

# Personality in Captive Killer Whales (*Orcinus orca*): A Rating Approach Based on the Five-Factor Model

Yulán Úbeda  
Universitat de Girona

Sara Ortín  
Fundació Universitat de Girona: Innovació i Formació

Judy St. Leger  
SeaWorld Parks and Entertainment, San Diego (UU.EE)

Miquel Llorente  
Universitat de Girona and Institut de Recerca i Estudis en  
Primatologia—IPRIM, Girona, Spain

Javier Almunia  
Loro Parque Foundation, Tenerife, Spain

The comparative study of animal personality has received great interest in recent years. Some studies have analyzed personalities in cetaceans (exclusively in dolphins), but none have analyzed the factorial structure of personality of any species in this order. Our objective was to evaluate a sample of captive killer whales ( $n = 24$ ) adapting one of the most widely used models of personality in humans and nonhuman animals: the five-factor model. A total of 38 personality descriptive adjectives were rated by 55 raters (mainly trainers and curators). Principal components analysis and regularized exploratory factor analysis revealed four statistically significant factors with acceptable standards of interrater reliability and validity, accounting for 49.85% of the variance. The first factor indicated an Extraversion factor, the second one revealed a combined factor of Conscientiousness and Agreeableness, the third one yielded in a Dominance factor, and the fourth one reflected a Careful factor very close to a combination of Conscientiousness and Agreeableness factor. The results were compared with the results obtained for humans and chimpanzees in prior studies. The similarities could be explained as a result of convergent adaptive traits despite a deep evolutionary divergence, adaptation to physically dissimilar environments, and very different neuroanatomical organization.

**Keywords:** killer whale, orca, personality, temperament, five factor model

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Studies investigating personality in nonhuman animals have been carried out over a wide range of species (see Gosling, 2001 and Carere & Maestriperi, 2013, for review). The species studied

range from invertebrates, such as mollusks and arthropods, to vertebrates, such as amphibians, reptiles, birds and fish, but the majority of studies examined personality in mammals. Regarding cetaceans, personality studies have been carried out exclusively in dolphins. Those studies have documented individual differences that remain consistent over time (Highfill & Kuczaj, 2007) and across contexts (Highfill & Kuczaj, 2010; Kuczaj, Highfill, & Byerly, 2012). Moreover, it has been documented how individual differences can predict neophilia (Skrzypczak, 2016) for the Atlantic spotted dolphin (*Stenella frontalis*) and how these differences play a role in various social contexts including play behavior (Kuczaj & Eskelinen, 2014), social rank (Frick, 2016; Highfill & Kuczaj, 2010), learning (Kuczaj, Yeater, & Highfill, 2012), and bonds (Birgersson, 2011; Moreno, 2017) for bottlenose dolphins (*Tursiops truncatus*). However, none of these studies have analyzed the factor structure of personality for the species by using data reduction. The current study examines the personality structure of a previously unstudied cetacean, the killer whale (*Orcinus orca*).

The study of animal personality has been approached from very different perspectives, including to analyzing the structures of

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Yulán Úbeda, Facultat d'Educació i Psicologia, Universitat de Girona; Sara Ortín, Facultat d'Educació i Psicologia, Fundació Universitat de Girona: Innovació i Formació; Judy St. Leger, Research and Science Department, SeaWorld Parks and Entertainment, San Diego (UU.EE); Miquel Llorente, Facultat d'Educació i Psicologia, Universitat de Girona and Institut de Recerca i Estudis en Primatologia—IPRIM, Girona, Spain; Javier Almunia, Loro Parque Foundation, Tenerife, Spain.

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Correspondence concerning this article should be addressed to Yulán Úbeda, Facultat d'Educació i Psicologia, Universitat de Girona, Pl. Sant Domènec, 9. 17071 Girona, Spain. E-mail: [yulanubeda@gmail.com](mailto:yulanubeda@gmail.com)

personality for different species (Gosling, 2001), comparing the personality profiles among species (Gosling & John, 1999; Morton et al., 2013; Uher & Asendorpf, 2008), validating the methodologies used (Carter, Marshall, Heinsohn, & Cowlshaw, 2012; Highfill, Hanbury, Kristiansen, Kuczaj, & Watson, 2010; Pederson, King, & Landau, 2005; Weiss, Inoue-Murayama, King, Adams, & Matsuzawa, 2012), comparing with humans (Budaev, 2000; Herrmann, Hare, Cissewski, & Tomasello, 2011; Nettle, 2006), or analyzing from an evolutionary perspective (Wolf, van Doorn, Leimar, & Weissing, 2013; Wolf & Weissing, 2012), among others. Moreover, some research has been focused on finding practical applications in the field of conservation (Bremner-Harrison, Prodohl, & Elwood, 2004; Carlstead, Mellen, & Kleiman, 1999; Martin & Réale, 2008; Powell et al., 2008; Wielebnowski, 1999; Wielebnowski, Fletchall, Carlstead, Busso, & Brown, 2002), management (Barlow, Caldwell, & Lee, 2006; Stoinski, Lukas, Kuhar, & Maple, 2004; Watters & Powell, 2012; Wielebnowski et al., 2002), health and well-being (Capitanio, 2011; Gartner & Weiss, 2013a; Jin, Su, Tao, Guo, & Yu, 2013; King & Landau, 2003; Maninger, Capitanio, Mendoza, & Mason, 2003; Mehta & Gosling, 2008; Weiss, Adams, & King, 2011), or welfare (Gartner & Weiss, 2013b; Martin, 2005; Murray, 1998; Weiss et al., 2009; Wielebnowski, 1999), among others.

There are two primary methods for evaluating personality in nonhuman animals: behavioral coding and trait rating (Gosling, 2001; Highfill et al., 2010; Vazire & Gosling, 2004). In the behavioral coding method, the researcher measures the frequency or duration of specific activities that occur during a period of time or exposes subjects to some novel environmental factor or a problem to solve, and records individual responses to the test conditions (Capitanio, 2017). In the trait rating method, raters such as keepers, researchers, or volunteers who are familiar with the animals are responsible for evaluating the personality of the individuals, usually using Likert's scale adjectives lists (Vazire & Gosling, 2004). This method has a number of advantages over coding because it is shown as an effective, quick, and easy method (see Freeman, Gosling, & Schapiro, 2011 for a review).

Personality-rating instruments have relied on two main methods: top-down and bottom-up (Freeman & Gosling, 2010). These lists of adjectives are created by a "bottom-up" approach, specific for the species of the study, or by the "top-down" approach, adapting instruments originally designed to be used in another species, usually humans (Freeman et al., 2013; Uher, 2008). Top-down models have been applied in nonhuman animals using different approaches, for example, the Subjective Well-Being Scale has been used to measure happiness (King & Landau, 2003), whereas the Emotions Profile Index (Buirski, Kellerman, Plutchik, Weininger, & Buirski, 1973), the Eysenck model (Úbeda & Llorente, 2015), or the five-factor model (FFM; King & Figueredo, 1997) have been used to measure personality. In fact, one of the most widely used instruments to measure personality in nonhuman animals with a top-down perspective has been the five-factor model (Goldberg, 1990). This model has been used in chimpanzees (*Pan troglodytes*; King & Figueredo, 1997), horses (*Equus* sp.; Kristiansen & Kuczaj, 2013), dogs (*Canis familiaris*), cats (*Felis catus*), rabbits (*Oryctolagus* sp.), hedgehogs (*Atelerix* sp.), and ferrets (*Mustela putorius furo*; Gosling & Bonnenburg, 1998), among others.

The FFM is a hierarchical model with five bipolar factors (Goldberg, 1990; McCrae & Costa, 1999): Neuroticism, Extraversion, Agreeableness, Conscientiousness, and Openness to Experience. One review summarized the evidence for cross-species commonalities in personality factors (Gosling & John, 1999) of 12 different species. It concluded that the dimensions of Extraversion, Neuroticism, and Agreeableness showed considerable generality across all the species included in the review, whereas other factors showed less cross-species generality. Although the five factors of the model are proposed as temperament dimensions, the first three are considered to be associated with emotional reactivity and individual physiological processes.

The main objective of this study was to evaluate the factor structure of personality in a group of captive killer whales following the "top-down" method (Freeman et al., 2013) by using the FFM. The intent is to analyze the factorial personality profile of a cetacean by data reduction and compare these results with humans and chimpanzees.

## Materials and Method

### Sample and Study Site

This research was reviewed and approved by Loro Parque's and Sea World's Institutional Animal Care and Use Committee and was performed in accordance with the Animal Welfare Act for the care of Marine Mammals. We studied 24 killer whales (13 females and 11 males) hosted at Loro Parque (Tenerife, Spain), SeaWorld Orlando (Florida), and SeaWorld San Diego (California). Six of the killer whales were caught in the wild, whereas the remaining 18 were born in captivity and ranged in age from 3.16 to 29.42 years ( $M = 15.89 \pm SD = 8.58$  years).

The whales are housed in interconnected pools with a mean total volume of 22.845 m<sup>3</sup> ( $SD = 571.77$  m<sup>3</sup>). Water quality management programs are based on treatment of marine water, whereas canopies provide direct shade. Training sessions including public presentations occur three to eight times daily and vary in time, duration, and focus. The total diet is distributed across six to eight feedings daily. The diet comprises herring, sardines, capelin, sprat, mackerel, squid, and salmon fed in quantities from 22.7 kg to 68 kg per animal. Animal groupings and pool access are variable throughout the day.

### Raters

Questionnaires were completed by 17 raters from Loro Parque (13 trainers, three show audio-visual staff, and one behavioral researcher), 20 raters from SeaWorld Orlando (17 trainers and three curators), and 21 raters from SeaWorld San Diego (16 trainers, four curators, and one veterinarian). All raters had a high level of contact with the animals. Trainers and curators were in contact with the animals for a mean of over 94 months ( $SD = 18.04$ ) and audio-visual staff a mean of 52 months ( $SD = 2.42$ ). The veterinarian has over 9 years of continuous contact with the subjects, whereas the researcher developed an intensive behavioral research during 5 months. All of the raters evaluated all the subjects in their facility. Raters were instructed to base their judgments on general impressions of the killer whales, not on

frequency estimates of past behaviors. Raters were asked to avoid discussing their answers with others completing the surveys.

### Questionnaire

The questionnaire was the same used by Úbeda and Llorente (2015) with chimpanzees, which was based on Goldberg's study (1990) in humans. The total number of adjectives used in the FFM questionnaire in our study was 38, with a Likert rating scale of 1 to 7 (see in the online supplemental materials). We used the synonym–antonym evaluation, whereby the antonyms were based on the adjectives used in the King and Figueredo (1997) study.

### Interrater Reliability of Adjectives

The observer agreement of the 58 raters was assessed for each adjective using two intraclass correlation coefficients (ICC; Shrout & Fleiss, 1979). To compute ICCs, the mean squares for killer whales and Rater  $\times$  Killer whales were obtained using a general linear model with Type III sums of squares (SAS Institute, 1999). The first ICC (3, 1) indicates the reliability of the scores for a single evaluator. The second ICC (3, k) indicates the reliability for the mean scores of the evaluators, in our case, based on an average of 19 raters per killer whale ( $SD = 0.99$ ). Internal agreement of each component was measured using Cronbach's  $\alpha$ , which assesses the correlation of two tests that measure the same variables.

### Data Reduction: Principal Components Analysis and Regularized Exploratory Factor Analysis

To determine the personality trait domains, we first transformed our data into  $z$  scores using a principal components analysis (PCA) to identify the dimensions underlying the mean ratings. To determine the number of factor components to extract (only the factors that exceeded the 95th percentile of the values derived from random matrices were extracted), we examined the scree plot and used parallel analysis (Horn, 1965; O'Connor, 2000). After determining the number of components, we subjected those components to an orthogonal (varimax) and oblique (promax) rotation. For the purpose of interpreting and scoring factors, we defined absolute loadings  $\geq 0.40$  as salient. The component scores were unit-weighted, and thus the  $z$  scores of items with salient primary loadings were assigned weights of +1 or -1, depending on the direction of the loading. Items with nonsalient loadings were assigned weights of 0. Unit-weighted scores are more generalizable across studies and are highly correlated with differentially weighted scores (Gorsuch, 1984). Moreover, due to the small sample, we used regularized exploratory factor analysis (REFA), a technique specifically designed to derive factors when the sample size is very small (Jung & Lee, 2011; Jung & Takane, 2008). For this analysis, we used quartimax rotation and specified unweighted least squares for factor extraction. As REFA loadings are shrunk toward zero (Jung & Lee, 2011), they are more conservative than loadings obtained via PCA. We, therefore, defined loadings  $\geq 0.30$  as salient.

### Cross-Species Comparisons

We compared the killer whale factor structure of personality with the structure of personality obtained for chimpanzees using

the same questionnaire (Úbeda and Llorente, 2015). To do so we created unit-weighted factor scores and examined the correlations between them.

## Results

### Interrater Reliability of Adjectives

The ICCs for the single (3, 1) and average (3, k) ratings were strong, indicating that raters tended to agree in their judgments about the personality traits of the killer whales. The mean ICC (3, 1) was .37 ( $SD = .15$ ; range = .06–.73). The mean ICC (3, k) was .96 ( $SD = .03$ ; range = .81–.99). The overall reliability of the 38 adjectives was 0.96, and Cronbach's  $\alpha$  levels ranged from 0.73 to 0.99. The interrater reliabilities of all 38 items are presented in Table 1.

### Data Reduction: PCA and REFA

An examination of the scree plot for the mean ratings of the 24 killer whales suggested four principal components, and the parallel

Table 1  
*Interrater Reliabilities of Adjectives*

Adjective	ICC (3,1)	ICC (3,k)
Playful	.61	.99
Inquisitive	.48	.98
Cheerful	.44	.98
Sociable	.49	.98
Affectionate	.34	.97
Active	.64	.99
Imitative	.32	.97
Friendly	.33	.97
Gregarious	.60	.99
Inventive	.42	.98
Patient	.42	.98
Constant	.47	.98
Peaceable	.43	.98
Predictable	.33	.97
Not defiant	.31	.96
Gentle	.33	.97
Stable	.37	.97
Trustful	.19	.94
Not bullying	.21	.94
Calm	.28	.96
Stubborn	.25	.95
Impulsive	.37	.97
Generous	.12	.90
Unemotional	.19	.94
Bold	.50	.98
Brave	.36	.97
Dominant	.73	.99
Protective	.47	.98
Intelligent	.33	.97
Laborious	.59	.99
Helpful	.24	.95
Prudent	.24	.95
Sensitive	.14	.91
Sympathetic	.26	.96
Organized	.34	.97
Responsible	.33	.97
Independent	.32	.97
Not decisive	.06	.81

Note. ICC = intraclass correlation coefficient.

analysis (Horn, 1965; O'Connor, 2000) indicated that the eigenvalues of the first four components exceeded the 95th percentile of eigenvalues expected by chance. Therefore, a PCA with varimax rotation was used to extract four components. The analysis indicated appropriate sampling adequacy (Kaiser–Meyer–Olkin measure = .86), accounting for the 49.9% of the total variance.

We extracted four factors from the mean ratings of the 24 killer whales using REFA and subjected these factors to a quartimax rotation. From the 38 adjectives analyzed, two of them (Decisive and Dependent) did not have salient loadings in any factor from both PCA and REFA. The dimensions extracted by REFA and those extracted by PCA were comparable (Table 2). Correlations obtained between the same labeled factors for PCA and REFA show statistical concordance, whereas correlations obtained between some of the other factors show statistical similarities that could be due to the sample size (Table 3). None of the extractions led to differences in how the dimensions were interpreted. From

the four components extracted, the promax rotation revealed that the absolute interfactor correlations ranged from .03 to .37, with a mean of .14 (Table 4).

The first factor was described by the adjectives Playful, Social, Active, Cheerful or Gregarious, among others. These adjectives in humans and chimpanzees load on the factor Extraversion (Table 5). Therefore, we labeled this factor Extraversion. The second factor was characterized by the adjectives Patient, Predictable, Gentle, Generous, or Peaceable, among others, where some of them are related with the Conscientiousness and Neuroticism factors in humans, but most of them are related with the Agreeableness factor in humans. Likewise, most of those adjectives loaded on a factor termed Conscien-agreeableness in chimpanzees (Table 5), which correlates with the same labeled factor obtained for killer whales (Table 6). Therefore, we decided to label this factor as Conscien-agreeableness. The third factor was defined by the traits Bold, Brave, Dominant, Protective, Intelligent and La-

Table 2

*Factor Loadings Obtained According to the Five-Factor Model for Captive Killer Whale Personalities*

Adjectives	Principal component analysis				Regularized exploratory factor analysis			
	Ext	Cons-agr	Dom	Care	Ext	Cons-agr	Dom	Care
Playful	<b>.83</b>	-.03	.16	-.06	<b>.84</b>	-.05	.03	-.05
Inquisitive	<b>.75</b>	-.07	.19	.06	<b>.75</b>	-.04	.10	.07
Cheerful	<b>.68</b>	.19	.35	-.06	<b>.71</b>	.15	.22	-.17
Sociable	<b>.68</b>	.11	<b>.42</b>	-.02	<b>.72</b>	.10	<b>.30</b>	-.13
Affectionate	<b>.64</b>	.15	.07	.31	<b>.62</b>	.25	.04	.19
Active	<b>.64</b>	-.07	<b>.41</b>	-.12	<b>.67</b>	-.11	.28	-.12
Imitative	<b>.63</b>	-.01	-.06	.07	<b>.56</b>	.02	-.09	.08
Friendly	<b>.63</b>	<b>.40</b>	.04	.03	<b>.59</b>	<b>.38</b>	-.05	-.09
Gregarious	<b>.60</b>	-.03	<b>.50</b>	.02	<b>.66</b>	-.02	<b>.40</b>	-.08
Inventive	<b>.54</b>	-.13	.26	.23	<b>.55</b>	-.04	.22	.18
Patient	.19	<b>.72</b>	-.02	.14	.17	<b>.70</b>	-.05	-.08
Constant	-.20	<b>.69</b>	.20	.28	-.16	<b>.73</b>	.23	-.04
Peaceable	.24	<b>.69</b>	-.31	.17	.19	<b>.70</b>	-.33	.01
Predictable	-.19	<b>.67</b>	.11	.18	-.17	<b>.66</b>	.12	-.09
Not defiant	.07	<b>.65</b>	-.10	.22	.05	<b>.66</b>	-.09	.03
Gentle	.19	<b>.59</b>	-.11	.29	.17	<b>.63</b>	-.10	.10
Stable	.13	<b>.53</b>	<b>.51</b>	.02	.20	<b>.49</b>	<b>.42</b>	-.25
Trustful	.23	<b>.52</b>	.36	-.13	.26	<b>.41</b>	.24	-.27
Not bullying	-.04	<b>.50</b>	-.34	-.03	-.10	<b>.42</b>	-.32	-.06
Calm	-.28	<b>.43</b>	-.12	.09	-.26	<b>.39</b>	-.08	-.01
Stubborn	-.26	-. <b>.42</b>	.04	-.20	-.22	-. <b>.43</b>	.03	-.07
Impulsive	.34	-. <b>.42</b>	.39	-.07	<b>.37</b>	-. <b>.40</b>	<b>.32</b>	.01
Generous	.13	<b>.42</b>	.03	.33	.12	<b>.47</b>	.06	.14
Unemotional	-.23	<b>.42</b>	.02	-.07	-.20	<b>.32</b>	.00	-.12
Bold	.22	-.22	<b>.74</b>	-.05	<b>.32</b>	-.23	<b>.67</b>	-.12
Brave	.16	.01	<b>.74</b>	-.03	.26	-.02	<b>.64</b>	-.14
Dominant	.00	-.22	<b>.72</b>	.09	.12	-.17	<b>.67</b>	-.01
Protective	.03	-.06	<b>.52</b>	.28	.12	.04	<b>.48</b>	.10
Intelligent	.15	.18	<b>.51</b>	.23	.23	.23	<b>.46</b>	.05
Laborious	<b>.41</b>	-.01	<b>.45</b>	.27	<b>.46</b>	.08	<b>.41</b>	.16
Helpful	.23	.27	.26	<b>.65</b>	.27	<b>.47</b>	<b>.33</b>	<b>.42</b>
Prudent	-.17	.20	.19	<b>.65</b>	-.11	<b>.39</b>	<b>.30</b>	<b>.39</b>
Sensitive	.33	.07	-.23	<b>.62</b>	.29	.28	-.13	<b>.50</b>
Sympathetic	.31	.38	-.14	<b>.62</b>	.29	<b>.56</b>	-.07	<b>.46</b>
Organized	-.15	.30	<b>.41</b>	<b>.55</b>	-.07	<b>.45</b>	<b>.48</b>	.28
Responsible	-.32	<b>.47</b>	.20	<b>.48</b>	-.27	<b>.59</b>	.29	.20
Independent	-.35	.24	.20	-.13	-.28	.15	.15	-.13
Not decisive	-.16	-.04	-.30	.03	-.19	-.02	-.22	.05

*Note.* Ext = Extraversion; Cons-agr = Conscien-agreeableness; Dom = Dominance; Car = Careful. Boldface indicates salient loadings.



Table 3  
*Correlations Between Principal Component Analysis and Regularized Exploratory Factor Analysis Results for Captive Killer Whales*

Factor	Principal component analysis			
	Extraversion	Conscien-agree	Dominance	Careful
Regularized exploratory factor analysis				
Extraversion	<b>.99</b>	-.21	<b>.72</b>	.19
Conscien-agree	-.15	<b>.99</b>	-.01	<b>.82</b>
Dominance	<b>.55</b>	-.02	<b>.99</b>	.39
Careful	-.01	.37	-.14	<b>.67</b>

Note. Conscien-agree = Conscien-agreeableness.

borious (only present in the PCA). We named this factor Dominance according to the same labeled factor found for chimpanzees, with which it also correlates (Table 6). Finally, on the fourth factor, two of the adjectives that loaded on this factor in PCA changed their distribution in REFA. This factor was characterized by adjectives related with the Agreeableness (Helpful, Sympathetic, or Sensitive) and Conscientiousness (Organized, Prudent, and Responsible) factors for humans (Goldberg, 1990). We could have labeled this factor as Conscien-agreeableness; instead, we decided to maintain this name for the second factor and to label this factor Careful.

### Cross-Species Comparisons

Correlations of factor scores obtained for killer whales and chimpanzees, using the FFM as a framework, revealed that the factors of Extraversion, Conscien-agreeableness, and Dominance are highly positively correlated for both species (+0.80 to +0.94). The factor Careful in killer whales was positively correlated (+0.75) with the factor Conscien-agreeableness in chimpanzees (Table 6).

### Discussion

This study provided two main results. First, captive killer whales present a clear personality structure, characterized by four factors with acceptable standards of interrater reliability and validity. Second, the results found are similar to those found in humans and chimpanzees.

Gosling (2001) found that the mean interrater reliability of animal personality studies is around 0.52. The overall reliability of the 38 adjectives of the current study was high (0.96), indicating

that raters tended to agree in their judgments about the personality traits of the killer whales (Table 1).

The validity for the data obtained in this study is expressed from the convergent and discriminant validity of the factors (Campbell & Fiske, 1959). By using the magnitudes of the adjectives loadings onto the factors to which they are assigned, convergent validity can be estimated. From the 38 adjectives evaluated, in the PCA, 29 loaded with values superior to .50, whereas seven adjectives ranged between .50 and .40, and two of them did not have salient loading on any of the factors, even though the ICC values were moderately high. In any case, there was a good evidence of convergent validity as indicated by the overall pattern of factor loadings. The low intercorrelation values of the oblique factors demonstrate factorial independence and discriminate validity. In our case, the mean absolute value is .14 (Table 4). This value falls into the range of mean factor intercorrelations reported for chimpanzees (.13; King & Figueredo, 1997), rhesus macaques (.14; Weiss, Adams, & Johnson, 2011), white-faced capuchins (.15; Manson & Perry, 2013), orangutans (.18; Weiss, King, & Perkins, 2006), or Barbary macaques (.19; Konečná, Weiss, Lhota, & Wallner, 2012), among others. However, one of our values was moderately high (0.37), but we should take into account that human studies (Borkenau & Ostendorf, 1990; Costa, McCrae, & Dye, 1991; Graziano & Ward, 1992) typically show at least two or three moderately high interfactor correlations (viz., approaching .50).

Regarding the labeling of the factors, those obtained for killer whales are similar to those found in humans and chimpanzees, although with some distinctive features. Both Extraversion and Conscien-agreeableness factors are related with the equivalent factors for humans and are positively correlated with the same factors for chimpanzees. Dominance factor correlates positively with the same factor for chimpanzees. We decided to use the label "Dominance" for this factor because many authors have emphasized the importance of this factor in primates and other orders (Freeman & Gosling, 2010; Gosling, 2008; Gosling & John, 1999). Finally, we could label the fourth factor as Conscien-agreeableness because we found adjectives related with the Conscientiousness and Agreeableness factors for humans (Goldberg, 1990), and this factor correlates with chimpanzee Conscien-agreeableness factor. However, we decided to maintain this name for the second factor because it has more loading and to label the fourth factor Careful (despite the fact that this label has not been found previously in other nonhuman animals).

Table 4  
*Factor Intercorrelation Matrix for the Factor Obtained for Captive Killer Whales*

Factor	Ext	Cons-agr	Dom	Care
Ext	—			
Cons-agree	.06	—		
Dom	.21	.05	—	
Care	.10	.37	.03	—

Note. Ext = Extraversion; Con-agr = Conscien-agreeableness; Dom = Dominance; Car = Careful.

Table 5

*Personality Structure Obtained in This Study (According to Regularized Exploratory Factor Analysis) for Killer Whales Using the Five-Factor Model (Compared With Humans [Goldberg, 1990] and Chimpanzees [Úbeda & Llorente, 2015])*

Adjectives	Killer whales This study	Humans Goldberg, 1990	Chimpanzees Úbeda & Llorente, 2015
Playful	Extraversion	Extraversion	Extraversion
Inquisitive	Extraversion	Openness	Extraversion
Cheerful	Extraversion	Extraversion	Extraversion
Sociable	Extraversion	Extraversion	Extraversion
Affectionate	Extraversion	Agreeableness	Extraversion
Active	Extraversion	Extraversion	Extraversion
Imitative	Extraversion	Openness	—
Friendly	Extraversion	Agreeableness	Extraversion
Gregarious	Extraversion	Extraversion	Extraversion
Inventive	Extraversion	Openness	Conscien-open
Patient	Conscien-agree	Agreeableness	Conscien-agree
Constant	Conscien-agree	Conscientiousness	Conscien-open
Peaceable	Conscien-agree	Agreeableness	Conscien-agree
Predictable	Conscien-agree	Conscientiousness	Conscien-agree
Not defiant	Conscien-agree	Agreeableness	Conscien-agree
Gentle	Conscien-agree	Agreeableness	Extraversion
Stable	Conscien-agree	Neuroticism	Conscien-agree
Trustful	Conscien-agree	Neuroticism	Extraversion
Not bullying	Conscien-agree	Agreeableness	Conscien-agree
Calm	Conscien-agree	Neuroticism	Conscien-agree
Stubborn	Conscien-agree	Conscientiousness	Conscien-open
Impulsive	Conscien-agree	Extraversion	Conscien-agree
Generous	Conscien-agree	Agreeableness	Conscien-agree
Unemotional	Conscien-agree	Neuroticism	Dominance
Bold	Dominance	Extraversion	Extraversion
Brave	Dominance	Neuroticism	Dominance
Dominant	Dominance	Neuroticism	Dominance
Protective	Dominance	Conscientiousness	—
Intelligent	Dominance	Openness	Conscien-open
Laborious	Extraversion	Openness	Conscien-open
Helpful	Conscien-agree	Agreeableness	Extraversion
Prudent	Careful	Conscientiousness	Conscien-agree
Sensitive	Careful	Agreeableness	Extraversion
Sympathetic	Conscien-agree	Agreeableness	Extraversion
Organized	Dominance	Conscientiousness	Conscien-open
Responsible	Conscien-agree	Conscientiousness	Conscien-agree
Independent	—	Neuroticism	Conscien-open
Not decisive	—	Conscientiousness	Extraversion

*Note.* Conscien-agree = Conscien-agreeableness; Conscien-open = Conscien-openness.

To better define the personality factors, it would be interesting to compare the results obtained for killer whales in the current study with other cetaceans (e.g., dolphins). However, despite the fact that some studies have analyzed personality in

cetaceans (exclusively in bottlenose dolphins) by using the rating method (Birgersson, 2011; Highfill & Kuczaj, 2007, 2010; Kuczaj et al., 2012), as yet, none of them have analyzed the factorial structure of this order by applying a data reduction. Instead, we compared our results for killer whales with those for primates, for which there are relevant data. Despite their deep evolutionary divergence, adaptation to physically dissimilar environments, and very different neuroanatomical organization, some primates and cetaceans show convergence in complex cognitive abilities (Marino, 2002, 2011), self-awareness (Marino, 2011), and very similar encephalization quotient (Marino, 1998) (EQ; chimpanzee EQ = 2.3; killer whales EQ = 2.6; Jerison, 1973; which is a measure of observed brain size relative to expected brain size, derived from a regression of brain weight on body weight for a sample of species). Like chimpanzees, killer whales have a fission–fusion social structure (at least for some types of killer whales; Beck, Kuningas,

Table 6

*Correlations Between Captive Killer Whale (This Study) and Sanctuary Chimpanzee Personality Structures (Úbeda & Llorente, 2015)*

Chimpanzee structure	Killer whale structure			
	Extraversion	Conscien-agree	Dominance	Careful
Extraversion	<b>.80</b>	.34	.23	.32
Conscien-agree	−.02	<b>.91</b>	−.04	<b>.75</b>
Dominance	.16	−.06	<b>.94</b>	−.19
Conscien-openness	−.68	.23	.44	.03

*Note.* Conscien-agree = Conscien-agreeableness. Boldface indicates correlations among factors.

Esteban, & Foote, 2012; Ivkovich, Filatova, Burdin, Sato, & Hoyt, 2010), present cooperative behavior (Pitman & Durban, 2012; Similä & Ugarte, 1993), and possess cultural traditions (Rendell & Whitehead, 2001). Cultural learning of behaviors may proceed through motor imitation or perhaps even through direct teaching (pedagogy), (Galef, 1992; Tomasello, 1994) as may be the case for killer whale calves instructed in the beach capture of pinnipeds by their mothers (Guinet & Bouvier, 1995; Rendell & Whitehead, 2001). Action imitation (Abramson, Hernández-Lloreda, Call, & Colmenares, 2013), hunting imitation (Baird, 2000; Similä & Ugarte, 1993), and vocal imitation (Bain, 1986; Deecke, Ford, & Spong, 2000; Foote et al., 2006; Ford, 1991; Janik & Slater, 1997; Yurk, Barrett-Lennard, Ford, & Matkin, 2002) also occurs, such as the development of new motor schema, hunting techniques not seen in any other killer whale populations, or dialects among killer whale family groups.

Given the small sample size of our study, we must be cautious in our conclusions. However, the similarity of personality structure across primate species and killer whales suggests evolutionary convergence (Marino, 2002, 2011). Perhaps this type of personality structure, and the distinct individual differences in behavior that this structure implies, are associated with complex sociality (including long-term dyadic relationships) and the cognitive abilities that go along with complex sociality. Alternatively (and not mutually exclusively), this type of personality structure may support behavioral variability across varying ecological contexts. However, it should be taken into account that some differences may be found because disparities have been described even within the same species (e.g., between Western and non-Western cultures for humans; Church & Katigbak, 1989; Narayanan, Menon, & Levine, 1995; Yang & Bond, 1990). It should also be kept in mind that adjectives can have different connotations in different species. For example, the adjective “inquisitive” in humans has connotations of acquisition of experience, and therefore it is often related to the Openness factor (Goldberg, 1990), whereas “affectionate,” which can have connotations of warmth with a conspecific, is identified as a Agreeableness component in humans. However, both adjectives are related with the Extraversion factor in killer whales and chimpanzees, reflecting differences in social style. Accordingly, the degree of convergence in personality structure across species cannot be measured simply or directly from the agreement in factor labels and the magnitude of loadings of specific adjectives on certain factors. In future research, it will be interesting to adapt this methodology to other cetaceans to obtain the factor structure to compare from an evolutionary perspective.

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