp.22168

Furuichi, T. (2011). Female contributions to the peaceful nature of bonobo society. *Evolutionary Anthropology, 20*, 131-142. doi: 10.1002/evan.20308

Glazko, G. V., & Nei, M. (2003). Estimation of divergence times for major lineages of primate species. *Molecular Biology and Evolution, 20*, 424-434. doi: 10.1093/molbev/msg050

Gold, K. C., & Maple, T. L. (1994). Personality assessment in the gorilla and its utility as a management tool. *Zoo Biology, 13*, 509-522.

Goldberg, L. R. (1990). An alternative "description of personality": the Big-Five factor structure. *Journal of Personality and Social Psychology, 59*, 1216-1229. doi: 10.1037/0022-3514.59.6.1216

Gosling, S. D. (2001). From mice to men: What can we learn about personality from animal research? *Psychological Bulletin, 127*, 45-86. doi: 10.1037/0033-2909.127.1.45

Gosling, S. D., & Graybeal, A. (2007). Tree thinking: A new paradigm for integrating comparative data in psychology. *The Journal of General Psychology, 134*, 259-277. doi: 10.3200/GENP.134.2.259-278

Hare, B., Wobber, V., & Wrangham, R. (2012). The self-domestication hypothesis: evolution of bonobo psychology is due to selection against aggression. *Animal Behaviour, 83*, 573-585. doi: 10.1016/j.anbehav.2011.12.007

King, J. E., & Figueredo, A. J. (1997). The Five-Factor Model plus Dominance in chimpanzee personality. *Journal of Research in Personality, 31*, 257-271. doi: 10.1006/jrpe.1997.2179

King, J. E., Weiss, A., & Farmer, K. H. (2005). A chimpanzee (*Pan troglodytes*) analogue of cross-national generalization of personality structure: Zoological parks and an African sanctuary. *Journal of Personality, 73*, 389-410. doi: 10.1111/j.1467-6494.2005.00313.x

King, J. E., Weiss, A., & Sisco, M. M. (2008). Aping humans: Age and sex effects in chimpanzee (*Pan troglodytes*) and human (*Homo sapiens*) personality. *Journal of Comparative Psychology, 122*, 418-427. doi: 10.1037/a0013125

Konečná, M., Lhota, S., Weiss, A., Urbánek, T., Adamová, T., & Pluháček, J. (2008). Personality in free-ranging Hanuman langur (*Semnopithecus entellus*) males: Subjective ratings and recorded behavior. *Journal of Comparative Psychology, 122*, 379-389. doi: 10.1037/a0012625

Konečná, M., Weiss, A., Lhota, S., & Wallner, B. (2012). Personality in Barbary macaques (*Macaca sylvanus*): Temporal stability and social rank. *Journal of Research in Personality, 46*, 581-590. doi: 10.1016/j.jrp.2012.06.004

Lorenzo-Seva, U., & ten Berge, J. M. F. (2006). Tucker's congruence coefficient as a meaningful index of factor similarity. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 2*, 57-64.

McCrae, R. R., & Costa, P. T., Jr. (1999). A Five-Factor Theory of personality. In L. Pervin & O. P. John (Eds.), *Handbook of Personality* (2 ed., pp. 159-181). New York: Guilford Press.

McCrae, R. R., Zonderman, A. B., Bond, M. H., Costa, P. T., Jr., & Paunonen, S. V. (1996). Evaluating replicability of factors in the Revised NEO Personality Inventory: Confirmatory factor analysis versus Procrustes rotation. *Journal of Personality and Social Psychology, 70*, 552-566. doi: 10.1037/0022-3514.70.3.552

Morton, F. B., Lee, P. C., Buchanan-Smith, H. M., Brosnan, S. F., Thierry, B., Paukner, A., . . . Weiss, A. (2013). Personality structure in brown capuchin monkeys (*Sapajus apella*): Comparisons with chimpanzees (*Pan troglodytes*), orangutans (*Pongo spp.*), and rhesus macaques (*Macaca mulatta*). *Journal of Comparative Psychology, 127*, 282-298. doi: 10.1037/a0031723

Nakagawa, S., & Schielzeth, H. (2010). Repeatability for Gaussian and non-Gaussian data: A practical guide for biologists. *Biological Reviews, 85*, 935-956.

Palagi, E. (2006). Social play in bonobos (*Pan paniscus*) and chimpanzees (*Pan troglodytes*): Implicationsfor natural social systems and interindividual relationships. *American Journal of Physical Anthropology, 129*, 418-426. doi: 10.1002/ajpa.20289

Reinartz, G. E. (1997). *Patterns of genetic variation in the bonobo (Pan paniscus).* University of Wisconsin, Milwaukee, Milwaukee, WI.

Revelle, W. (2015). psych: Procedures for personality and psychological research (Version 1.2.12). Evanston, IL: Northwestern University. Retrieved from http://personality-project.org/r/psych.manual.pdf

Robbins, M. M. (2011). Gorillas: Diversity in ecology and behavior. In C. J. Campbell, A. Fuentes, K. C. MacKinnon, S. K. Bearder, & R. M. Stumpf (Eds.), *Primates in perspective* (2nd ed., pp. 326–339). Oxford: Oxford University Press.

Schaefer, S. A., & Steklis, H. D. (2014). Personality and subjective well-being in captive male western lowland gorillas living in bachelor groups. *American Journal of Primatology, 76*, 879-889. doi: 10.1002/ajp.22275

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin, 86*, 420-428. doi: 10.1037/0033-2909.86.2.420

Stevens, J. M. G., de Groot, E., & Staes, N. (2015). Relationship quality in captive bonobo groups. *Behaviour, 152*, 259-283. doi: 10.1163/1568539X-00003259

Stevens, J. M. G., Vervaecke, H., de Vries, H., & van Elsacker, L. (2007). Sex differences in the steepness of dominance hierarchies in captive bonobo groups. *International Journal of Primatology, 28*, 1417-1430. doi: 10.1007/s10764-007-9186-9

Vervaecke, H., De Vries, H., & Van Elsacker, L. (2000). The pivotal role of rank in grooming and support behavior in a captive group of bonobos (Pan paniscus). *Behaviour, 137*, 1463-1485. doi: 10.1163/156853900502673

Weiss, A., Adams, M. J., Widdig, A., & Gerald, M. S. (2011). Rhesus macaques (*Macaca mulatta*) as living fossils of hominoid personality and subjective well-being. *Journal of Comparative Psychology, 125*, 72-83. doi: 10.1037/a0021187

Weiss, A., Inoue-Murayama, M., Hong, K.-W., Inoue, E., Udono, S., Ochiai, T., . . . King, J. E. (2009). Assessing chimpanzee personality and subjective well-being in Japan. *American Journal of Primatology, 71*, 283-292. doi: 10.1002/ajp.20649

Weiss, A., King, J. E., & Hopkins, W. D. (2007). A cross-setting study of chimpanzee (*Pan troglodytes*) personality structure and development: Zoological parks and Yerkes National Primate Research Center. *American Journal of Primatology, 69*, 1264-1277. doi: 10.1002/ajp.20428

Weiss, A., King, J. E., & Perkins, L. (2006). Personality and subjective well-being in orangutans (*Pongo pygmaeus* and *Pongo abelii*). *Journal of Personality and Social Psychology, 90*, 501-511. doi: 10.1037/0022-3514.90.3.501

Footnotes

[1]The English language version of the HPQ for chimpanzees is at

http://extras.springer.com/2011/978-1-4614-0175-9/weiss_chimpanzee_personality.pdf

Table S1
Inter-rater Reliabilities of Items

	Period 1		Period 2	
Adjective	ICC(3,1)	ICC(3,k)	ICC(3,1)	ICC(3,k)
Fearful	0.31	0.54	0.49	0.74
Dominant	0.65	0.83	0.82	0.93
Persistent	0.38	0.63	0.58	0.80
Cautious	0.18	0.38	0.29	0.54
Stable	0.42	0.66	0.46	0.71
Autistic	0.46	0.69	0.53	0.76
Curious	0.40	0.64	0.42	0.68
Thoughtless	0.17	0.35	0.38	0.64
Stingy	0.39	0.64	0.49	0.73
Jealous	0.38	0.62	0.51	0.75
Individualistic	0.25	0.47	0.38	0.63
Reckless	0.45	0.68	0.46	0.71
Sociable	0.42	0.67	0.61	0.82
Distractable	0.21	0.42	0.24	0.48
Timid	0.52	0.75	0.55	0.78
Sympathetic	0.23	0.45	0.41	0.67
Playful	0.59	0.79	0.52	0.75
Solitary	0.59	0.79	0.47	0.72
Vulnerable	0.53	0.75	0.46	0.71
Innovative	0.30	0.54	0.60	0.81
Active	0.50	0.73	0.50	0.75
Helpful	0.20	0.40	0.33	0.59
Bullying	0.62	0.81	0.75	0.90
Aggressive	0.55	0.77	0.61	0.82
Manipulative	0.46	0.70	0.50	0.74
Gentle	0.42	0.66	0.47	0.72
Affectionate	0.24	0.46	0.59	0.81
Excitable	0.24	0.46	0.43	0.68
Impulsive	0.25	0.48	0.30	0.55
Inquisitive	0.41	0.65	0.48	0.73
Submissive	0.70	0.86	0.54	0.77
Cool	0.25	0.47	0.43	0.69
Dependent	0.33	0.57	0.57	0.79
Irritable	0.22	0.43	0.37	0.63
Unperceptive	0.17	0.35	0.38	0.64
Predictable	0.14	0.30	0.31	0.57
Decisive	0.33	0.57	0.40	0.65
Depressed	0.47	0.70	0.60	0.81
Conventional	0.18	0.38	0.27	0.51
Sensitive	0.04	0.11	0.35	0.61

	Period 1		Period 2	
Adjective	ICC(3,1)	ICC(3,k)	ICC(3,1)	ICC(3,k)
Defiant	0.38	0.62	0.58	0.80
Intelligent	0.12	0.27	0.51	0.75
Protective	0.37	0.62	0.43	0.68
Quitting	0.10	0.24	0.26	0.50
Inventive	0.34	0.58	0.48	0.72
Clumsy	0.15	0.32	0.30	0.55
Erratic	0.11	0.25	0.09	0.21
Friendly	0.26	0.49	0.29	0.54
Anxious	0.46	0.69	0.56	0.78
Lazy	0.48	0.71	0.35	0.61
Disorganized	0.08	0.19	0.50	0.74
Unemotional	0.14	0.31	0.29	0.54
Imitative	0.36	0.61	0.42	0.67
Independent	0.27	0.50	0.37	0.63

Note. Period 1 results based on 218 ratings of 81 bonobos (k = 2.69) by 40 raters. Period 2 results based on 115 ratings of 40 bonobos (k = 2.88) by 24 raters.

Table S2
Promax-Rotated Factor Loadings

	Factor						
Adjective	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Anxious	**-.86**	-.12	-.13	.13	.04	-.19	.71
Timid	**-.79**	.23	-.07	.07	-.03	-.14	.69
Fearful	**-.75**	.02	-.13	.00	-.04	-.13	.64
Independent	**.73**	-.16	-.01	.00	.01	-.28	.66
Dominant	**.71**	**-.54**	-.32	-.02	.12	.09	.82
Vulnerable	**-.71**	.23	.18	.13	-.18	-.39	.67
Submissive	**-.67**	**.42**	.24	.00	.05	-.21	.66
Cool	**.66**	.14	-.04	-.08	.22	-.06	.50
Stable	**.64**	.28	.12	-.06	.13	.02	.52
Dependent	**-.58**	.09	.16	-.30	.28	.32	.71
Decisive	**.46**	-.09	.06	.33	.07	.00	.49
Persistent	**.50**	-.39	.11	.07	.12	.06	.49
Excitable	**-.55**	-.36	-.06	.03	.08	-.02	.39
Cautious	**-.47**	.21	-.08	.27	.33	-.13	.41
Quitting	-.16	.05	-.18	-.18	.15	-.01	.14
Bullying	.25	**-.76**	-.05	.12	-.11	.09	.68
Aggressive	.11	**-.76**	.05	.15	-.09	.07	.63
Stingy	.22	**-.71**	-.01	-.12	.05	-.03	.58
Irritable	-.12	**-.72**	-.18	.02	-.05	-.19	.60
Jealous	-.03	**-.66**	.17	-.08	.02	-.06	.53
Gentle	-.05	**.61**	.02	-.04	.48	-.11	.73
Erratic	-.25	**-.61**	-.01	-.19	.06	-.18	.57
Defiant	.12	**-.54**	.21	-.08	-.13	-.03	.46
Reckless	.17	**-.50**	.19	-.38	-.11	-.02	.57
Manipulative	.14	**-.61**	-.01	.21	.16	.14	.42
Impulsive	-.31	**-.46**	.28	-.04	-.06	-.06	.45
Predictable	.24	.38	-.21	-.10	.22	-.07	.33
Active	-.18	-.08	**.75**	-.06	.12	.18	.68
Playful	-.13	-.01	**.71**	-.04	.11	.18	.59
Inquisitive	.13	.04	**.68**	.17	.07	.01	.57
Inventive	.27	.03	**.67**	.13	-.01	-.25	.62
Imitative	-.07	.09	**.63**	-.26	.20	.10	.50
Innovative	.31	.10	**.66**	-.02	.02	-.22	.56
Conventional	-.10	.04	**-.61**	.11	.31	-.02	.51
Curious	.04	-.12	**.58**	.23	.15	-.10	.46
Lazy	.27	.03	**-.49**	**-.45**	.11	-.28	.54
Unemotional	.21	.14	-.25	-.18	.12	-.01	.14
Disorganized	.02	-.06	.03	**-.75**	-.04	-.17	.63
Intelligent	-.05	-.18	.11	**.74**	.26	.01	.65
Clumsy	.26	.09	.01	**-.79**	.04	-.13	.50

	Factor						
Adjective	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Thoughtless	.02	-.09	-.06	**-.70**	-.07	.00	.56
Distractible	-.07	-.05	.07	**-.60**	.05	.13	.42
Unperceptive	-.22	-.15	-.11	**-.47**	.21	-.24	.47
Friendly	-.03	.33	.18	-.20	**.72**	.17	.77
Affectionate	.15	.19	.14	-.01	**.69**	.26	.76
Protective	.19	-.18	-.15	.23	**.68**	-.07	.66
Sympathetic	-.01	.26	.03	.12	**.59**	-.19	.56
Helpful	-.07	.04	.16	.30	**.56**	-.02	.51
Sociable	.09	-.11	.30	-.06	**.58**	.30	.57
Sensitive	.10	.02	-.16	**.46**	**.47**	-.08	.62
Solitary	-.13	.20	-.15	-.08	-.13	**-.67**	.61
Depressed	-.39	-.13	-.07	-.12	.01	**-.68**	.72
Autistic	-.37	-.22	-.01	-.25	.04	**-.44**	.55
Individualistic	.19	-.12	.29	-.23	.01	**-.42**	.33
Proportion of variance	.14	.12	.09	.08	.08	.05	

Note. [a]Factor was reflected. Ast = Assertiveness, Con = Conscientiousness, Opn = Openness, Att = Attentiveness, Agr = Agreeableness, Ext = Extraversion. Loadings ≥ |.4| in boldface. For ease of comparison, adjectives are listed in the same order as in Table 1.

Table S3

Factor Inter-Correlations

Factor	Ast[a]	Con[a]	Opn	Att[a]	Agr
Con[a]	-.03				
Opn	.10	-.14			
Att[a]	.46	.22	.07		
Agr	.16	.27	.00	.24	
Ext[a]	-.01	.05	.15	.05	.11

Note. [a]Factor was reflected. Ast = Assertiveness, Con = Conscientiousness, Opn = Openness, Att = Attentiveness, Agr = Agreeableness, Ext = Extraversion.

Table S4
Varimax- and Promax-Rotated Component Loadings

	Component						Component						
Adjective	Ast[a]	Con[a]	Opn	Agr	Att[a]	Ext[a]	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Anxious	**-0.82**	-0.03	-0.18	-0.02	-0.06	-0.16	**-0.86**	-0.09	-0.15	0.11	0.05	-0.18	0.73
Timid	**-0.76**	0.29	-0.14	-0.02	-0.09	-0.11	**-0.78**	0.25	-0.09	0.05	0.00	-0.13	0.71
Fearful	**-0.75**	0.08	-0.18	-0.08	-0.17	-0.11	**-0.75**	0.04	-0.15	-0.03	-0.03	-0.12	0.66
Independent	**0.72**	-0.21	-0.01	0.03	0.13	-0.32	**0.74**	-0.17	0.01	0.00	0.02	-0.31	0.69
Cool	**0.69**	0.12	-0.07	0.30	0.03	-0.04	**0.72**	0.12	-0.06	-0.12	0.25	-0.05	0.59
Stable	**0.68**	0.26	0.13	0.19	0.09	0.03	**0.70**	0.29	0.14	-0.07	0.12	0.02	0.59
Vulnerable	**-0.68**	0.24	0.09	-0.18	0.01	-0.36	**-0.70**	0.26	0.16	0.13	-0.15	-0.38	0.69
Dominant	**0.67**	**-0.53**	-0.23	0.08	0.08	0.03	**0.67**	**-0.55**	-0.29	0.00	0.09	0.06	0.79
Submissive	**-0.62**	**0.45**	0.16	0.05	-0.10	-0.14	**-0.64**	**0.45**	0.22	-0.03	0.07	-0.18	0.65
Dependent/Follower	**-0.59**	0.12	0.16	0.19	-0.39	0.39	**-0.56**	0.08	0.15	-0.32	0.24	0.36	0.73
Excitable	**-0.59**	-0.34	-0.05	0.01	-0.08	-0.03	**-0.63**	**-0.40**	-0.06	0.07	0.09	-0.03	0.47
Decisive	**0.58**	-0.09	0.08	0.17	**0.40**	-0.01	**0.50**	-0.09	0.05	0.32	0.12	-0.02	0.54
Persistent	**0.54**	**-0.43**	0.15	0.13	0.13	0.04	**0.51**	**-0.43**	0.11	0.06	0.14	0.05	0.54
Stingy/Greedy	0.19	**-0.76**	0.01	-0.04	-0.14	-0.05	0.22	**-0.76**	-0.02	-0.13	0.05	-0.03	0.64
Bullying	0.28	**-0.76**	-0.01	-0.18	0.08	0.07	0.27	**-0.75**	-0.07	0.10	-0.14	0.11	0.70
Aggressive	0.15	**-0.76**	0.09	-0.16	0.08	0.07	0.12	**-0.75**	0.03	0.12	-0.10	0.10	0.64
Irritable	-0.14	**-0.72**	-0.19	-0.13	-0.09	-0.21	-0.14	**-0.74**	-0.21	0.01	-0.03	-0.18	0.64
Jealous	-0.06	**-0.72**	0.19	-0.07	-0.15	-0.08	-0.06	**-0.71**	0.16	-0.09	0.03	-0.06	0.59
Gentle	-0.02	**0.66**	-0.01	**0.55**	0.03	-0.05	-0.05	**0.59**	0.03	-0.03	0.50	-0.11	0.73
Erratic	-0.33	**-0.62**	-0.01	-0.06	-0.29	-0.20	-0.30	**-0.63**	-0.01	-0.20	0.06	-0.19	0.62
Defiant	0.10	**-0.61**	0.24	-0.20	-0.11	-0.06	0.13	**-0.57**	0.21	-0.10	-0.14	-0.03	0.50
Manipulative	0.20	**-0.61**	0.03	0.17	0.16	0.17	0.13	**-0.67**	-0.04	0.18	0.21	0.18	0.50
Reckless	0.07	**-0.59**	0.19	-0.26	-0.37	-0.06	0.17	**-0.53**	0.19	-0.38	-0.18	-0.03	0.61
Impulsive	-0.35	**-0.50**	0.33	-0.16	-0.11	-0.09	-0.36	**-0.48**	0.32	-0.02	-0.08	-0.08	0.53

	Component						Component						
Adjective	Ast[a]	Con[a]	Opn	Agr	Att[a]	Ext[a]	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Predictable	0.27	**0.43**	-0.25	0.27	-0.04	-0.05	0.30	**0.40**	-0.22	-0.13	0.22	-0.07	0.39
Active	-0.13	-0.11	**0.77**	0.06	-0.10	0.26	-0.15	-0.06	**0.75**	-0.10	0.09	0.23	0.70
Playful	-0.09	-0.05	**0.75**	0.09	-0.05	0.23	-0.12	-0.01	**0.73**	-0.06	0.10	0.20	0.63
Inquisitive	0.22	-0.01	**0.70**	0.12	0.20	0.05	0.16	0.04	**0.69**	0.14	0.10	0.02	0.59
Innovative	0.32	0.02	**0.68**	0.05	0.09	-0.28	0.30	0.11	**0.73**	-0.01	0.05	-0.31	0.66
Inventive	0.33	-0.05	**0.67**	0.04	0.20	-0.27	0.28	0.03	**0.70**	0.13	0.04	-0.29	0.68
Conventional	-0.05	0.15	**-0.66**	0.37	0.04	0.02	-0.07	0.03	**-0.67**	0.07	0.36	0.01	0.60
Imitative	-0.08	0.05	**0.66**	0.17	-0.27	0.15	-0.05	0.09	**0.67**	-0.31	0.20	0.12	0.56
Curious	0.15	-0.15	**0.59**	0.21	0.22	-0.07	0.06	-0.14	**0.59**	0.20	0.22	-0.11	0.50
Lazy	0.15	0.02	**-0.54**	0.07	**-0.42**	-0.34	0.28	0.00	**-0.49**	**-0.48**	0.12	-0.33	0.61
Unemotional	0.22	0.14	-0.32	0.20	-0.22	0.04	0.29	0.11	-0.31	-0.29	0.19	0.04	0.26
Protective	0.30	-0.07	-0.11	**0.72**	0.25	-0.03	0.19	-0.20	-0.13	0.21	**0.73**	-0.08	0.69
Affectionate	0.22	0.26	0.20	**0.70**	0.06	0.32	0.15	0.17	0.17	-0.01	**0.67**	0.26	0.75
Friendly	0.01	0.39	0.19	**0.70**	-0.15	0.26	-0.01	0.31	0.19	-0.21	**0.69**	0.20	0.77
Sympathetic	0.07	0.34	0.02	**0.69**	0.12	-0.13	0.00	0.25	0.05	0.09	**0.68**	-0.20	0.63
Helpful	0.06	0.13	0.19	**0.63**	0.31	0.05	-0.07	0.03	0.18	0.30	**0.62**	-0.01	0.55
Sensitive	0.26	0.12	-0.16	**0.60**	**0.45**	-0.01	0.12	0.00	-0.19	**0.43**	**0.56**	-0.06	0.66
Sociable	0.14	-0.08	0.38	**0.57**	-0.03	0.38	0.08	-0.14	0.33	-0.08	**0.58**	0.33	0.63
Cautious	-0.38	0.30	-0.11	**0.44**	0.19	-0.09	**-0.48**	0.19	-0.09	0.26	**0.44**	-0.14	0.48
Disorganized	-0.18	-0.14	-0.02	-0.19	**-0.74**	-0.20	0.00	-0.07	0.05	**-0.77**	-0.09	-0.19	0.68
Clumsy	0.07	0.01	-0.02	-0.09	**-0.72**	-0.19	0.27	0.08	0.05	**-0.81**	-0.02	-0.18	0.58
Thoughtless	-0.17	-0.17	-0.09	-0.21	**-0.71**	-0.01	0.01	-0.12	-0.05	**-0.72**	-0.13	0.01	0.61
Intelligent	0.19	-0.09	0.14	0.38	**0.68**	0.08	-0.01	-0.17	0.08	**0.70**	0.34	0.05	0.68
Distractible	-0.21	-0.11	0.06	-0.06	**-0.67**	0.18	-0.06	-0.08	0.07	**-0.67**	0.01	0.19	0.54
Unperceptive	-0.33	-0.17	-0.17	0.11	**-0.54**	-0.25	-0.24	-0.19	-0.11	**-0.50**	0.22	-0.26	0.54
Quitting	-0.21	0.06	-0.24	0.18	-0.26	0.06	-0.17	0.00	-0.23	-0.24	0.21	0.05	0.21

	Component						Component						
Adjective	Ast[a]	Con[a]	Opn	Agr	Att[a]	Ext[a]	Ast[a]	Con[a]	Opn	Att[a]	Agr	Ext[a]	h^2
Solitary	-0.19	0.18	-0.26	-0.12	-0.08	**-0.71**	-0.15	0.21	-0.15	-0.06	-0.08	**-0.71**	0.65
Depressed	**-0.42**	-0.11	-0.19	-0.05	-0.22	**-0.67**	-0.39	-0.12	-0.10	-0.14	0.05	**-0.67**	0.72
Individualistic	0.11	-0.19	0.31	-0.05	-0.16	**-0.56**	0.16	-0.12	0.38	-0.20	0.02	**-0.57**	0.49
Autistic	**-0.45**	-0.22	-0.08	-0.06	-0.34	**-0.46**	-0.39	-0.22	-0.02	-0.26	0.05	**-0.46**	0.58
Proportion Variance	0.15	0.13	0.10	0.09	0.09	0.06	0.15	0.13	0.10	0.09	0.09	0.06	

Note. [a]Factor was reflected. Ast = Assertiveness, Con = Conscientiousness, Opn = Openness, Att = Attentiveness, Agr = Agreeableness, Ext = Extraversion. Loadings ≥ |.4| in boldface.

Table S5

Component Inter-Correlations

Factor	Ast[a]	Con[a]	Opn	Att[a]	Agr
Con[a]	-0.04				
Opn	0.06	-0.15			
Att[a]	0.42	0.12	0.10		
Agr	0.15	0.27	-0.01	0.16	
Ext[a]	0.01	0.07	0.15	0.03	0.15

Note. [a]Factor was reflected. Ast = Assertiveness, Con = Conscientiousness, Opn = Openness, Att = Attentiveness, Agr = Agreeableness, Ext = Extraversion.