**Dominance in Human Personality Space and in Hominoid Phylogeny**

**Abstract**

Unlike nonhuman primates, individual differences between humans in dominance do not appear as broad personality factors. This may be attributable to differences between the questionnaires used to study human and nonhuman primate personality. Alternatively, this may reflect a difference in the organization of personality in humans and nonhuman primates. To determine which of these two possibilities was most likely 1147 participants were asked to rate their personality and/or that of somebody else on the Hominoid Personality Questionnaire (HPQ), which has been used to study nonhuman primate personality. A large subset of these participants (~80%) also completed self- and/or rater reports of one of three questionnaires used to measure human personality. Exploratory factor analyses of HPQ rater report data yielded five factors. These factors correlated mostly in expected ways with scales from questionnaires used to study human personality. Exploratory factor analyses of HPQ self-report data yielded no clear number of factors and no consistent evidence with respect to the presence of a dominance factor. Subsequent analyses compared HPQ scales that represented dominance factors in chimpanzees, bonobos, mountain gorillas, and orangutans, to scales derived from the Revised NEO Personality Inventory, including Fearless Dominance, which combined Neuroticism, Agreeableness, Conscientiousness, and Extraversion facets, Emotional Stability (the inverse of Neuroticism), and Extraversion’s Assertiveness facet. Fearless Dominance was most like the great ape dominance factors. The absence of human dominance factors, therefore, appears to reflect present or past social conditions of our species.

**Keywords:** egalitarianism, evolution, factors, structure, traits

**Dominance in Human Personality Space and Hominoid Phylogeny**

Research on human personality has identified a model in which correlations between lower-level traits that characterize people with regards to stable behavioral, emotional, and cognitive dispositions are summarized by five broad factors. These factors are commonly labeled Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness, and are known collectively as the “Big Five” (Costa & McCrae, 1992; Digman, 1990; Goldberg, 1993).

The Big Five are stable over time (Costa et al., 2019), heritable (Bouchard & Loehlin, 2001), and related to survival (Strickhouser et al., 2017) and reproductive success (Alvergne et al., 2010; Gurven et al., 2014; Jokela et al., 2011). The Big Five are also found in nearly all human societies (McCrae et al., 2005; Schmitt et al., 2007). Finally, this structure, which is known as the “Five-Factor Model”, is the product of genetic correlations between lower-order traits (McCrae et al., 2001; Yamagata et al., 2006). These findings have led to the view that the Five-Factor Model is a product of human evolution (see, e.g., McCrae & Costa, 1999) and to theories that seek to explain the Big Five’s evolutionary origins (Penke et al., 2007a, 2007b). What these theories have in common is that they ascribe one or more domains of functioning to each of the Big Five. For example, both Nettle (2006) and Denissen and Penke (2008) ascribe a social function to Extraversion whereas DeYoung (2015) suggests that the function of Extraversion is related to reward sensitivity.

The comparative method (Harvey & Pagel, 1991; Nunn, 2011) is one approach to identifying the evolutionary origins and function of personality factors. The application of the comparative method in the study of personality involves trying to determine reasons for the presence, absence, or form of personality factors by assessing personality in species or populations that vary in how related they are, and the degree to which their social structures or habitats differ (Gosling, 2001; Gosling & Graybeal, 2007; Gosling & John, 1999; Weiss, 2018; Weiss & Adams, 2013; Weiss & Gartner, 2016).

One difference between humans and nonhuman primates that has emerged from comparative personality research concern traits related to assertiveness, dominance, and competitive prowess. In nonhuman primates, these traits define dominance factors, which are labeled, for example, “Confidence”, “Dominance”, or “Assertiveness” (for reviews, see Freeman & Gosling, 2010; Weiss, 2018). In humans, however, these traits define lower-order facets (Costa & McCrae, 1995; Soto & John, 2017) and aspects (DeYoung et al., 2007) of the Five-Factor Model (Costa & McCrae, 1992; Digman, 1990; Goldberg, 1993), and of other models of human personality (e.g., Cattell et al., 1970; Eysenck & Eysenck, 1975; Gough, 1956; Lee et al., 2005; Tellegen, 1982).

The present study investigated why human personality at the level of broad traits lacks a dominance factor. The absence of a dominance factor in humans is surprising for humans exhibit and vary in traits and behaviors related to dominance and rank (Altemeyer, 2006; Benning et al., 2003; Burgoon et al., 1998). To address this question, data from humans who rated themselves and/or somebody they knew on a close adaptation of the Hominoid Personality Questionnaire (HPQ; Weiss, 2017) were analyzed. A subsample of these participants also rated themselves and/or somebody they knew on the Revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992), the NEO Five-Factor Inventory (NEO-FFI; Costa & McCrae, 1992), or the Big Five Inventory (BFI; Benet-Martínez & John, 1998; John et al., 1991; John et al., 2008)

The HPQ has been used in studies of several nonhuman primate taxa, including great apes and both Old- and New-World monkeys (Adams et al., 2015; Eckardt et al., 2015; Garai et al., 2016; Inoue-Murayama et al., 2018; Morton, Lee, Buchanan-Smith, et al., 2013; Weiss et al., 2011; Weiss et al., 2006; Weiss et al., 2015). This questionnaire has consistently identified dominance factors in these species. However, those findings may be artifacts emerging because of how the HPQ items (and those of other primate personality questionnaires) were written (cf. Block, 1995). The HPQ, for example, includes items, such as *dominant*, *submissive*, *bullying*, and *aggressive*, with descriptor sentences that refer to competitive interactions (King & Figueredo, 1997; Weiss et al., 2009). One way to try to rule out this explanation is to collect personality data on humans using the HPQ to see whether the Five-Factor Model emerges from these data or whether a structure that includes a dominance factor emerges. In addition to addressing this question, by collecting data on humans using measures of the Five-Factor Model, it will be possible to address a second question, namely where dominance exists in human five-factor space.

Research on dominance in humans and/or nonhuman primates suggests that there are at least three possible places where dominance traits exist in five-factor space. The first is that dominance is, in fact, Emotional Stability. This possibility is consistent with the fact that traits related to negative affect often have negative loadings on dominance factors. For example, although there are exceptions (Inoue-Murayama et al., 2018; Koski et al., 2017; Weiss et al., 2006), across several taxa, *fearfulness* has a negative loading on Dominance (Adams et al., 2015; Eckardt et al., 2015; King & Figueredo, 1997; Konečná et al., 2008; Konečná et al., 2012; Manson & Perry, 2013; Morton, Lee, Buchanan-Smith, et al., 2013; Weiss et al., 2011; Weiss et al., 2015; Wilson et al., 2018). Support also comes from a study by Latzman et al. (2016) in which people were asked to rate somebody they knew on a chimpanzee personality questionnaire developed by Freeman et al. (2013) and on the BFI. This study found a large negative correlation between a scale representing chimpanzee Dominance and the BFI’s Neuroticism scale. There are reasons to believe that dominance factors are not solely measures of Emotional Stability. For one, in chimpanzees and other primate species, traits associated with sociability, self-control, and aggression also load on dominance factors (Adams et al., 2015; Eckardt et al., 2015; King & Figueredo, 1997; Konečná et al., 2008; Konečná et al., 2012; Manson & Perry, 2013; Morton, Lee, Buchanan-Smith, et al., 2013; Weiss et al., 2011; Weiss et al., 2015; Wilson et al., 2018). Also, Latzman et al. (2016) found a positive correlation between Dominance and Extraversion in humans that was of a similar magnitude to the negative correlation between Dominance and Emotional Stability.

Two further possible answers to the question of where dominance can be found in five-factor space are derived from the theory that a lot of human behavior can be explained by the fact that humans evolved in small-scale, relatively egalitarian societies (Boehm, 1999; von Rueden, 2020). In such societies, because there would be less competition over resources, and competition would incur social or energetic costs, social pressures would inhibit the display of dominance and/or blunt the effects of its display on others. Evidence for this theory in primates includes findings from a study of six macaque species. In that study, Adams et al. (2015) found that the items that loaded on factors related to social competence and aggression differed as a function of how despotic versus tolerant these species were (Thierry, 1985, 2000; Thierry et al., 2008; Thierry et al., 2004). Evidence for this theory in great apes and other taxa, however, is mixed. Results consistent with the theory come from Garai et al. (2016) who did not find a dominance factor in wild bonobos (*Pan paniscus*), a species that, like chimpanzees, is closely related to humans but, unlike chimpanzees, is relatively egalitarian (Vigilant, 2007). On the other hand, a study of captive bonobos found a factor (Assertiveness) that resembled chimpanzee Dominance (Weiss et al., 2015). The evidence is also mixed in cetaceans. Morton et al. (2021) did not find a dominance factor in bottlenose dolphins (*Tursiops truncates*), which live in societies that are not characterized by contest-based hierarchies (Shane et al., 1986). On the other hand, although killer whales (*Orcinus orca*) also do not live in strongly hierarchical societies (Ford et al., 2011), they possess a dominance factor (Úbeda et al., 2018).

The first of these explanations is that the traits that load on dominance factors became part of Extraversion. This possibility is supported because Assertiveness, which resembles dominance factors in nonhuman primates, is a facet of human Extraversion (Costa & McCrae, 1995; Soto & John, 2017). Further evidence that dominance became part of Extraversion comes from longitudinal studies of humans. One study found that, unlike other Extraversion facets, Assertiveness increases until around age 60 and then declines (Terracciano et al., 2005). Likewise, a meta-analysis found that human personality traits related to “social dominance” increase until age 60 but that traits related to “social vitality” decline throughout life (Roberts et al., 2006). These trajectories resemble those of Dominance and Extraversion, respectively, in orangutans (*Pongo spp.*) and chimpanzees (King et al., 2008; Weiss & King, 2015; Weiss et al., 2007), which are the only nonhuman primate studies that tested for nonlinear age differences in personality. There is also evidence that is not consistent with this explanation. Specifically, traits other than assertiveness and social prowess also load on nonhuman primate dominance factors (Adams et al., 2015; Eckardt et al., 2015; King & Figueredo, 1997; Konečná et al., 2008; Konečná et al., 2012; Manson & Perry, 2013; Morton, Lee, Buchanan-Smith, et al., 2013; Weiss et al., 2011; Weiss et al., 2015; Wilson et al., 2018). For example, in common squirrel monkeys (*Saimiri sciureus*), fearfulness and sociability load negatively and positively on Assertiveness, respectively (Wilson et al., 2018).

The second of these explanations is that that the traits that make up dominance factors in nonhuman primates load on multiple human personality factors. This possibility is supported by findings from a meta-analysis, which found that, although Extraversion is most consistently associated with leadership, Neuroticism, Openness to Experience, and Conscientiousness are also significantly associated with leadership (Judge et al., 2002). Support for this possibility also comes from attempts to develop a dominance scale—Fearless Dominance (Benning et al., 2003)—from the Psychopathic Personality Inventory (Lilienfeld & Andrews, 1996). People high in Fearless Dominance are sociable, socially dominant, charming, fearless, thrill-seeking, and narcissistic, and have low levels of anxiety, social phobia, and depression (Benning et al., 2005). Fearless Dominance therefore resembles dominance factors found in several nonhuman primate species (Adams et al., 2015; Eckardt et al., 2015; King & Figueredo, 1997; Konečná et al., 2008; Konečná et al., 2012; Manson & Perry, 2013; Morton, Lee, Buchanan-Smith, et al., 2013; Weiss et al., 2011; Weiss et al., 2015; Wilson et al., 2018). Fearless Dominance is also related to multiple indices of leadership in U.S. presidents (Lilienfeld et al., 2012).

To test which of these possibilities has the most support, the relationships between three variables—Emotional Stability, Assertiveness, and Fearless Dominance—and a variable representing chimpanzee Dominance, bonobo Assertiveness, orangutan Dominance, or mountain gorilla (*Gorilla gorilla beringei*)Dominance were examined. For these analyses, Emotional Stability, Assertiveness, and Fearless Dominance were based on NEO-PI-R data. Factors related to dominance in great apes were based on HPQ data. In the first analysis, Dominance was based on the definition of chimpanzee Dominance. In the second, third, and fourth analyses, Dominance was based on the definition of bonobo Assertiveness, mountain gorilla Dominance, and orangutan Dominance, respectively. Eight models were fit for each great ape dominance factor. These models included a null model, models that tested whether Fearless Dominance, Assertiveness, or Emotional Stability, respectively, were associated with Dominance, a further three models that tested how all possible pairs of these factors were associated with Dominance, and a final model that tested whether all three were associated with Dominance. These models acknowledge that these explanations are not mutually exclusive. For example, Dominance in humans may be characterized by Fearless Dominance and Emotional Stability.

**Methods**

**Openness and Transparency**

Sample size was based on the availability of archival data. All data exclusions, all manipulations, and all measures in the study were reported in Methods. Some of these data were analyzed for student projects. There was also an attempt to conduct a multitrait-multimethod analysis on some of these data, but there were not enough data to fit such a model. The data, combined as they were for the present study, were not analyzed previously.

**Participants**

Four suitable archival datasets were identified and analyzed. All four datasets included HPQ ratings of humans. Data were on 1184 participants who rated themselves and/or somebody they knew on the HPQ. A total of 904 of these participants also rated themselves and/or somebody they knew on the NEO-PI-R, the NEO-FFI, or the BFI. Data were screened to remove invalid responses, which were defined as missing more than a sixth of the personality questionnaire items (cf. Costa & McCrae, 1992; Morton, Lee, Buchanan-Smith, et al., 2013).

***Dataset 1: HPQ Rater-Report Data***

Data collection took place in 2005. As part of a demonstration, undergraduates in a psychology course at the University of Texas rated someone they knew on the HPQ.

Of the 205 ratings, three had too many missing responses (more than nine items). These ratings were excluded. Of the data from the remaining 202 participants, .13% of the possible responses were missing: eight participants did not answer one item, a ninth participant did not answer two items, and a tenth participant did not answer four items. These missing responses were substituted with a 4 (the HPQ response scale’s midpoint).

The remaining participants included 122 women, 73 men, and seven individuals who did not report their gender. No other demographic data were collected.

***Dataset 2: HPQ and NEO-PI-R Multiple Informant Data***

From 2005 to 2006, data came from a study conducted by third year undergraduates at the University of Edinburgh. One hundred and twenty-nine participants were recruited and paid £5.35 to rate their own personality on the HPQ and on the NEO-PI-R. From 2006 to 2009 data came from 75 pairs of participants (37 recruited at the University of Edinburgh and 38 recruited at the University of Leeds) who were asked to rate their personality and that of the other member of the pair on both the HPQ and the NEO-PI-R. Each of these participants was paid £10.70 (£5.35 per person rated).

Of the 279 total ratings (204 self-reports and 75 rater reports) collected from 2005 to 2009, too many items were missing from 12 HPQ self-reports and 13 HPQ rater reports. These ratings were excluded. In addition, too many items (more than 40) were missing from three NEO-PI-R self-reports and three NEO-PI-R rater reports. These ratings were also excluded. For the remaining 192 HPQ self-reports, .14% of the possible responses were missing: six participants did not answer one item and a seventh participant did not answer nine items. For the remaining 62 HPQ rater reports, .30% of the possible responses were missing: two participants did not answer one item and a third participant did not answer eight items. The HPQ’s midpoint was substituted for these missing responses. For the remaining 201 NEO-PI-R self-reports, .08% of the possible responses were missing: 22 participants did not answer one item, two participants did not answer two items, each; and three participants did not answer three, four, and six items, respectively. For the remaining 72 NEO-PI-R rater reports, .05% of the possible responses were missing: seven participants did not answer one item and an eighth did not answer two items. The midpoint (2) of the NEO-PI-R scales, which range from 0 to 4 (Costa & McCrae, 1992), was substituted for missing responses.

Of the 277 participants who contributed valid HPQ or NEO-PI-R data, 72 did not report their gender, age, ethnicity, educational background, and whether they were students; five did not report their age but answered the other demographic questions. The mean of the reported ages was 28.7 years (*SD* = 11.6) with the mean age of the 66 men being 26.0 years (*SD* = 9.6) and the mean age of the 139 women being 30.0 years (*SD* = 12.2). Most participants identified themselves as “white British” (*n* = 173) with the remainder identifying themselves as another white ethnicity, e.g., “white Irish” (*n* = 21), or one of the other eight categories: “Asian Indian” (*n* = 3), “black other” or “black British” (*n* = 3), British (*n* = 1), Japanese (*n* = 1), Chinese or Chinese Pilipino (*n* = 2), or “other” (*n* = 1). The participants had an average of 14 years of education (*SD* = 2.4) and included 108 full-time students, one part-time student, and 96 nonstudents.

***Dataset 3: HPQ and NEO-FFI Self-Report Data***

Data collection took place in 2012. Second year undergraduates at the University of Edinburgh recruited an approximately equal number of younger (18-21 years old) and older (22+ years old) men and women. These participants were asked to complete self-report versions of the HPQ and the NEO-FFI. Participants also completed the Type D Scale-14 (Denollet, 2005), but these data were not used in the present study.

Of the 467 ratings, too many items were missing from 12 HPQ self-reports and three NEO-FFI self-reports (more than 10). For the remaining 455 HPQ self-reports, .24% of the possible responses were missing: 29 participants did not answer one item, six participants did not answer two items, and one participant, each, did not answer three, six, and nine items. For the remaining 464 NEO-FFI self-reports, .45% of the possible responses were missing: 37 participants did not answer one question; eight participants did not answer two questions; and one participant, each, did not answer three, four, five, and seven questions. These missing responses were substituted with the midpoint of the NEO-FFI’s response scale (2).

The mean age of the 464 participants who provided valid HPQ and/or valid NEO-FFI data was 27.1 years (*SD* = 12.2). These participants included 232 men with a mean age of 26.8 years (*SD* = 12.0) and 232 women with a mean age of 27.3 years (*SD* = 12.4). No additional demographic data were collected.

***Dataset 4: HPQ and BFI Self-Report Data***

Data collection took place in 2012. For a study, third year psychology undergraduates at the University of Edinburgh collected self-report HPQ and BFI data. Participants also completed the Empathy Quotient (Baron-Cohen & Wheelwright, 2004), but these data were not used in the present study.

Of the data from 233 participants, HPQ data from 74 participants and BFI data from 30 participants were excluded because they missed too many items. For the remaining 159 HPQ self-reports, .31% of the possible responses were missing: 18 participants did not answer one question; two participants did not answer two questions, each; and five participants did not answer one question. In these cases, missing responses were substituted with the midpoint of the response scale. For the remaining 203 BFI self-reports, .52% of the possible responses were missing: 17 participants did not answer one question; eight participants did not answer two questions; two participants did not answer three questions; and one participant did not answer seven questions. These missing responses were substituted with the midpoint (3) of the BFI’s response scale.

A total of 204 participants provided valid ratings data on the HPQ and/or the BFI. Of these participants, 198 reported their gender and age. The mean age of these participants was 26.0 years (*SD* = 11.8), the mean age of the 51 men was 28.3 years (*SD* = 15.1), and the mean age of the 147 women was 25.1 years (*SD* = 10.1). Most of the participants identified as “white” (*n* = 150) with the remainder identifying as “Indian or East Asian” (*n* = 31), some other ethnic background (*n* = 12), mixed ethnicity (*n* = 9), or black (*n* = 2). The mean years of education reported by the 192 participants who provided data was 13.7 (*SD* = 4.6).

**Instruments**

***Hominoid Personality Questionnaire***

The HPQ is a 54-item rater report questionnaire (Weiss, 2017; Weiss et al., 2009). The HPQ was derived from the Chimpanzees Personality Questionnaire, a 43-item rater report questionnaire (King & Figueredo, 1997), and the Orangutan Personality Questionnaire, a 48-item rater report questionnaire (Weiss et al., 2006).

King and Figueredo (1997) created the Chimpanzee Personality Questionnaire by first sampling 41 adjectives from Goldberg’s (1990) taxonomy of the Big Five. They also devised the adjectives *clumsy* and *autistic* for the purpose of rating chimpanzees. To turn the 43 adjectives into questionnaire items, King and Figueredo paired each adjective with one to three clarifying sentences, which framed the adjective in the context of behavior. For example, the item *playful* was “**PLAYFUL:** Subject is eager to engage in lively, vigorous, sportive, or acrobatic behaviors with or without other chimpanzees.” (boldface and capitals in the original). The Chimpanzee Personality Questionnaire’s instructions asks raters to rate each trait using a 7-point scale ranging from 1 (*Displays either total absence or negligible amounts of the trait*) to 7 (*Displays extremely large amounts of the trait*).

The Orangutan Personality Questionnaire (Weiss et al., 2006) was identical to the Chimpanzee Personality Questionnaire but included five new items: *anxious*, *vulnerable*, *cool*, *curious*, and *conventional*. The items *anxious* and *vulnerable* were based on the NEO-PI-R Neuroticism facets N1: Anxiety and N6: Vulnerability. The items *curious* and *conventional* were based on adjective pairs that loaded on Openness (McCrae & Costa, 1985). The item *cool* and the clarifying sentences for the five new items were devised by Weiss and colleagues.

The HPQ (Weiss et al., 2009) was identical to the Orangutan Personality Questionnaire but included six new items. The items *thoughtless*, *distractible*, and *quitting* were based on adjective pairs that loaded on Conscientiousness, and the items *individualistic*, *innovative*, and *unperceptive* were based on adjective pairs that loaded on Openness to Experience (McCrae & Costa, 1985). The clarifying sentences for the six new items were devised by Weiss and colleagues.

Studies of nonhuman primates that have used the HPQ (e.g., Weiss et al., 2015), the Orangutan Personality Questionnaire (Weiss et al., 2006), or the Chimpanzee Personality Questionnaire (e.g., King & Figueredo, 1997), have established the interrater and retest reliabilities of these instruments. Studies have also found associations between these instruments and observed behavior (Pederson et al., 2005), performance on cognitive tasks (Altschul et al., 2017; Altschul et al., 2016; Morton, Lee, & Buchanan-Smith, 2013), well-being (King & Landau, 2003; Weiss et al., 2009), and mortality (Altschul et al., 2018).

Minor modifications were made to the HPQ so that it could be used to collect rater reports of humans. Clarifying sentences were changed so that they referred to people and references to “enclosure” were changed to “environment”. In addition, behaviors from clarifying sentences were omitted if they made little sense for humans. For example, the clarifying sentence for *fearful* was changed from “Subject reacts excessively to real or imagined threats by displaying behaviors such as screaming, grimacing, running away or other signs of anxiety or distress.” to “Subject reacts excessively to real or imagined threats by displaying signs of anxiety or distress.” The self-report version of the HPQ was created by changing descriptor sentences so that they referred to the first person.

Along with these modifications, some participants who completed the HPQ and the NEO-PI-R (the participants in Dataset 2) reported that some clarifying sentences were too extreme. These sentences were thus modified further with care taken to not distort their meaning. For example, the sentence for *bullying* was changed from “I am overbearing and intimidating towards younger or otherwise disadvantaged individuals.” to “I am overbearing and intimidating towards others.” This version of the self-report HPQ was administered to the participants in Datasets 3 and 4.

***The NEO Inventories***

The NEO-PI-R (Costa & McCrae, 1992) consists of 240 items. Each item is a statement, e.g., “I really like people.”, to which one can respond *Strongly Disagree*, *Disagree*, *Neutral*, *Agree*, and *Strongly Agree*. The NEO-PI-R operationalizes each of the Five-Factor Model’s 30 facets by 8 items and each of its five factors (Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness) by six facets (Costa & McCrae, 1992). The NEO-FFI is a 60-item questionnaire that operationalizes each of the five factors by 12 items sampled from the NEO-PI-R (Costa & McCrae, 1992). The interrater and retest reliabilities of the NEO-PI-R and NEO-FFI are well-documented (Costa & McCrae, 1992). Both instruments are also related to numerous outcomes, including, well-being (Anglim et al., 2020) and mortality (Weiss & Costa, 2005). The NEO-PI-R’s structure replicates across many cultures (McCrae et al., 2005). For this study, NEO-PI-R and NEO-FFI raw domain scores, and raw NEO-PI-R facet scores, were created following the instructions in the NEO *Manual* (Costa & McCrae, 1992).

***The Big Five Inventory***

The BFI consists of 44 items (Benet-Martínez & John, 1998; John et al., 1991; John et al., 2008). Each item is a statement, e.g., “Does a thorough job”. Neuroticism and Extraversion are measured by eight items, each, Agreeableness and Conscientiousness are measured by nine items, each, and Openness is measured by 10 items. Responses to the items are made on a 5-point scale ranging from 1 (*Disagree Strongly*) to 5 (*Agree Strongly*). The interrater reliability and retest reliability of the BFI are well-documented (John et al., 1991; John et al., 2008). The BFI has been related to many of the same outcomes as the NEO-PI-R and NEO-FFI (Anglim et al., 2020; Graham et al., 2017). The BFI’s structure also replicates across many (Schmitt et al., 2007), but not all (e.g., Gurven et al., 2013), cultures. For this study, raw scores for each factor were created according to the BFI’s instructions (Benet-Martínez & John, 1998; John et al., 1991; John et al., 2008).

**Analyses**

 All analyses were conducting using the R package (R Core Team, 2019). Two sets of analyses were used to address the research questions. The first set of analyses addressed whether the identification of factors related to dominance in nonhuman primates was an artifact arising from the use of the HPQ. The second set addressed where dominance was in five-factor space. This set involved fitting generalized linear models in which HPQ scale scores based on great ape dominance factors were associated with Emotional Stability, E3: Assertiveness, and Fearless Dominance scores from the NEO-PI-R.

***Exploratory Factor Analysis of Hominoid Personality Questionnaire Data***

The fa()function (Revelle, 2018) was used to conduct exploratory factor analyses of four sets HPQ data. Factor extraction was carried out using the method of minimum residuals (Harman & Jones, 1966).

Three methods were used to guide decisions about how many factors to extract. First, a parallel analysis (Horn, 1965) was conducted using the fa.parallel()function (Revelle, 2018). Because parallel analysis for principal components is a more accurate indicator of the number of factors (Auerswald & Moshagen, 2019), parallel analyses were used to determine how many components from data had eigenvalues greater than expected at the 95th percentile of eigenvalues from 1000 sets of random data. The second method was the number of factors associated with the lowest Bayesian Information Criterion (BIC; Schwarz, 1978) with the caveat that BIC differences greater than or equal to 2 are considered evidence against the null hypothesis that the fit associated with fewer factors does not differ from the fit with more factors (see second table on page 777 of Kass & Raftery, 1995). BICs were obtained using the VSS()function (Revelle, 2018). The third was to use the Hull method, which finds the number of factors that optimizes the balance of model fit and parsimony (Lorenzo-Seva et al., 2011). This method was chosen because it performs well on personality data as it tends to only identify major factors (Lorenzo-Seva et al., 2011). The index of model fit was the amount of variance accounted for by the common factor model (Lorenzo-Seva et al., 2011, p. 349). The hullEFA()function was used to conduct this analysis (Navarro-Gonzalez & Lorenzo-Seva, 2020). Decisions of how many factors to extract were also informed by inspections of scree plots and by factor interpretability.

 After factors were extracted, they were subjected to an orthogonal (varimax) rotation, which fixes correlations between factors to zero, and an oblique (promax) transformation, which allows factors to correlate with one another. If interfactor correlations obtained from the promax transformation were mostly modest, and the orthogonal and oblique factors were similar, that is, factor congruences obtained using factor.congruence()(Revelle, 2018) exceeded .85 (Lorenzo-Seva & ten Berge, 2006), the orthogonal factors were interpreted. Otherwise, the oblique factors were interpreted. To be consistent with previous studies that used the HPQ (Weiss, 2017), when interpreting factors, loadings greater than or equal to |.4| were defined as salient.

***Interrater Reliabilities of HPQ and NEO-PI-R Factors***

For these analyses, the NEO-PI-R’s factors were represented by raw (unweighted) domain scores (Costa & McCrae, 1992). For simplicity, these scores will be referred to as “factor scores” throughout. Variance components were obtained from linear models in which each factor was regressed onto participant ID. These variance components were used to compute intraclass correlation coefficients for a design in which each target is assessed by an independent set of judges. The first intraclass correlation coefficient was *ICC*(1,1), which indicates the reliability of ratings from a single judge. The second, *ICC*(1,*k*), indicates the reliability of average scores from *k* judges (Shrout & Fleiss, 1979).

***Factor Validities***

Pearson correlation coefficients were used to examine the convergent and discriminant validities (Campbell & Fiske, 1959) of HPQ factors. The first six sets included four monomethod correlations: HPQ and NEO-PI-R factors from self-reports, HPQ and NEO-PI-R factors from rater reports, HPQ and NEO-FFI factors from self-reports, and HPQ and BFI factors from self-reports. The fifth and six set were heteromethod correlations between self-report HPQ factors and rater report NEO-PI-R factors, and *vice versa*. Statistical tests for these analyses were two-tailed (α = .05) and the Holm-Bonferroni method (Holm, 1979) was used to adjust for multiple tests.

There were two further sets of monomethod correlations: One between HPQ factors and NEO-PI-R facets from self-report data and one between HPQ factors and NEO-PI-R facets from rater report data. For these analyses, significance tests were not reported. Instead, correlations greater than |.4| were inspected to see whether they were consistent with what one would expect based on the meaning of the HPQ factor and NEO-PI-R facet. As with the previous analyses, weighted averages of these correlations were also reported.

***Great Ape Dominance Factors and the Five-Factor Model***

 Four sets of generalized linear models with Gaussian error distributions were used to test whether, in humans, scales that represented great ape dominance factors resembled Emotional Stability, Assertiveness, or Fearless Dominance. Self-report HPQ and NEO-PI-R data from Dataset 2 were used for these analyses. In each set of these models, the dependent variable was a unit-weighted HPQ scale based on the definitions of chimpanzee (Weiss et al., 2009), mountain gorilla (Eckardt et al., 2015), or orangutan Dominance factor (Weiss et al., 2006), or the bonobo Assertiveness factor (Weiss et al., 2015) (see Table 1). The independent variables were scored from the NEO-PI-R. Fearless Dominance was the sum of all 30 facets after they had been multiplied by the weights from Table 3 of Ross et al. (2009), Assertiveness was represented by the facet E3: Assertiveness, and Emotional Stability was the inverse of Neuroticism, that is, Neuroticism multiplied by -1. The eight models fit in each set of analyses were the following: 1) intercept only, 2) intercept and Fearless Dominance, 3) intercept and Assertiveness, 4) intercept and Emotional Stability, 5) intercept, Fearless Dominance, and Assertiveness, 6) intercept, Fearless Dominance, and Emotional Stability, 7) intercept, Assertiveness, and Emotional Stability, and 8) intercept, Fearless Dominance, Assertiveness, and Emotional Stability. An information theoretic approach (Burnham & Anderson, 2002) was used to compare the degree to which each model was supported as it indicated the normalized probability that one model should be favored (Wagenmakers & Farrell, 2004) and, when appropriate, compute model averaged parameter estimates.

**Table 1**

*Formula for Creating Dominance Scores Based on Responses to the Hominoid Personality Questionnaire*

|  |
| --- |
| Chimpanzee Dominancea |
|  dominant + independent + decisive + intelligent + persistent + bullying + stingy/greedy +  manipulative – submissive – dependent – fearful – timid – cautious – vulnerable – anxious |
|  |
| Bonobo Assertivenessb |
|  – anxious – timid – fearful – independent – dominant – vulnerable – submissive + cool + stable – dependent/follower + decisive + persistent – excitable |
|  |
| Mountain gorilla Dominancec |
|  intelligent + decisive + protective – timid – anxious + independent + dominant – fearful + sensitive – distractible + helpful + bullying – dependent/follower – disorganized – submissive – imitative + persistent – clumsy – vulnerable |
|  |
| Orangutan Dominanced |
|  bullying + aggressive + stingy/greedy + jealous + dominant – gentle + defiant – submissive + manipulative + persistent + irritable + reckless |

*Note*. To ensure that scores were on a 7-point scale, a constant equal to 8 times the product of the number of subtracted items was added to each and the final score was divided by the number of items.

a Chimpanzee definition from Weiss et al. (2009).

b Bonobo definition from Weiss et al. (2015).

c Mountain gorilla definition from Eckardt et al. (2015).

d Orangutan definition from Weiss et al. (2006).

**Ethics**

This study complied with all relevant ethical regulations. Informed consent was granted by all study participants. Ethical clearance was granted by the Psychology Research Ethics Committee at the University of Edinburgh.

**Results**

**Exploratory Factor Analysis of the Hominoid Personality Questionnaire**

***Analyses of Rater Report Data***

All 264 HPQ rater reports (202 from Dataset 1 and 62 from Dataset 2) were used for these analyses. Parallel analysis, BICs, and the Hull method indicated that there were five factors, and the scree plot leveled off after five factors. All five factors were interpretable. Five factors that accounted for 41% of the variance were therefore extracted. The orthogonally rotated factors were interpreted because absolute correlations between factors were mostly modest (range = .02 to .55, *M* = .22, *SD* = .17) and the oblique and orthogonal solutions were similar (congruence coefficients [φs] = .940 to .993). The orthogonally rotated factors are presented in Table 2 and the oblique solution is presented in Table S1.

The factors were identifiable as the Big Five. The first was characterized by positive loadings of six markers of high Openness (e.g., *inventive*), a negative loading of a marker of low Openness (*conventional*), and positive loadings of two markers of high Extraversion (*playful* and *active*) and two markers of high Agreeableness (*protective* and *affectionate*). The second factor was characterized by positive loadings of eight markers of low Agreeableness (e.g., *manipulative*) and negative loadings of three markers of high Agreeableness (e.g., *gentle*). The third factor was characterized by a negative loading of a marker of high Conscientiousness (*decisive*) and positive loadings of nine markers of low Conscientiousness (e.g., *disorganized*). The fourth factor was characterized by positive loadings of six markers of high Neuroticism (e.g., *vulnerable*) and negative loadings of three markers of low Neuroticism (e.g., *cool*). The fifth factor was characterized by positive loading of two markers of high Extraversion (*sociable* and *friendly*) and negative loadings of three markers of low Extraversion (e.g., *solitary*). Based on these results, the first factor was named Openness, the fourth Neuroticism, and, after reflecting (multiplying loadings by -1) them, the second, third, and fifth factors were named Agreeableness, Conscientiousness, and Extraversion, respectively.

**Table 2**

*Standardized Loadings from an Exploratory Factor Analysis of Hominoid Personality Questionnaire Rater Reports*

| Item | Factor | *h*2 |
| --- | --- | --- |
|  | Opn | Agra | Cona | Neu | Exta |  |
| Inventive | **.69** | -.02 | .02 | -.09 | .08 | .49 |
| Innovative | **.61** | -.04 | .14 | -.04 | .10 | .41 |
| Conventional | **-.60** | -.02 | -.01 | .08 | -.22 | .41 |
| Inquisitive | **.59** | .03 | .15 | .10 | .23 | .44 |
| Impulsive | **.57** | -.25 | -.31 | .23 | .15 | .56 |
| Individualistic | **.52** | -.19 | .04 | .01 | -.07 | .32 |
| Independent | **.48** | -.02 | **.44** | -.20 | -.16 | .49 |
| Playful | **.47** | -.02 | .16 | -.09 | .35 | .38 |
| Protective | **.44** | .21 | .20 | .28 | .19 | .39 |
| Affectionate | **.42** | .36 | .11 | .33 | .36 | .56 |
| Active | **.41** | -.07 | .22 | -.10 | .32 | .33 |
| Predictable | -.36 | .08 | .15 | -.08 | -.20 | .21 |
| Curious | .31 | -.10 | .07 | .25 | .17 | .20 |
| Gentle | .11 | **.65** | .15 | .11 | .02 | .47 |
| Dominant | .28 | **-.62** | .10 | .07 | .19 | .51 |
| Manipulative | .07 | **-.61** | -.03 | .07 | .08 | .39 |
| Aggressive | .25 | **-.60** | -.02 | .05 | -.01 | .42 |
| Bullying | .02 | **-.60** | -.03 | .04 | -.01 | .36 |
| Irritable | -.08 | **-.56** | -.15 | .35 | -.23 | .52 |
| Jealous | .04 | **-.53** | -.20 | .36 | -.10 | .46 |
| Defiant | .39 | **-.52** | .05 | .08 | .03 | .43 |
| Helpful | .28 | **.50** | .34 | .18 | .20 | .52 |
| Stingy/greedy | -.13 | **-.47** | -.20 | .15 | -.20 | .34 |
| Sympathetic | .32 | **.42** | .30 | .38 | .26 | .58 |
| Submissive | -.23 | .38 | -.31 | .17 | -.27 | .39 |
| Decisive | .17 | -.08 | **.64** | .03 | -.02 | .44 |
| Disorganized | -.04 | -.02 | **-.59** | -.03 | -.09 | .36 |
| Lazy | -.16 | -.14 | **-.54** | .08 | -.31 | .44 |
| Distractible | .17 | -.03 | **-.54** | .09 | .10 | .34 |
| Quitting | -.12 | -.08 | **-.54** | .20 | -.13 | .37 |
| Reckless | .19 | -.37 | **-.53** | -.06 | .05 | .47 |
| Thoughtless | -.01 | -.29 | **-.53** | .01 | -.10 | .37 |
| Dependent/follower | **-.40** | .19 | **-.45** | .24 | -.09 | .47 |
| Clumsy | .01 | .04 | **-.43** | .17 | -.10 | .22 |
| Erratic | .33 | -.29 | **-.40** | .23 | -.06 | .41 |
| Imitative | -.22 | -.17 | -.39 | .24 | .04 | .29 |
| Unperceptive | -.25 | -.14 | -.38 | -.07 | -.25 | .29 |
| Intelligent | .32 | .14 | .36 | -.02 | .09 | .25 |
| Persistent | .24 | -.33 | .34 | .10 | -.08 | .30 |
| Vulnerable | -.04 | .02 | -.15 | **.62** | -.13 | .42 |
| Fearful | -.03 | -.07 | -.14 | **.60** | -.14 | .40 |
| Anxious | .09 | -.14 | -.20 | **.57** | -.21 | .44 |
| Cool | .05 | .13 | .18 | **-.55** | -.16 | .38 |
| Unemotional | -.17 | .02 | -.19 | **-.51** | -.27 | .39 |
| Stable | .17 | .32 | .09 | **-.46** | .05 | .35 |
| Excitable | **.42** | -.04 | -.08 | **.46** | .19 | .43 |
| Sensitive | .28 | .24 | .37 | **.42** | .22 | .50 |
| Cautious | -.22 | .25 | .28 | **.40** | -.33 | .46 |
| Solitary | -.08 | -.07 | .07 | -.05 | **-.72** | .54 |
| Sociable | .34 | -.02 | .06 | .14 | **.72** | .66 |
| Depressed | -.12 | -.06 | -.19 | .26 | **-.67** | .57 |
| Timid | -.30 | .20 | -.28 | .27 | **-.54** | .57 |
| Friendly | .27 | .38 | .12 | .21 | **.50** | .53 |
| Autistic | -.21 | -.15 | -.12 | .00 | -.23 | .13 |
| Proportion of variance | .10 | .09 | .09 | .07 | .07 |  |

*Note.* Factors were extracted using method of minimum residuals and rotated using the varimax procedure.

*N* = 264.

a Factor has been reflected. Opn = Openness, Agr = Agreeableness, Con = Conscientiousness, Neu = Neuroticism, Ext = Extraversion, *h*2 = item communalities.

***Analyses of Self-Report Data***

All 806 HPQ self-reports were used for these analyses. However, some clarifying sentences in the HPQ completed by Dataset 2 participants differed from the HPQ completed by participants from Datasets 3 and 4. Therefore prior to combining self-report data, separate exploratory factor analyses were conducted on the Dataset 2 (*N* = 192) and on Datasets 3 and 4 (*N* = 614) self-report data, and their factor structures were compared.

For Dataset 2, parallel analysis and the Hull method indicated that there were five factors, and BICs indicated that there were four factors. The scree plot leveled off after five or six factors. Given these results, and especially those from the parallel analysis and Hull method, which mirrored the results for rater reports, a decision was made to extract five factors. These factors were interpretable and explained 38% of the variance (see Table S2). When these factors were subjected to an oblique transformation, the absolute correlations between factors turned out to be modest (range = .01 to .38, *M* = .18, *SD* = .14). In addition, orthogonal rotation and oblique transformation yielded similar factors (φs = .965 to .990).

For Datasets 3 and 4, parallel analysis and the BICs indicated that there were eight factors, and the Hull method indicated that there were five. The scree plot leveled off after eight or nine factors. After an oblique transformation, four items had salient loadings on the fifth factor, three items had salient loadings on the sixth factor, four more items had loadings on the seventh factor, and three items had salient loadings on the eighth factor (see Table S3). Half the factors, therefore, appeared to be minor factors. Given this, the Hull method results, and the results from the factor analyses of rater reports and the self-reports from Dataset 2, a decision was made to extract five factors, which explained 34% of the variance (see Table S4). An oblique transformation revealed that absolute correlations between these factors were modest (range = .04 to .54, *M* = .21, *SD* = .15). An inspection of the orthogonal and oblique factors, and their congruences (φs = .946 to .989), indicated that the orthogonal and oblique solutions were similar.

Rotating the five orthogonal factors from Datasets 3 and 4 towards the five orthogonal factors from Dataset 2 (see Table S5) yielded congruence coefficients for the five factors that indicated fair similarity (φs = .870 to .945). The congruence coefficient based on all the loadings (φ = .914) also indicated fair similarity. Given that the five orthogonal factors extracted from Dataset 2 and Datasets 3 and 4 were similar, these datasets were merged. Five factors were then extracted from the merged self-report data (*N* = 806). These factors accounted for 34% of the variance. Because the absolute correlations between factors obtained from an oblique transformation (see Table S6) were mostly modest (range = .05 to .52, *M* = .22, *SD* = .14) and the differences between the two rotated structures were slight (φs = .953 to .986), the decision was made to interpret the orthogonally rotated factors (see Table 3). The first, second, and fourth factors were Conscientiousness (reflected), Agreeableness, and Neuroticism. The third factor was a blend of traits related to Dominance (e.g., *dominant*) and Openness (e.g., *innovative*), and so appeared to capture a tendency to be iconoclastic or rebellious. The fifth factor (reflected) could be interpreted as Excitement-Seeking, which is usually found as a facet of Extraversion (Costa & McCrae, 1992).

**Table 3**

*Standardized Loadings from an Exploratory Factor Analysis of Hominoid Personality Questionnaire Self Reports*

| Item | Factor | *h*2 |
| --- | --- | --- |
|  | Cona | Agr | Dom/Opn | Neu | ExSka |  |
| Disorganized | **-.70** | -.02 | .04 | -.08 | .13 | .51 |
| Lazy | **-.57** | -.09 | -.02 | .03 | -.25 | .40 |
| Distractible | **-.56** | .04 | .10 | .05 | .23 | .38 |
| Erratic | **-.53** | -.06 | .28 | .29 | .15 | .47 |
| Clumsy | **-.52** | .01 | -.05 | .08 | -.02 | .28 |
| Quitting | **-.50** | -.11 | -.08 | .04 | .01 | .27 |
| Thoughtless | **-.50** | -.13 | .05 | -.01 | .17 | .30 |
| Timid | **-.42** | -.07 | -.25 | .19 | **-.40** | .44 |
| Decisive | **.42** | .16 | .32 | -.10 | -.09 | .33 |
| Dependent/follower | **-.42** | .05 | -.33 | .25 | -.23 | .40 |
| Imitative | **-.42** | -.03 | -.03 | .13 | -.12 | .21 |
| Submissive | **-.40** | .09 | -.31 | .11 | -.20 | .31 |
| Depressed | -.37 | -.20 | .08 | .17 | -.33 | .32 |
| Autistic | -.32 | -.02 | .06 | .11 | -.04 | .12 |
| Sympathetic | .04 | **.66** | -.10 | .09 | .00 | .46 |
| Affectionate | .02 | **.64** | .00 | .14 | .11 | .45 |
| Helpful | .08 | **.64** | -.09 | -.14 | -.02 | .44 |
| Friendly | .07 | **.57** | -.04 | -.08 | .19 | .38 |
| Protective | .05 | **.54** | .13 | .07 | .03 | .32 |
| Gentle | -.04 | **.53** | -.25 | -.11 | -.17 | .39 |
| Inquisitive | -.10 | **.49** | **.42** | -.02 | .17 | .46 |
| Sociable | .06 | **.48** | .11 | .04 | .39 | .40 |
| Sensitive | .06 | **.47** | .05 | .06 | -.09 | .24 |
| Intelligent | .14 | **.41** | .33 | -.07 | -.05 | .30 |
| Unperceptive | -.31 | -.34 | .03 | .02 | -.09 | .22 |
| Curious | -.19 | .34 | .32 | .12 | .04 | .27 |
| Dominant | .09 | .03 | **.61** | .00 | .09 | .39 |
| Individualistic | -.06 | .19 | **.60** | -.08 | .06 | .41 |
| Manipulative | -.09 | -.15 | **.51** | .05 | -.03 | .29 |
| Defiant | -.01 | -.10 | **.50** | -.04 | .11 | .27 |
| Aggressive | -.10 | -.27 | **.49** | .20 | .11 | .38 |
| Bullying | -.14 | -.27 | **.48** | .08 | .05 | .33 |
| Persistent | .16 | .08 | **.47** | .00 | .01 | .25 |
| Inventive | -.01 | .18 | **.46** | -.14 | .15 | .29 |
| Independent | .12 | .25 | **.44** | -.24 | .09 | .33 |
| Innovative | .08 | .38 | **.40** | -.15 | .28 | .41 |
| Reckless | -.36 | -.13 | .37 | -.05 | .36 | .42 |
| Active | .27 | .22 | .29 | -.06 | .26 | .27 |
| Stingy/greedy | -.26 | -.22 | .28 | .18 | -.16 | .25 |
| Cool | -.03 | -.06 | .18 | **-.64** | -.13 | .47 |
| Stable | .14 | .16 | .03 | **-.60** | -.01 | .41 |
| Anxious | **-.46** | .02 | .01 | **.47** | -.23 | .48 |
| Fearful | -.29 | .06 | -.06 | **.46** | -.17 | .33 |
| Excitable | -.26 | .32 | .20 | **.44** | .18 | .44 |
| Unemotional | -.12 | -.34 | .09 | **-.42** | -.26 | .38 |
| Vulnerable | -.27 | .15 | -.14 | **.42** | -.14 | .31 |
| Irritable | -.29 | -.21 | .27 | **.40** | -.17 | .39 |
| Jealous | -.29 | -.05 | .20 | .30 | -.09 | .23 |
| Conventional | -.03 | -.10 | -.22 | .05 | **-.46** | .27 |
| Predictable | .12 | -.03 | -.14 | -.11 | **-.45** | .25 |
| Cautious | .10 | .21 | -.08 | .08 | **-.44** | .26 |
| Solitary | -.22 | -.10 | .19 | -.04 | **-.43** | .28 |
| Impulsive | -.36 | .15 | .32 | .22 | .36 | .44 |
| Playful | .13 | .26 | .25 | -.09 | .36 | .28 |
| Proportion of variance | .09 | .08 | .08 | .05 | .05 |  |

*Note.* Factors were extracted using method of minimum residuals and rotated using the varimax procedure.

*N* = 806. Loadings greater than or equal to |.4| are shown in boldface.

a Factor has been reflected. Con = Conscientiousness, Opn/Dom = Openness/Dominance, Neu = Neuroticism, ExSk = Excitement-seeking, *h*2 = item communalities.

These five factors from self-report data differed from those from rater report data. Targeted orthogonal Procrustes rotation (McCrae et al., 1996) was therefore used to test whether the self-report structure was a rotational variant of the rater report structure. The results of rotating factors based on self-reports towards those based on rater reports are shown in Table 4. The overall similarity was fair; the similarities between the Openness factors and the Extraversion and Excitement-Seeking factors were also fair; the similarities between the Agreeableness, Conscientiousness, and Neuroticism factors were good. Finally, only four items—*conventional*, *manipulative*, *imitative*, and *autistic*—had congruences below .85.

Because the factor structure from self-report data was close to that derived from rater report data, for further analyses, unit-weighted scores representing the five HPQ factors were based on the rater report structure. To create these scores, items with the largest absolute salient loadings on a factor were multiplied by +1 if the loading was positive or -1 if the loading was negative, and then the products were summed. Unit-weighting was used because they generalize more to different samples and are usually highly correlated with factor scores computed using different methods (Gorsuch, 1983).

**Table 4**

*Standardized Loadings from an Exploratory Factor Analysis of Hominoid Personality Questionnaire Self-Reports Rotated Towards Standardized Loadings from an Exploratory Factor Analysis of Hominoid Personality Questionnaire Rater Reports*

| Item | Factor | Congruence |
| --- | --- | --- |
|  | Opn | Agra | Cona | Neu | Exta |  |
| Inventive | **.497** | .172 | -.084 | -.071 | -.021 | .943 |
| Innovative | **.586** | .030 | -.146 | -.046 | -.209 | .984 |
| Conventional | -.321 | -.149 | -.059 | .112 | .365 | .822 |
| Inquisitive | **.644** | -.007 | -.058 | .175 | -.090 | .959 |
| Impulsive | **.406** | .255 | .333 | .240 | -.193 | .978 |
| Individualistic | **.569** | .262 | -.104 | .009 | .091 | .993 |
| Independent | **.505** | .072 | -.226 | -.143 | -.001 | .920 |
| Playful | **.403** | .040 | -.103 | -.076 | -.317 | .997 |
| Protective | .387 | -.212 | -.181 | .279 | -.118 | .994 |
| Affectionate | .365 | -.323 | -.126 | .371 | -.238 | .986 |
| Active | .339 | .090 | -.260 | -.075 | -.273 | .988 |
| Predictable | -.208 | -.184 | -.218 | -.027 | .347 | .864 |
| Curious | **.437** | .054 | .026 | .278 | .018 | .873 |
| Gentle | .151 | **-.565** | -.076 | .187 | .050 | .975 |
| Dominant | **.424** | **.408** | -.194 | -.030 | .023 | .861 |
| Manipulative | .249 | **.445** | -.014 | .000 | .177 | .815 |
| Aggressive | .152 | **.592** | .064 | .044 | .043 | .986 |
| Bullying | .182 | **.519** | .085 | -.036 | .136 | .915 |
| Irritable | -.040 | **.424** | .166 | .342 | .249 | .987 |
| Jealous | .059 | .259 | .178 | .317 | .163 | .939 |
| Defiant | .313 | **.400** | -.045 | -.101 | .039 | .945 |
| Helpful | .338 | **-.506** | -.195 | .149 | -.096 | .965 |
| Stingy/greedy | .019 | .358 | .156 | .146 | .279 | .940 |
| Sympathetic | .297 | **-.437** | -.163 | .359 | -.160 | .977 |
| Submissive | -.141 | -.267 | .331 | .263 | .207 | .958 |
| Decisive | .228 | .077 | **-.511** | -.092 | -.001 | .967 |
| Disorganized | .224 | .009 | **.657** | .048 | .161 | .916 |
| Lazy | -.010 | -.004 | **.444** | .169 | **.419** | .915 |
| Distractible | .251 | .082 | **.542** | .132 | .004 | .971 |
| Quitting | -.010 | .014 | **.487** | .095 | .162 | .960 |
| Reckless | .355 | .357 | .387 | -.104 | -.070 | .942 |
| Thoughtless | .116 | .126 | **.513** | .007 | .058 | .940 |
| Dependent/follower | -.221 | -.215 | .352 | .378 | .204 | .919 |
| Clumsy | .061 | -.027 | **.456** | .192 | .162 | .989 |
| Erratic | .224 | .338 | **.463** | .295 | .056 | .978 |
| Imitative | -.009 | .013 | .337 | .221 | .214 | .734 |
| Unperceptive | -.146 | .213 | .310 | -.047 | .239 | .969 |
| Intelligent | **.442** | -.056 | -.310 | .092 | .019 | .912 |
| Persistent | .327 | .273 | -.262 | -.005 | .031 | .950 |
| Vulnerable | -.099 | -.064 | .185 | **.509** | .060 | .982 |
| Fearful | -.111 | .059 | .186 | **.519** | .118 | .984 |
| Anxious | -.075 | .121 | .307 | **.556** | .243 | .958 |
| Cool | .255 | -.104 | -.034 | **-.531** | .325 | .894 |
| Unemotional | -.052 | .061 | .086 | **-.420** | **.439** | .913 |
| Stable | .257 | -.301 | -.157 | **-.469** | .084 | .963 |
| Excitable | .301 | .127 | .160 | **.522** | -.178 | .962 |
| Sensitive | .263 | -.252 | -.202 | .263 | -.024 | .934 |
| Cautious | -.074 | -.220 | -.273 | .238 | .271 | .968 |
| Solitary | .025 | .100 | .026 | .066 | **.519** | .955 |
| Sociable | **.428** | -.142 | -.050 | .139 | **-.419** | .910 |
| Depressed | -.105 | .173 | .230 | .210 | **.423** | .952 |
| Timid | -.263 | -.127 | .304 | .316 | **.405** | .981 |
| Friendly | .369 | -.376 | -.107 | .126 | -.270 | .935 |
| Autistic | .056 | .077 | .253 | .162 | .140 | .488 |
| Congruence | .917 | .957 | .963 | .958 | .873 | .935 |

*Note.* a For consistency, the name of the factor when reflected has been applied. Opn = Openness, Agr = Agreeableness, Con = Conscientiousness, Neu = Neuroticism, Ext = Extraversion.

***Sensitivity Analyses***

Because missing HPQ data were rare, substituting the midpoint of the scale was not likely to have affected the results of the exploratory factor analyses (Xiao et al., 2019). To test this, sensitivity analyses were conducted. In these analyses, pairwise deletion was used to handle missingness. The results of these analyses did not differ from those obtained when midpoint substitution was used (see Supplementary Report).

**Interrater Reliabilities of Hominoid Personality Questionnaire and NEO-PI-R Factors**

Interrater reliabilities were computed for pairs of Dataset 2 participants who rated themselves using HPQ and/or the NEO-PI-R and the other member of the pair using rater report versions of these instruments. These interrater reliability estimates were lower than those reported in the NEO-PI-R *Manual* (Costa & McCrae, 1992), and the interrater reliabilities of Neuroticism were effectively zero. However, the interrater reliabilities for the HPQ and NEO-PI-R factors were comparable (see Table 5).

**Table 5**

*Interrater Reliabilities of Unit-Weighted HPQ and NEO-PI-R Factors*

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | *ICC*(1,1) |  | *ICC*(1,*k*) |
|  | HPQ | NEO-PI-R |  | HPQ | NEO-PI-R |
| Openness | .30 | .37 |  | .46 | .54 |
| Agreeableness | .30 | .28 |  | .46 | .43 |
| Conscientiousness | .34 | .28 |  | .51 | .44 |
| Neuroticism | -.24 | -.21 |  | -.62 | -.53 |
| Extraversion | .29 | .35 |  | .45 | .52 |

*Note*. 61 pairs of participants completed the HPQ and 71 pairs of participants completed the NEO-PI-R.

*ICC* = Intraclass correlation coefficient.

**Convergent and Discriminant Validity of the HPQ Factors**

***Correlations of HPQ Factors with NEO-PI-R, NEO-FFI, and BFI Factors***

The correlations between factors from the HPQ and the NEO-PI-R, NEO-FFI, and BFI and their weighted averages are shown in Table 6. Overall, these correlations were consistent with what one would expect if the HPQ measured the Big Five, that is, there was evidence for convergent and discriminant validity (Campbell & Fiske, 1959). Moreover, the weighted averages indicated that for HPQ Neuroticism, Extraversion, Agreeableness, and Conscientiousness, the correlation with the same factor was markedly higher than their correlations with different factors. On the other hand, HPQ Openness showed good evidence of convergent validity, but evidence for discriminant validity was poor. Its correlation with Extraversion was higher than its correlation with Openness. To a lesser extent, the same was true for HPQ Extraversion: it had high convergent validity and poor discriminant validity, although it was more highly correlated with Extraversion than with Openness.

**Table 6**

*Pearson Correlations Between Hominoid Personality Questionnaire Factors and Factors from the NEO-PI-R, NEO-FFI, and BFI*

| Scale | HPQ Factor |
| --- | --- |
|  | Neu | Ext | Opn | Agr | Con |
| Rater Report NEO-PI-R (*N* = 60) |  |  |  |  |  |
| Neuroticism | **.60** | -.22 | -.19 | -.31 | -.28 |
| Extraversion | .00 | **.58** | **.56** | .08 | .34 |
| Openness to Experience | .16 | .28 | **.61** | .29 | .24 |
| Agreeableness | .01 | .04 | -.02 | **.70** | .30 |
| Conscientiousness | .13 | -.08 | .19 | .23 | **.74** |
| Self-Report NEO-PI-R (*N* = 190) |  |  |  |  |  |
| Neuroticism | **.62** | **-.44** | **-.21** | -.19 | **-.46** |
| Extraversion | -.04 | **.68** | **.56** | -.07 | **.22** |
| Openness to Experience | .14 | .18 | **.52** | .03 | .02 |
| Agreeableness | .15 | .10 | **-.26** | **.75** | .15 |
| Conscientiousness | -.05 | .20 | .14 | .15 | **.72** |
| Self-Report NEO-FFI (*N* = 455) |  |  |  |  |  |
| Neuroticism | **.55** | **-.35** | -.12 | -.12 | **-.41** |
| Extraversion | -.03 | **.68** | **.54** | .12 | **.18** |
| Openness to Experience | .10 | -.02 | **.33** | .00 | -.10 |
| Agreeableness | .04 | **.23** | -.08 | **.62** | **.19** |
| Conscientiousness | -.11 | **.18** | .08 | .11 | **.62** |
| Self-Report BFI (*N* = 158) |  |  |  |  |  |
| Neuroticism | **.60** | **-.39** | -.15 | -.21 | **-.32** |
| Extraversion | -.11 | **.61** | **.37** | .02 | .22 |
| Openness | .01 | .04 | **.41** | -.09 | -.16 |
| Agreeableness | .05 | .20 | .10 | **.48** | .17 |
| Conscientiousness | .01 | .05 | .05 | .22 | **.65** |
| Weighted Averages |  |  |  |  |  |
| Neuroticism | .58 | -.37 | -.15 | -.17 | -.39 |
| Extraversion | -.05 | .66 | .51 | .05 | .21 |
| Openness | .10 | .06 | .40 | .01 | -.06 |
| Agreeableness | .07 | .18 | -.08 | .63 | .19 |
| Conscientiousness | -.06 | .14 | .10 | .15 | .65 |

*Note*. The form (rater or self-report) of the Hominoid Personality Questionnaire used was the same as that of the other inventory.

Neu = Neuroticism, Ext = Extraversion, Opn = Openness, Agr = Agreeableness, Con = Conscientiousness.

For the top four panels, correlations in bold are significant at *p* < .05 after a Holm-Bonferroni adjustment for multiple tests.

The cross-method/cross-instrument validity correlations were lower than the interrater reliabilities and cross-instrument validity correlations (see Table 7). The pattern of correlations, however, was similar: Extraversion, Agreeableness, and Conscientiousness showed evidence of convergent and discriminant validity and Openness showed evidence for convergent, but not discriminant validity. The correlation for Neuroticism was, like its interrater reliability, negative, suggesting that its cross-method/cross-instrument convergent validity was poor.

**Table 7**

*Cross-Method Cross-Instrument Correlations*

| NEO-PI-R Rater Report | HPQ Self-Report |
| --- | --- |
|  | Neu | Ext | Opn | Agr | Con |
| Neuroticism | -.18 | -.08 | .07 | -.09 | -.05 |
| Extraversion | -.03 | **.41** | .16 | -.05 | .13 |
| Openness to Experience | .08 | .28 | .34 | .05 | .07 |
| Agreeableness | -.13 | .08 | .20 | .10 | .09 |
| Conscientiousness | -.04 | .15 | .09 | .06 | .24 |
|  |  |  |  |  |  |
| NEO-PI-R Self-Reports |  HPQ Rater Report |
| Neuroticism | **-.41** | -.11 | -.02 | .01 | -.16 |
| Extraversion | -.07 | .18 | .22 | .20 | -.07 |
| Openness to Experience | -.17 | .17 | .06 | -.01 | .01 |
| Agreeableness | .07 | .11 | .18 | .30 | .01 |
| Conscientiousness | -.17 | .08 | -.01 | .15 | .21 |
|  |  |  |  |  |  |
| Factor | Weighted Averages |
| Neuroticism | -.29 | -.10 | .02 | -.04 | -.10 |
| Extraversion | -.05 | .30 | .19 | .07 | .03 |
| Openness | -.05 | .23 | .20 | .02 | .04 |
| Agreeableness | -.03 | .10 | .19 | .20 | .05 |
| Conscientiousness | -.11 | .12 | .04 | .11 | .22 |

*Note*. *N* = 59.

Neu = Neuroticism, Ext = Extraversion, Opn = Openness, Agr = Agreeableness, Con = Conscientiousness.

For the top two panels, correlations in bold are significant at *p* < .05 after a Holm-Bonferroni adjustment for multiple tests.

***Correlations with NEO-PI-R Facets***

The pattern of correlations between the HPQ factors and the NEO-PI-R facets (see Table 8) is consistent with the pattern of results from correlations between factors. The NEO-PI-R’s six Agreeableness and six Conscientiousness facets were most strongly correlated with HPQ Agreeableness and Conscientiousness, respectively. For Neuroticism, the weighted average was greater than |.4| in four cases (N1: Anxiety, N3: Depression, N4: Self-Consciousness, and N6: Vulnerability), but there was only evidence of discriminant validity for N1: Anxiety and N4: Self-Consciousness. For Extraversion, the weighted average was also greater than |.4| in four cases (E1: Warmth, E2: Gregariousness, E3: Assertiveness, and E6: Positive Emotions), but there was only evidence of discriminant validity for E1: Warmth, E2: Gregariousness, and possibly E6: Positive Emotions. For Openness, the weighted average was greater than |.4| in O4: Actions and O5: Ideas.

**Table 8**

*Pearson Correlations Between the Hominoid Personality Questionnaire Factors and the Revised NEO Personality Inventory Facets*

| Facet | Rater Reports (*N* = 60) |  | Self-Reports (*N* = 190) |  | Weighted Averages |
| --- | --- | --- | --- | --- | --- |
|  | Neu | Ext | Opn | Agr | Con |  | Neu | Ext | Opn | Agr | Con |  | Neu | Ext | Opn | Agr | Con |
| N1: Anxiety | **.61** | -.14 | -.12 | -.11 | .02 |  | **.57** | **-.35** | -.26 | .07 | -.21 |  | **.58** | -.30 | -.22 | .02 | -.16 |
| N2: Angry hostility | **.48** | -.03 | -.12 | **-.53** | -.12 |  | .32 | -.17 | .15 | **-.54** | -.19 |  | .35 | -.14 | .08 | **-.54** | -.18 |
| N3: Depression | **.41** | **-.43** | -.19 | -.08 | -.19 |  | **.48** | **-.46** | -.21 | -.03 | **-.45** |  | **.46** | **-.45** | -.20 | -.04 | -.39 |
| N4: Self-consciousness | **.42** | -.32 | -.17 | -.02 | -.09 |  | **.41** | **-.40** | -.29 | .03 | -.28 |  | **.41** | -.38 | -.26 | .02 | -.24 |
| N5: Impulsiveness | .19 | .18 | .04 | -.27 | **-.42** |  | .29 | -.01 | -.04 | -.28 | -.29 |  | .27 | .04 | -.02 | -.28 | -.32 |
| N6: Vulnerability | .37 | -.10 | -.19 | -.28 | **-.41** |  | **.47** | -.36 | -.25 | -.01 | **-.47** |  | **.44** | -.30 | -.23 | -.08 | **-.45** |
| E1: Warmth | .16 | **.57** | .24 | .33 | **.44** |  | .11 | **.58** | .32 | .22 | .19 |  | .12 | **.58** | .30 | .25 | .25 |
| E2: Gregariousness | .12 | **.50** | .23 | .07 | .06 |  | .09 | **.56** | .20 | .11 | .02 |  | .10 | **.55** | .21 | .10 | .03 |
| E3: Assertiveness | .03 | .29 | .35 | -.32 | .27 |  | -.17 | **.49** | **.50** | -.28 | .30 |  | -.13 | **.44** | **.46** | -.29 | .30 |
| E4: Activity | -.02 | .27 | **.70** | -.10 | **.43** |  | -.02 | .32 | **.49** | -.12 | .35 |  | -.02 | .31 | **.54** | -.12 | .37 |
| E5: Excitement-seeking | -.37 | .34 | .35 | -.05 | -.05 |  | -.18 | .23 | .36 | -.28 | -.12 |  | -.23 | .26 | .36 | -.22 | -.10 |
| E6: Positive emotions | .07 | **.42** | **.44** | .39 | .24 |  | .02 | **.58** | **.44** | .10 | .16 |  | .03 | **.55** | **.44** | .17 | .18 |
| O1: Fantasy | .09 | .21 | **.45** | -.08 | -.22 |  | .06 | .00 | .30 | -.15 | -.16 |  | .07 | .05 | .34 | -.14 | -.18 |
| O2: Aesthetics | .19 | .28 | .38 | .22 | .27 |  | .18 | .12 | .30 | .12 | -.03 |  | .18 | .15 | .32 | .15 | .04 |
| O3: Feelings | **.45** | .14 | .36 | .16 | .22 |  | **.50** | .21 | .29 | .03 | .11 |  | **.48** | .20 | .31 | .06 | .14 |
| O4: Actions | .06 | .30 | **.58** | .19 | .27 |  | .00 | .19 | .35 | .09 | .00 |  | .02 | .22 | **.40** | .11 | .06 |
| O5: Ideas | -.05 | .14 | **.42** | .31 | .30 |  | -.13 | .10 | **.50** | -.03 | .13 |  | -.11 | .11 | **.48** | .05 | .17 |
| O6: Values | -.17 | -.11 | -.03 | .34 | .05 |  | -.03 | .12 | .18 | .11 | .04 |  | -.06 | .07 | .13 | .16 | .04 |
| A1: Trust | .01 | .21 | .21 | **.45** | .25 |  | .04 | .24 | .00 | **.51** | .22 |  | .03 | .23 | .05 | **.50** | .23 |
| A2: Straightforwardness | .01 | -.11 | -.21 | **.56** | .19 |  | .13 | -.06 | -.27 | **.61** | .09 |  | .10 | -.07 | -.25 | **.60** | .11 |
| A3: Altruism | .15 | .23 | .10 | **.65** | **.44** |  | .10 | .36 | .03 | **.53** | .32 |  | .11 | .33 | .05 | **.56** | .35 |
| A4: Compliance | -.26 | -.01 | -.14 | **.54** | .24 |  | .10 | -.01 | -.37 | **.65** | .02 |  | .01 | -.01 | -.31 | **.62** | .08 |
| A5: Modesty | .08 | -.21 | -.03 | **.44** | .08 |  | .14 | -.12 | -.33 | **.48** | -.03 |  | .13 | -.14 | -.26 | **.47** | -.01 |
| A6: Tendermindedness | .14 | .12 | .01 | **.56** | .22 |  | .17 | .09 | -.13 | **.44** | .10 |  | .16 | .09 | -.09 | **.47** | .13 |
| C1: Competence | .13 | .07 | .34 | .15 | **.68** |  | -.15 | .27 | .37 | .00 | **.55** |  | -.08 | .23 | .36 | .04 | **.58** |
| C2: Order | .19 | -.13 | .22 | .07 | **.53** |  | .04 | .11 | .00 | .07 | **.54** |  | .08 | .05 | .05 | .07 | **.54** |
| C3: Dutifulness | .04 | -.15 | .14 | .31 | **.62** |  | -.07 | .16 | .00 | .29 | **.57** |  | -.04 | .09 | .04 | .29 | **.58** |
| C4: Achievement striving | .09 | -.08 | .24 | .13 | **.60** |  | .05 | .27 | .31 | -.04 | **.56** |  | .06 | .19 | .29 | .00 | **.57** |
| C5: Self-discipline | .12 | -.03 | .17 | .24 | **.75** |  | -.12 | .26 | .13 | .18 | **.72** |  | -.06 | .19 | .14 | .19 | **.73** |
| C6: Deliberation | .07 | -.03 | -.13 | .26 | **.57** |  | .00 | -.14 | -.16 | .20 | .36 |  | .01 | -.11 | -.15 | .21 | **.41** |

*Note*. Correlations greater than |.4| are in boldface.

Neu = Neuroticism, Ext = Extraversion, Opn = Openness, Agr = Agreeableness, Con = Conscientiousness.

**Great Ape Dominance Factors and the Five-Factor Model**

***Chimpanzee Dominance***

The difference between the fit of Model 8, which included the intercept, Fearless Dominance, Emotional Stability, and Assertiveness (the global model), and Model 1, which only included the intercept (the null model), was significant, χ2(3) = 103.280, *p* < .001. Model parameter estimates, weighted AICs, and AIC-weighted parameter estimates for the seven models that tested whether chimpanzee Dominance manifested as Fearless Dominance, Emotional Stability, and/or Assertiveness are presented in Table 9. The strongest support was for Model 2, which only included the intercept and Fearless Dominance. Support was not overwhelming, however, as Model 2’s AIC weight was not greater than or equal to 0.9. There was also support for the three other models that included Fearless Dominance. In order, from highest to lowest support, these models were the global model, Model 6 (Fearless Dominance and Emotional Stability), and Model 5 (Fearless Dominance and Assertiveness). The normalized probability that one should choose one of these more complex models over Model 2 (the simpler model) is equal to the ratio of the weight of the more complex model to the sum of the weights of the more complex model and the simpler model). Thus, the probability that one should choose one of these more complicated models over the simpler one ranged from 0.20 to 0.39. The AIC-weighted parameter estimates indicated that only the confidence interval for the association between Fearless Dominance and scores based on chimpanzee Dominance did not include zero.

**Table 9**

*Model Selection Results for Scores Based on the Chimpanzee Dominance Factor*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | βFD | βE3 | βES | *df* | log likelihood | AIC | Δ*i* | *wi* |
| 2 | 0.737 |  |  | 3 | -194.573 | 395.147 | 0.000 | 0.434 |
| 5 | 0.736 | -0.051 |  | 4 | -194.020 | 396.040 | 0.893 | 0.278 |
| 6 | 0.759 |  | -0.033 | 4 | -194.443 | 396.886 | 1.739 | 0.182 |
| 8 | 0.748 | -0.048 | -0.019 | 5 | -193.980 | 397.959 | 2.813 | 0.106 |
| 7 |  | -0.144 | 0.483 | 4 | -243.974 | 495.948 | 100.802 | 0.000 |
| 4 |  |  | 0.461 | 3 | -246.438 | 498.876 | 103.729 | 0.000 |
| 1 |  |  |  | 2 | -269.097 | 542.194 | 147.047 | 0.000 |
| 3 |  | -0.069 |  | 3 | -268.640 | 543.281 | 148.134 | 0.000 |
| βMAP  | 0.742 | -0.019 | -0.008 |  |  |  |  |  |
| *L*95% CI | 0.633 | -0.097 | -0.082 |  |  |  |  |  |
| *U*95% CI | 0.851 | 0.058 | 0.066 |  |  |  |  |  |

*Note*. *N* = 190. Models ordered from best to worst balance of fit and parsimony. Intercepts are all 0 and so are not shown. Model 1 is the null model.

βFD = standardized parameter estimates for Fearless Dominance; βE3 = standardized parameter estimates for Assertiveness; βES = standardized parameter estimates for Emotional Stability; βMAP = model averaged parameter estimates; *L*95% CI = Lower bound of the 95% confidence interval; *U*95% CI = Upper bound of the 95% confidence interval; AIC = Akaike’s Information Criterion; Δ*i* = difference in Akaike Information Criterion between the *i*th model and the best model (lowest AIC); *wi* = model weight.

***Bonobo Assertiveness***

The difference between the fit of the global and null model was significant, χ2(3) = 114.470, *p* < .001. Model parameter estimates, weighted AICs, and AIC-weighted parameter estimates for the seven models that tested whether bonobo Assertiveness manifested as Fearless Dominance, Emotional Stability, or Assertiveness are presented in Table 10. Model 6, which included Fearless Dominance and Emotional Stability, was the most strongly supported of the models, but support for this model was not overwhelming, and Model 8 was also supported. The normalized probability that one should choose the more complex model was 0.27. The AIC-weighted parameter estimates indicated that confidence intervals for associations between scores based on bonobo Assertiveness and both Fearless Dominance and Emotional Stability did not include zero.

**Table 10**

*Model Selection Results for Scores Based on the Bonobo Assertiveness Factor*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | βFD | βE3 | βES | *df* | log Likelihood | AIC | Δ*i* | *wi* |
| 6 | 0.522 |  | 0.330 | 4 | -180.724 | 369.448 | 0.000 | 0.726 |
| 8 | 0.525 | 0.010 | 0.327 | 5 | -180.699 | 371.398 | 1.950 | 0.274 |
| 2 | 0.737 |  |  | 3 | -194.728 | 395.456 | 26.008 | 0.000 |
| 5 | 0.738 | 0.066 |  | 4 | -193.819 | 395.639 | 26.191 | 0.000 |
| 4 |  |  | 0.669 | 3 | -212.623 | 431.246 | 61.798 | 0.000 |
| 7 |  | -0.056 | 0.678 | 4 | -212.086 | 432.173 | 62.724 | 0.000 |
| 1 |  |  |  | 2 | -269.097 | 542.194 | 172.746 | 0.000 |
| 3 |  | 0.048 |  | 3 | -268.876 | 543.753 | 174.304 | 0.000 |
| βMAP  | 0.523 | 0.003 | 0.329 |  |  |  |  |  |
| *L*95% CI | 0.403 | -0.047 | 0.208 |  |  |  |  |  |
| *U*95% CI | 0.643 | 0.053 | 0.449 |  |  |  |  |  |

*Note*. *N* = 190. Models ordered from best to worst balance of fit and parsimony. Intercepts are all 0 and so are not shown. Model 1 is the null model.

βFD = standardized parameter estimates for Fearless Dominance; βE3 = standardized parameter estimates for Assertiveness; βES = standardized parameter estimates for Emotional Stability; βMAP = model averaged parameter estimates; *L*95% CI = Lower bound of the 95% confidence interval; *U*95% CI = Upper bound of the 95% confidence interval; AIC = Akaike’s Information Criterion; Δ*i* = difference in Akaike Information Criterion between the *i*th model and the best model (lowest AIC); *wi* = model weight.

***Mountain Gorilla Dominance***

The difference between the fit of the global and null model was significant, χ2(3) = 94.453, *p* < .001.Modelparameter estimates and weighted AICs for the seven models that tested whether mountain gorilla Dominance manifested as Fearless Dominance, Emotional Stability, or Assertiveness are presented in Table 11. There was overwhelming support for the global model and little or no support for the other models. Fearless Dominance, Assertiveness, and Emotional Stability all had associations with scores based on mountain gorilla Dominance. Confidence intervals for these parameter estimates did not include zero.

**Table 11**

*Model Selection Results for Scores Based on the Mountain Gorilla Dominance Factor*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | βFD | βE3 | βES | *df* | log Likelihood | AIC | Δ*i* | *wi* |
| 8 | 0.534 | 0.174 | 0.199 | 5 | -203.295 | 416.590 | 0.000 | 0.942 |
| 5 | 0.665 | 0.207 |  | 4 | -207.337 | 422.675 | 6.085 | 0.045 |
| 6 | 0.497 |  | 0.250 | 4 | -208.575 | 425.150 | 8.560 | 0.013 |
| 2 | 0.660 |  |  | 3 | -214.857 | 435.715 | 19.125 | 0.000 |
| 7 |  | 0.105 | 0.557 | 4 | -229.661 | 467.323 | 50.733 | 0.000 |
| 4 |  |  | 0.573 | 3 | -231.210 | 468.420 | 51.830 | 0.000 |
| 3 |  | 0.191 |  | 3 | -265.552 | 537.103 | 120.513 | 0.000 |
| 1 |  |  |  | 2 | -269.097 | 542.194 | 125.604 | 0.000 |
| 95% CI (β8) | βFD | βE3 | βES |  |  |  |  |  |
| 2.5% | 0.398 | 0.069 | 0.062 |  |  |  |  |  |
| 97.5% | 0.670 | 0.278 | 0.337 |  |  |  |  |  |

*Note*. *N* = 190. Models ordered from best to worst balance of fit and parsimony. Intercepts are all 0 and so are not shown. Model 1 is the null model.

βFD = standardized parameter estimates for Fearless Dominance; βE3 = standardized parameter estimates for Assertiveness; βES = standardized parameter estimates for Emotional Stability; 95% CI (β8) = upper and lower bound of 95% confidence interval for parameter estimates from Model 8, which overwhelmingly had the best fit; AIC = Akaike’s Information Criterion; Δi = difference in Akaike Information Criterion between the *i*th model and the best model (lowest AIC); *wi* = model weight.

***Orangutan Dominance***

The difference between the fit of the global and null model was significant, χ2(3) = 85.387, *p* < .001.Modelparameter estimates and weighted AICs for the seven models that tested whether orangutan Dominance manifested as Fearless Dominance, Emotional Stability, or Assertiveness are presented in Table 12. There was overwhelming support for the global model and no support for any of the other models. Fearless Dominance, Assertiveness, and Emotional Stability all had associations with scores based on orangutan Dominance. The confidence intervals for these parameter estimates did not include zero. However, unlike mountain gorilla Dominance, orangutan Dominance was characterized by lower Emotional Stability and lower Assertiveness.

**Table 12**

*Model Selection Results for Scores Based on the Orangutan Dominance Factor*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | βFD | βE3 | βES | *df* | log Likelihood | AIC | Δ*i* | *wi* |
| 8 | 0.737 | -0.278 | -0.547 | 5 | -211.994 | 433.988 | 0.000 | 1.000 |
| 6 | 0.797 |  | -0.629 | 4 | -223.938 | 455.876 | 21.888 | 0.000 |
| 5 | 0.379 |  | -0.371 | 4 | -236.844 | 481.687 | 47.699 | 0.000 |
| 2 | 0.388 |  |  | 3 | -253.636 | 513.271 | 79.283 | 0.000 |
| 3 |  | -0.380 |  | 3 | -254.257 | 514.513 | 80.525 | 0.000 |
| 7 |  | -0.372 | -0.053 | 4 | -253.949 | 515.898 | 81.910 | 0.000 |
| 4 |  |  | -0.111 | 3 | -267.927 | 541.855 | 107.867 | 0.000 |
| 1 |  |  |  | 2 | -269.097 | 542.194 | 108.206 | 0.000 |
| 95% CI (β8) |  |  |  |  |  |
| 2.5% | 0.594 | -0.388 | -0.692 |  |  |  |  |  |
| 97.5% | 0.880 | -0.168 | -0.402 |  |  |  |  |  |

*Note*. *N* = 190. Models ordered from best to worst balance of fit and parsimony. Intercepts are all 0 and so are not shown. Model 1 is the null model.

βFD = standardized parameter estimates for Fearless Dominance; βE3 = standardized parameter estimates for Assertiveness; βES = standardized parameter estimates for Emotional Stability; 95% CI (β8) = upper and lower bound of 95% confidence interval for parameter estimates from Model 8, which overwhelmingly had the best fit; AIC = Akaike’s Information Criterion; Δ*i* = difference in Akaike Information Criterion between the *i*th model and the best model (lowest AIC); *wi* = model weight.

**Discussion**

Exploratory factor analysis of rater report HPQ data in which humans were targets yielded five factors that resembled the Big Five. Exploratory factor analyses of HPQ self-report data yielded five rotational variants of the five rater report factors. Correlations between the HPQ factors and NEO-PI-R factors and facets and the BFI factors were mostly consistent with their definitions. Follow-up analyses showed that Fearless Dominance resembled dominance factors found in chimpanzees, bonobos, mountain gorillas, and orangutans.

These findings suggest that it is unlikely that the dominance factors found in great apes and other primates are artifacts resulting from how questionnaires were written. Instead, these findings suggest that, perhaps as a consequence of humans having evolved in small-scale egalitarian societies (Boehm, 1999; von Rueden, 2020), the dominance factors found in our great ape cousins dissipated during hominid evolution, and are found among the Five-Factor Model’s facets in the form of Fearless Dominance (Benning et al., 2003; Lilienfeld & Andrews, 1996). Findings from other studies are also consistent with this explanation. For one, among closely related species, socioecological features, such as despotism and competitiveness, are associated with the personality structure of certain traits (Adams et al., 2015; Masilkova et al., 2020; Wilson et al., 2018). Two notable differences between great ape dominance factors are also consistent with this explanation. The first difference is between the narrow Dominance factor found in orangutans (Weiss et al., 2006) and the broad dominance factors found in African great apes (Eckardt et al., 2015; King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007; Weiss et al., 2015). This may reflect orangutans’ semi-solitary nature (Galdikas, 1985a, 1985b, 1985c). The second difference is between chimpanzee Dominance (King & Figueredo, 1997; Weiss et al., 2009; Weiss et al., 2007) and bonobo Assertiveness (Weiss et al., 2015). Specifically, chimpanzee Dominance is primarily characterized by high dominance and independence, and low submissiveness and dependence, whereas bonobo Assertiveness is primarily characterized by low anxiety, timidity, and fearfulness, and high independence. This difference may reflect the contrast between chimpanzees who evolved in aggressive (Wilson & Wrangham, 2003), strongly hierarchical (Goodall, 1986) societies and bonobos who evolved in more peaceful (Wilson et al., 2014), more egalitarian (Furuichi, 2011) societies.

Some of the present study’s findings were not consistent with the possibility that the absence of a human dominance factor is a product of our species’ egalitarian past. First, unlike rater report data, self-report data did not reveal the canonical human five-factor structure. In fact, one analysis of self-report data identified a factor that combined aspects of Dominance and Openness. This finding, however, may be attributable to the fact that the HPQ includes items such as *dominant*, *bullying*, and *manipulative*. The HPQ may therefore not have been ideal for obtaining self-reports because responses to these sorts of items may have been positively or negatively biased, and this may have led to the emergence of that factor. This explanation is consistent with findings from studies by Biesanz and West (2004) and by Riemann and Kandler (2010). Their studies found that higher-order phenotypic or genetic factors, respectively, that purportedly underlie the human Big Five, do not appear in multitrait-multimethod data (Campbell & Fiske, 1959). This possibility is also consistent with the finding that rephrasing personality items so that they are neutral eliminates general factors related to socially desirable responding (Bäckström et al., 2009). These findings, and those from the present, suggest that if the HPQ is to be used as a human self-report instrument, it should be revised again so that its items are less affected by social desirability bias. More generally, these findings point to the need for caution when developing self-report measures of dominance (e.g., Suessenbach et al., 2019).

In addition to addressing research questions pertaining to dominance, the present study yielded findings that address the question of whether impulsiveness is a marker of high Neuroticism (e.g., Costa & McCrae, 1995; McCrae & Costa, 1985), low Conscientiousness (e.g., Roberts et al., 2005), or both (e.g., Digman & Inouye, 1986). The item *impulsive* was one that King and Figueredo (1997) sampled from Goldberg (1990), where it was a marker of Surgency (Extraversion). The descriptor sentences for *impulsive*, which were not changed for this study, suggest that it should be related to Neuroticism: “Subject often displays some spontaneous or sudden behavior that could not have been anticipated. There often seems to be some emotional reason behind the sudden behavior”. Nevertheless, in rater report data, *impulsive* had a positive, salient loading on Openness and in self-report data it had a positive loading on both Dominance/Openness and Excitement-seeking, and a negative loading on Conscientiousness (the latter three loadings were not salient). Moreover, although the NEO-PI-R’s N5: Impulsiveness facet was most strongly associated with low HPQ Conscientiousness in rater report data, in self-report data it was associated equally with high Neuroticism, low Agreeableness, and low Conscientiousness. Together, these findings suggest that where impulsivity loads may depend on item wording, the presence and wording of other traits, whether self- or rater reports are used, and possible interactions between these characteristics of questionnaires.

Some of the present findings also highlighted limitations of the HPQ as a measure of the Five-Factor Model. First, compared to the other factors, the content coverage of Openness was low (it only correlated with two of the NEO-PI-R’s Openness to Experience facets). This contrasts with the other HPQ factors, and especially Agreeableness and Conscientiousness. Second, the discriminant validities of Openness and Extraversion were poor. This also contrasts with the other factors, which had excellent convergent and discriminant validities. These findings, and especially those related to the discriminant validities of Extraversion and Openness, may mean that these factors are related to a higher-order factor, such as one related to superiority striving, agency, achieving, status, and power motivation (Digman, 1997). The more likely possibility, however, is that this finding reflects the fact that, because the HPQ was developed to assess personality in primates, its Openness items often refer to social situations. For example, the descriptor sentence for *inventive* reads “Subject is more likely than others to do new things, including novel *social* or non-social behaviors.” (emphasis added). Although the HPQ’s Openness items may not be ideal for rating humans, they appear to work well in nonhuman primates. This is even true in brown capuchin monkeys *Sapajus apella* (Morton, Lee, Buchanan-Smith, et al., 2013), which share only a distant common ancestor with great apes and humans (Purvis, 1995), but where one nevertheless would expect to find Openness given that this species, like humans and chimpanzees, uses tools (Ottoni & Izar, 2008). That said, these findings related to Openness should be borne in mind when interpreting results from nonhuman primates.

One limitation of this study was highlighted by low interrater reliabilities, including a negative (essentially zero) interrater reliability for HPQ and NEO-PI-R Neuroticism. This finding suggests possible problems with the quality of ratings. For instance, the pair members may not have known one another well enough, as would, for example, spouses or parent-offspring pairs (cf. Costa & McCrae, 1992; Vazire, 2010). It may also reflect the fact that, for the most part, convenience samples were used. If either problem affected data quality, then these problems may have also affected the personality structures obtained in these data (cf. McCrae et al., 2005).

A second limitation was that this study did not test whether human dominance is represented by one of the axes of the interpersonal circumplex (Traupman et al., 2009; Whiteman et al., 2001; Wiggins, 1979). This decision was made because a NEO-PI-R scale representing the control axis of the interpersonal circumplex (Traupman et al., 2009) was highly correlated with E3: Assertiveness, *r* = .95 (*N* = 190), and because Assertiveness was the more parsimonious explanation of the two. Studies that include the HPQ and a scale designed to measure interpersonal circumplex Dominance (e.g., the Interpersonal Adjective Scales; Wiggins, 1995), and the NEO-PI-R could lead to a better understanding of what happened during hominid evolution to the dominance factor.

There were also questions that this study could not address. Behavioral data on rank were not collected, and so it is impossible to say whether ratings related to dominance factors were based on rank, that is, whether valid cues were used to rate either humans or nonhuman primates (cf. Gosling et al., 2002). Likewise, this study did not test whether people who rate species that differ with respect to despotism versus tolerance (Thierry, 1985, 2000; Thierry et al., 2008; Thierry et al., 2004) use or respond to items in the same way (Stark et al., 2006).

It is tempting to ascribe these differences between humans and their primate cousins to evolved differences in personality. However, the present data cannot rule out the possibility that these differences reflect social or other pressures that inhibit individuals from behaving in ways that would make their ‘dominance’ apparent to others. To test hypotheses about the evolutionary origins of the absence of a dominance factor in humans, one would need to study additional species, subspecies, and populations. For example, western chimpanzees (*Pan troglodytes verus*) differ from eastern chimpanzees (*Pan troglodytes schweinfurthii*)in that western chimpanzees are less aggressive (Wilson et al., 2014). If factors related to dominance, characterized by Emotional Stability, are an adaptation for societies in which physical aggression is less often used when competing for status, one would predict that the dominance-related factor in Western chimpanzees would include aspects of Emotional Stability. An especially risky prediction, especially in light of the absence of a dominance factor among the relatively egalitarian Tsimané, a community of forager-farmers that live in the Bolivian Amazon (Gurven et al., 2013), would be that such a dominance would be found in the Yąnomamö in whose society coalitionary aggression is common and related to fitness (Chagnon, 1988).

If the differences between nonhuman primates and great apes identified in the present study are evolved differences in personality structure, then this study’s findings offer a possible evolutionary history of dominance factors. In all but one instance, the findings are consistent with a scenario in which the covariation of traits related to dominance underwent recent changes in the line that led to the great apes and humans. The most parsimonious scenario is one in which the common ancestor of great apes and humans had a factor that resembled Fearless Dominance. The earliest split led to the orangutans and the African apes. In the line that led to orangutans, the ancestral dominance factor came to include low Emotional Stability and low Assertiveness. The next split, led to mountain gorillas and to chimpanzees, bonobos, and humans. In the line that led to mountain gorillas, the ancestral dominance factor came to include high Assertiveness and high Emotional Stability. The next split was the human-chimpanzee split. In the line that led to modern humans, the traits that made up the dominance factor became incorporated into the Five-Factor Model. Finally, after the last split, in the line that led to bonobos, the dominance factor came to include high Emotional Stability and high Assertiveness. This scenario for the evolution of dominance factors, although plausible, needs to be tested, for example, by identifying which traits are related to rank in multiple species, including humans, and conducting phylogenetic analyses.

It is important to remember that these findings do not describe a qualitative difference between humans and our great ape relations. Personality factors are, after all, models of correlations among traits. These findings are therefore better described as showing ranges of possibilities along a spectrum occupied by different species of primates, including our own.

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