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Personality of killer whales (*Orcinus orca*) is related to welfare and subjective well-being

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Abstract

Questionnaires are very useful tools when it comes to assessing zoo based animal measures and caretakers of these animals (such as keepers, trainers and veterinarians) are in the best position to provide accurate answers to these assessments. Our goal was (a) to empirically demonstrate the utility of a welfare questionnaire and (b) to examine the relationship between personality, subjective well-being and welfare ratings, in a sample of killer whales (*Orcinus orca*) (n=26). For this purpose, we applied the 4-factor personality structure previously applied to the species (Úbeda et al., 2018), a 4-item subjective well-being questionnaire, and we designed and applied a 39-item welfare questionnaire. The welfare questionnaire was composed by positive and negative welfare indicators related to social and environmental interactions, physical health condition, presence of species-typical and stereotypical behaviors, the capacity to accept situations, and relationships with conspecifics and humans, among others. Each killer whale was rated by an average of 12.5 raters. The mean interrater reliability for subjective well-being and welfare questionnaires was high, and the Principal Components Analysis and the Regularized Exploratory Factor Analysis, revealed one and six factors, respectively. We found some correlations among the three constructs, for instance, Extraversion (r = 0.62, 95% CI 0.02-0.06) and Dominance (r = 0.61, 95% CI 0.03-0.09) were associated to the subjective well-being factor, while subjective well-being was negatively associated with the Abnormal (r = -0.73, 95% CI -0.13- -0.06) and Nervousness (r = -0.66, 95% CI 0.06-0.17) welfare factors, among others. According to the reliability and validity obtained, our research represents the first empirical evidence of the utility of assessing the welfare of cetaceans through the use of a questionnaire. Therefore, facilities housing cetaceans could use welfare questionnaires to gradually monitor welfare and to intervene if needed. Finally, some of the correlations found closely resembled previous correlations found in primates, which could indicate a possible evolutionary convergence between Orders.

Keywords: welfare, personality, subjective well-being, killer whales, orcas, cetaceans

Highlights

- An evaluation of a questionnaire for killer whale welfare assessment.
- Ratings of personality, welfare and subjective well-being were highly correlated.
- Questionnaires are a reliable and valid tool for assessing killer whale welfare.
- Similarities to primates' correlations were probably due to convergence.

1. Introduction

The psychological approach of the trait rating method has a number of psychometric and pragmatic advantages over the behavior coding method. These advantages include among others: higher reliability than the coding method, control of variability due to changes in an animal's situation or environment, aggregation of measures across time, a quicker and more efficient data collection and finally a rating method can capture a broader set of states (see Freeman et al., 2011 and Vazire et al., 2007 for a review). These psychometric and pragmatic advantages promote the use of rating method when behavioral characteristics of animals can be transferred into descriptor items (Meagher, 2009; Whitham and Wielebnowski, 2009). Consequently, the rating method has been used to assess a wider range of different traits in animals, such as: personality (Stevenson-Hinde and Zunz, 1978), subjective well-being (King and Landau, 2003), welfare (Robinson et al., 2017), emotions (Morris et al., 2008), social behavior (Rousing and Wemelsfelder, 2006) or psychopathology (Úbeda et al., 2020), among others.

Most of the animal rating studies have been conducted within personality research on a wide range of species, with the Primate order being one of the most commonly studied (see Carere and Maestripieri, 2013 and Gosling, 2001 for a review). Associations have been found between animal personality studies and biology, health, psychometrics or behavior, among others (see Freeman and Gosling, 2010; Gartner and Weiss, 2013a; Weinstein et al., 2008; or Weiss et al., 2011c for a review), as well as with conservation, welfare and management (Carere and Maestripieri, 2013; Gartner and Weiss, 2013a).

The use of the subjective well-being questionnaire (SWB) (King and Landau, 2003), which was based on a human happiness measure (Sandvik et al., 1993), is also commonly used in rating animal studies. The studies, which have primarily focused on detecting associations between SWB and personality, have been conducted in six primates species (King and Landau, 2003; Robinson et al., 2016; Schaefer and Steklis, 2014; Simpson et al., 2019; Weiss et al., 2020, 2006) and in four felids species to date (Gartner et al., 2016; Gartner and Weiss, 2013b).

Furthermore, it has been found that SWB is related to longevity (Weiss et al., 2011a), has a genetic overlap with personality (Adams et al., 2012; Weiss et al., 2002) and is associated with cortisol levels (Inoue-Murayama et al., 2018), among others.

Animal welfare is another research topic that is receiving increasing amounts of interest. Historically, this topic has been mainly assessed by using physiological, behavioral and health indicators (Hill and Broom, 2009; Melfi, 2009; Whitham and Wielebnowski, 2013). However, due to the aforementioned psychometric and pragmatic arguments, the use of questionnaires has also been transferred to the study of animal welfare (Meagher, 2009; Whitham and Wielebnowski, 2009). Through this method, rating approach tools have been applied, such as: the *Quality of Life* (QoL), in farm and domestic animals (Wemelsfelder, 2007; Wojciechowska et al., 2005); the *Animal Welfare Assessment Grid* (AWAG), in birds and primates (Justice et al., 2017; Wolfensohn et al., 2015) or versions of the "*Five Domains*" which were recently added to "The World Zoo and Aquarium Animal Welfare Strategy" of the World Association of Zoos and Aquariums (WAZA) (Mellor et al., 2015), among others.

As previously mentioned, most of the research on personality, SWB and welfare on zoo-housed animals have been carried out on primates. The focus on this order could be due to its phylogenetic proximity to humans (Prado-Martinez et al., 2013), and to its cognitive and emotional complexity (de Waal, 2007; Tomasello and Call, 1997; Whiten, 2000). However, the cetacean order, despite the phylogenetic distance (Kumar and Hedges, 1998), shares cognitive and emotional complexity with primates (Marino, 2017; Rendell and Whitehead, 2001), which make the research on these topics for cetaceans in zoological parks relevant (Lott and Williamson, 2017). Nevertheless, research on these cetacean constructs is still really scarce. Regarding personality, few studies have been carried out on bottlenose dolphins (*Tursiops truncatus*), Atlantic spotted dolphins (*Stenella frontalis*) and Killer whales (*Orcinus orca*) (see Úbeda et al., 2018). However, as previously mentioned, there is still no research on SWB on cetacean species.

In relation to welfare, very little research has been carried out on cetaceans (see Brando et al., 2018; and Clegg and Butterworth, 2017 for a review). More specifically, only two publications used the rating approaches to assess welfare: the WelfareQuality® rating (Blokhuis, 2008), which has been adapted to create a welfare assessment index for bottlenose dolphins (Clegg et al., 2015) and the Willingness to Participate (WtP) rating which is related to health (Clegg et al., 2019). Nonetheless, to our knowledge there is no systematic study on the validity and reliability of a multi-trait rating welfare questionnaire in cetaceans. Further, except for two primate species [brown capuchins (*Sapajus apella*) and chimpanzees (*Pan troglodytes*): Robinson et al., 2017, 2016], there are no studies in any species that search for correlations between personality, SWB and welfare constructs.

Therefore, our goals were to: (1) test the reliability and validity of a 39-item welfare questionnaire; and (2) determine the associations between personality, SWB and welfare factors in a group of killer whales. Since there are no similar studies on cetaceans to compare it to, our hypothesis is that associations among the three constructs will be similar to those found in primates. Thus, among others, we would expect to find positive associations between Extraversion and Dominance with subjective well-being and the obtained welfare factors related to positive welfare.

2. Methods

2.1. Subjects 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 to the Animal Welfare Act for the care of marine mammals. For this research, we studied 26 killer whales (14 females and 12 males) housed at Loro Parque (Tenerife, Spain), SeaWorld Orlando (Florida), SeaWorld San Diego (California) and SeaWorld San Antonio (Texas). Four of the killer whales were caught in the wild before 80s, while the remaining twenty-two were born within one of the facilities and ranged in age from 5.33 to 31.54 years (mean=17.38 ± SD = 9.73 years).

The whales are housed in interconnected pools with a mean total volume of 22.845 m^3 (SD = 571.77 m^3) either manufactured or natural salt water filtered systems. Training sessions including public presentations occur six 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 at 2 to 3% of the body weight per animal per day. Animal groupings and pool access are variable throughout the day.

2.2. Questionnaires

2.2.1. Personality Questionnaire

We included twenty-one of the killer whales (housed at Loro Parque, SeaWorld Orlando and SeaWorld San Diego) that were rated in our previous research according to a 38-item questionnaire which revealed four personality factors: Extraversion, Conscien-Agreeableness, Dominance and Careful (Úbeda et al., 2018). Five additional killer whales (from SeaWorld San Antonio) were rated with the same 38-item questionnaire, according to a 7-point Likert rating scale (Likert, 1932). Thus unit-weighted factor scores for the four factors described in our study were constructed for the San Antonio sample.

2.2.2. Welfare Questionnaire

The welfare questionnaire was designed by the researchers, so as to include a large amount of both positive and negative welfare indicators, related to: social and environmental interactions, physical health condition, presence of species-typical and stereotypical behaviors, the capacity to accept situations, and relationships with conspecifics and humans, among others. The questionnaire was composed by 39 items, which were rated on a 7-point Likert scale(Likert, 1932) ranging from least to most expression of the trait. The welfare questionnaire is available in supplementary materials.

2.2.3. Subjective Well-being Questionnaire

The subjective well-being questionnaire was identical to the King and Landau's 4-item questionnaire (2003). The first item asked raters to assess the amount of time the killer whale spends happy, the second item asked the degree to which the killer whale enjoyed social interactions, the third one, the ability of the killer whale to achieve goals, and the fourth asked raters to identify themselves with the killer whales and imagine how happy they would feel for a week. Raters were also asked to use a 7-point Likert scale (Likert, 1932) ranging from least to most expression of the trait.

2.3. Raters

Questionnaires were evaluated by 17 raters from Loro Parque (14 trainers and 4 show audio-visual staff), 12 raters from Sea World San Diego (8 trainers, 3 supervisors and 1 curator) 11 raters form SeaWorld Orlando (10 trainers and 1 veterinarian) and 10 raters from SeaWorld San Antonio (7 trainers, 2 supervisors and 1 curator). Raters all had a high level of contact with the animals. Trainers were in contact with the animals for a mean of over 66.11 months (SD = 49.67), audio-visual staff a mean of 74 months (SD = 42.79), supervisors a mean of 157 months (SD=125.75), curators a mean of 282 months (SD = 59.40) and the veterinarian 96 months. All of the raters evaluated all the subjects and all the three questionnaires. Raters were instructed to base their judgments on general impressions of the killer whales, not on frequency estimates of past behaviors. Evaluators were cautioned to avoid discussing their ratings with other raters. None of the researchers rated any of the questionnaires.

2.4. Data analysis

2.4.1. Intraclass correlations

The observer agreement of the 50 raters was assessed by using two intraclass correlation coefficients (ICC; Shrout and Fleiss, 1979). To compute ICCs, the mean squares scores for killer whales and Rater x Killer whales were obtained using a general linear model with Type III sums of squares. 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 12.5 raters per killer whale (SD = 3.11). Due to our small sample size, and further to ensure a high degree of interrater reliability, we chose to be conservative and to omit items with an ICC (3, k) < 0.60.

2.4.2. Data Reduction: Principal component analyses and regularized exploratory factor analyses

To determine the welfare 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 greater than or equal to 0.40 as salient. The component scores were unit-weighted, 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 non-salient loadings were assigned weights of 0. Unit-weighted scores are more generalizable across studies and are highly correlated with differentially weighted scores (Gorsuch, 1983). If an item had a loading greater than or equal to .40 on more than one component, we assigned the item to the component on which it had the highest loading. Due to the small sample, we used regularized exploratory factor analysis (REFA), a technique specifically designed to derive factors when the sample size is small (Jung and Lee, 2011; Jung and 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 and Lee, 2011), they are more conservative than loadings obtained via PCA. We therefore defined loadings greater than or equal to 0.30 as salient. In the event that an item had a loading greater than or equal to 0.30 on more than one component, we assigned the item to the component on which it had the highest loading. The same procedure was used to determine the subjective well-being domains. To calculate personality factor scores, we combined the results

for the five killer whales included in this study to those previously assessed on Úbeda et al (2018), in order to generate the factor scores for the personality factors obtained for this sample.

2.4.3. Pearson correlations

To examine the correlations among the factors obtained for personality, welfare and subjective well-being, we standardize the variables of the factor scores and used Pearson correlation.

3. Results

3.1. Intraclass correlations

There were no items with negative ICC values or with ICC (3,k) estimates below 0.60 to be excluded from further analyses from any of the questionnaires. The reliabilities of individual ratings, ICC (3, 1) for the 39 welfare items ranged from 0.07 to 0.79 with a mean reliability of 0.41, while the reliabilities of mean ratings, ICC (3, k) ranged from 0.79 to 0.99 with a mean reliability of .95 (Table 1). The reliabilities of individual ratings, ICC (3, 1) for the four SWB items ranged from 0.35 to 0.55 with a mean reliability of 0.43, while the reliabilities of mean ratings, ICC (3, k) ranged from .96 to .98 with a mean reliability of 0.97 (Table 2). The reliabilities of individual ratings, ICC (3, 1) for the 38 personality adjectives for San Antonio sample ranged from 0.16 to 0.89 with a mean reliability of 0.54, while the reliabilities of mean ratings, ICC (3, k) ranged from 0.69 to 0.99 with a mean reliability of 0.91.

— place Table 1 and 2 here —

3.2. Data reduction of Welfare questionnaire and Subjective well-being questionnaire

3.2.1. Welfare Questionnaire

An examination of the scree plot suggested six components and the Parallel analysis (Horn, 1965; O'connor, 2000) indicated that the eigenvalues of the first six components exceeded the 95th percentile of eigenvalues expected by chance. Therefore, a PCA with varimax rotation (K.M.O = .78) was used to extract six components, accounting for 52.98 % of the total variance. We extracted six factors from the 26 mean ratings using REFA and subjected these factors to a

quartimax rotation. The dimensions extracted by REFA and those extracted by PCA were comparable (see Table 3). Correlations obtained between the same labelled 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 4).With little exception, none of the extractions led to differences in how the dimensions were interpreted. From the six components extracted, the promax rotation produced moderately high correlations, with a mean absolute intercorrelation value of 0.19 (see Table 5).

On the first factor positively loaded items related to environment inspection, enrichment interaction, enclosure exploration and routine acceptance, among others, and negatively loaded items related to motionless behavior and attachment to objects. Therefore, we labelled this factor as Confidence. The second factor is negatively related to isolation and contact avoidance with conspecifics, and positively related to playful and affiliative interactions, among others. For this reason, we labelled this factor as Sociability. The third factor is positively associated with items related to stereotypes, abnormal and self-directed behaviors, among others, and negatively associated with species-typical behaviors. Thus, we labelled this factor as Abnormality. The fourth factor is characterized by items related to good physical condition and health, good alimentary habit, normal sexual response, as well as overall welfare and happiness. We labelled this factor as Overall welfare. The fifth factor is associated with items related to attack, dominance displays, frustration and breaching behaviors, among others. We labelled this factor as Nervousness. The sixth factor is mainly defined by items related to dependence and interaction with humans. Therefore, we labelled this factor as Self-sufficiency.

From the 39 items analyzed, three of them (*"4. The killer whale often shows visible physical injuries", "32. The killer whale tends to vocalize" and "33. The killer whale seeks the attention of his/her trainer"*) did not have salient loadings in any factor in PCA, although they loaded in a REFA factor.

— place Table 3, 4 and 5 here —

261 3.2.2. Subjective Well-being Questionnaire

262 We conducted a principal-components analysis of the mean ratings of the four subjective well-
263 being items. Only the first factor, designated as *Subjective well-being*, had an eigenvalue greater
264 than 1.00 (2.66), accounting for 66.39% of the variance. Factor loadings of the four items
265 ranged from .80 to .84. Therefore, each killer whale's subjective well-being score was defined
266 as the sum of the mean ratings for all four items.

267 *3.3. Correlations of personality, welfare and subjective well-being*

268 We found correlations between personality and welfare factors (Table 6), personality
269 factors and the subjective well-being factor (Table 7), and between welfare factors and the
270 subjective well-being factor (Table 8). The personality factor of *Extraversion* was positively
271 associated to the welfare *Confidence* factor (r= 0.82, P<0.001) and to the *subjective well-being*
272 factor (r= 0.62, P=0.001). The personality factor of *Dominance* was positively associated to the
273 *subjective well-being* factor (r=0.61, P=0.001) and to the welfare *Confidence* factor (r= 0.64,
274 P<0.001), and negatively associated to *Abnormality* (r= -0.60, P=0.001) and *Nervousness*
275 welfare factors (r= -0.57, P=0.003). The personality factor of *Conscien-Agreeableness* was
276 negatively associated to the *Nervousness* welfare factor (r= -0.55, P=0.003). The *Careful*
277 personality factor was negatively associated to the *Sociability* welfare factor (r= -0.73,
278 P<0.001). Finally, the *subjective well-being* factor was positively associated to the *Confidence*
279 welfare factor (r= 0.71, P<0.001) and negatively to the *Abnormality* (r= -0.73, P<0.001) and
280 *Nervousness* (r= -0.66, P<0.001) welfare factors.

281 — place Tables 6, 7 and 8 here —

282 **4. Discussion**

283 Our study presented two main results. First, the welfare questionnaire revealed six
284 factors with reliability and validity. Second, the correlations found between personality, welfare,
285 and subjective well-being, are similar to those found in primates, indicating a possible
286 convergence among species, and perhaps orders.

The utility of a welfare questionnaire is valuable only if it produces reliable and valid data (Meagher, 2009). The reliability measures the agreement among raters (Shrout and Fleiss, 1979), and in our case the value was high (0.95) and in line with the ones previously obtained from the welfare questionnaires applied to chimpanzees (0.92; Robinson et al., 2017) and capuchin brown monkeys (0.72; Robinson et al., 2016). The validity is obtained from the convergent and discriminant validity of the factors (Campbell and Fiske, 1959). On one hand, convergent validity is valued by the presence of correlations between different measures of the same construct (Campbell and Fiske, 1959), as well as by the values of the item loadings onto the factors to which they are assigned (Ferketich et al., 1991; Figueredo et al., 1991). In our case, some of the welfare factors were related to some of the personality factors (Table 6) and with the subjective well-being factor (Table 8). Likewise, from the 39 items of the PCA, 30 items were loaded with values superior to 0.50, 6 loaded with values between 0.50 and 0.40, and 3 did not have salient loadings (Table 3). On the other hand, discriminant validity is valued by the absence of unexpected correlations (Campbell and Fiske, 1959), as well as by the factorial independence obtained from the low intercorrelation values of the oblique factors (King and Figueredo, 1997). In our case, there were no unexpected correlations between welfare and personality factors (Table 6) and between welfare and Subjective well-being factor (Table 8). Likewise, the mean absolute factor intercorrelation value was 0.19 (Table 5). Thus, the welfare reliabilities and validities suggest that welfare ratings produced by the people in close contact to the animals are reliable, valid, and valuable (Meagher, 2009; Whitham and Wielebnowski, 2009). Moreover, the questionnaire covers a wide range of aspects related to positive and negative welfare, by obtaining six factors related to: basic welfare (*Overall Welfare* factor), social aspects (*Sociability* factor), extraverted behaviors (*Confidence* factor), abnormal and non-desirable behaviors (*Abnormality* factor), excitability (*Nervousness* factor) and relationship with humans (*Self-sufficiency* factor). Therefore, facilities housing animals can assess the welfare of the animals by using welfare questionnaires as pragmatic and trustworthy assessment tools.

As mentioned above, because of the lack of any systematic study that assesses the relationship between personality, subjective well-being and welfare on cetaceans, any comparison to previous results with cetaceans is not possible. Thus, on one hand, our results can only be compared to the studies on the six species of nonhuman primates and on the four species of felids that assessed the relationships between personality and subjective well-being. On the other, it can also be compared to the studies on chimpanzees and brown capuchins that assessed the relationship between personality, subjective well-being and welfare (which data reduction in the welfare questionnaire revealed a single combined factor of welfare-SWB). One of the most common association found among these constructs, is the positive correlation between *subjective well-being* and *Extraversion* found in humans (Steel et al., 2008), chimpanzees (King and Landau, 2003; Robinson et al., 2017; Weiss et al., 2009), orangutans (Weiss et al., 2006), and gorillas (Schaefer and Steklis, 2014). Similarly, other correlations have been found between the *subjective well-being* factor and the *Openness* factor for chimpanzees (Weiss et al., 2009) and rhesus macaques (Simpson et al., 2019), the *Sociability* factor for brown capuchins (Robinson et al., 2016) and common marmoset (Inoue-Murayama et al., 2018), and the *Friendliness* factor for rhesus macaques (Weiss et al., 2011b). In our study, we have also found a positive correlation between *subjective well-being* and *Extraversion* for killer whales. Additionally, we have found a correlation between the *subjective well-being* and the *Confidence* welfare factor, which reflects an aspect of welfare related to extraversion and openness (in fact, we have also found a correlation between *Extraversion* and the *Confidence* welfare factor). These associations demonstrate the importance of social relationships among intensively social cetaceans as the killer whales, which in the wild present complex social organizations (Baird, 2000; de Bruyn et al., 2013). Moreover, in captive settings, those relationships could explain the social buffering, a term related to the ability of a social partner to reduce stress responses (Hennessy et al., 2009; Kikusui et al., 2006). Another association found in killer whales is the negative correlation between *subjective well-being* and both *Abnormality* and *Nervousness* welfare factors. This finding does not come as a surprise, since abnormal behaviors, as well as those behaviors related to stress and anxiety, may indicate psychological

suffering and are known to have a negative impact on health outcomes in animals (Capitanio, 2011; Deary et al., 2010; Rollin, 2006). Thus, it would make sense that these results would spread across multiple species. Our results are in concordance with the negative correlation obtained between *subjective well-being* and abnormal behaviors (Robinson et al., 2017) and generalized anxiety (O'Connor et al., 2001) for chimpanzees, and are in accord with the negative correlation obtained between *subjective well-being* and *Neuroticism* found in humans (DeNeve and Cooper, 1998; Steel et al., 2008), chimpanzees (Robinson et al., 2017; Weiss et al., 2009), orangutans (Weiss et al., 2006), brown capuchins (Robinson et al., 2016), common marmosets (Inoue-Murayama et al., 2018), clouded leopards, snow leopards and African lions (Gartner et al., 2016). Another association found in our study with killer whales is the one between *subjective well-being* and *Dominance*, and the same correlation has been found in chimpanzees (King and Landau, 2003; Weiss et al., 2009). While in orangutans (Weiss et al., 2006) and gorillas (Schaefer and Steklis, 2014), *Dominance* was positively associated with the item related to the ability to achieve goals from the SWB questionnaire. The link between *Dominance* and *subjective well-being* could be due to the fact that dominance confers advantages that may lead to better welfare, including primary access to food, being less likely to be intimidated, more assertive and decisive, more adept at tactical deception and better at making allies (Weiss et al., 2002). We have also found a negative correlation between *Dominance* and both *Abnormality* and *Nervousness* welfare factors, as well as a positive correlation between *Dominance* and *Confidence* welfare factor. This is a logical correlation, since as previously mentioned, same correlations were found between those three welfare factors and the *subjective well-being* factor, and moreover the *subjective well-being* factor was related to *Dominance*. Finally, we have found a negative correlation between the *Conscien-Agreeableness* personality factor and the *Nervousness* welfare factor, and a negative correlation between the *Careful* personality factor with the *Sociability* welfare factor. We have not found similar correlations in the other studied species. However, the first correlation could be interpreted by the fact that those killer whales with higher conscientiousness and agreeableness

368 personalities are naturally calmer and more confident, while the second correlation may reflect
369 that cautious individuals tend to be less extroverted so as to avoid possible social conflicts.

370 Since there are no similar psychometric studies on cetaceans to serve as comparison to
371 our findings, in many respects' killer whales seem to have evolved associations among
372 personality, welfare and subjective well-being constructs, resembling closely to those found in
373 primates. Those results could be explained as evolutionary convergences, taking in
374 consideration that previous studies on social organization (Bearzi and Stanford, 2007; Connor et
375 al., 1998; Pearson, 2011), cognition (Marino, 2011, 2002; Reiss and Marino, 2001) or
376 personality (Úbeda et al., 2018), among others, indicated possible evolutionary convergences
377 due to the similarities shared between cetaceans and primates.

378 While welfare science itself is a rapidly evolving discipline that is still embroiled in
379 debate concerning the most effective methods for evaluating animal welfare, zoo and aquariums
380 associations are encouraging the development of studies and assessment tools to identify,
381 address and monitor welfare (Kagan et al., 2015; Whitham and Wielebnowski, 2013). Despite
382 this push, and unexpectantly due to the novelty of the science itself, to date very little behavioral
383 based research has focused on assessing and improving welfare on cetaceans in zoological parks
384 (see Brando et al., 2018 and Clegg and Butterworth, 2017 for a review). As a consequence of
385 the keeper's holistic knowledge of an animal's welfare, the use of the rating method is being
386 transferred to the assessment of animal welfare (Whitham and Wielebnowski, 2009). Being a
387 relatively new science, only a few studies related to cetacean welfare to date have used rating
388 methods (Clegg et al., 2019, 2015; Clegg and Butterworth, 2017; Joblon et al., 2014). However,
389 and to our knowledge, only Clegg and colleagues' study (2015) used multiple variables to
390 assess welfare in a cetacean, by applying 36 welfare measures to bottlenose dolphins, 58% of
391 them being animal-based measures (Whitham and Wielebnowski, 2013, 2009). Nevertheless,
392 this assessment needs more work to fully validate the measures, which are also currently
393 unweighted (Clegg and Delfour, 2018). Despite that, Clegg and colleagues' study represented
394 an important first step in the development of comprehensive and practical welfare assessment

tools for cetaceans. Our study in contrast, appears to be the earliest empirical proof of the use of a questionnaire for the welfare assessment on the order. Therefore, facilities housing cetaceans could use welfare questionnaires to gradually monitor welfare, so as to intervene if needed (Whitham and Wielebnowski, 2009). Additionally, it has been shown that personality is related to welfare in cetaceans, primates and felids. Thus, according to our results, those Introverted and less Dominant killer whales should be monitored more cautiously.

5. Conclusions

Our research represents the first empirical evidence of the utility of a welfare questionnaire for cetaceans, with (a) acceptable standards of reliability obtained among a high number of raters with high level of contact with the animals, and (b) validity evidenced with the correlations found with personality and subjective well-being questionnaires. It is crucial for cetacean welfare to increase the research efforts in this area. Therefore, future direction of this topic, must identify effective and useful assessment tools and applied them in an effort to improve cetacean welfare. Moreover, this study suggest that associations between personality and welfare previously found in primates, are also found in a cetacean species, probably due to evolutionary convergences.

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Authorship statement

This study was designed and conceptualized by YU and SO. YU, JA and TR coordinated the collection of the ratings at Loro Parque and SeaWorld. YU analyzed and interpreted the data.

The paper itself was written by YU. The paper was reviewed before submission by YU, SO, TR, ML and JA. All authors read and approved the final manuscript.

We conducted this research in accordance with all national and institutional guidelines for the care and management of cetaceans established by Loro Parque and SeaWorld.

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Table 1

Inter-rater reliabilities of welfare' items

Item	ICC(3,1)	ICC(3,k)
1. Good physical condition	.37	.97
2. Good feeding habit	.10	.85
3. Good health	.45	.98
4. Present injuries	.43	.97
5. Environment inspection	.37	.97
6. Abnormal behavior	.31	.96
7. Stereotypical behavior	.19	.92
8. Self-injury behavior	.49	.98
9. Species-typical behavior	.20	.92
10. Threatening/dominant displays	.59	.99
11. Receive aggressive behaviors	.40	.97
12. Perform aggressive behaviors	.42	.97
13. Enjoys environmental enrichment	.53	98
14. Likes changing enclosure	.46	.98
15. Likes changing group	.57	.98
16. Attachment to objects	.47	.98
17. Enclosure exploration	.21	.93
18. Breaching behavior	.52	.98
19. Motionless behavior	.54	.98
20. Problem solving	.08	.82
21. Frustration and stress	.60	.99
22. Self-directed behavior	.08	.80
23. Novelty acceptance	.79	.99
24. Social integration	.35	.96
25. Active affiliative context	.07	.79
26. Passive affiliative context	.51	.98
27. Avoids contact with conspecifics	.61	.99
28. Isolation	.55	.98
29. Playful engagement	.50	.98
30. Demanded to play	.49	.98
31. Normal sexual response	.31	.96
32. Vocalization	.24	.94
33. Seeks trainer attention	.45	.98
34. Dependency on humans	.38	.97
35. Adapts to routine	.56	.98
36. Collaboration in management	.51	.98
37. Interacts Humans > Conspecifics	.58	.99
38. Happy individual	.62	.99
39. Good Welfare	.22	.93

Note. First column indicates numbers and abbreviations of welfare items. Welfare items can be consulted on supplementary materials.

669 Table 2

670 *Inter-rater reliabilities of subjective well-being items*

Item	ICC(3,1)	ICC(3,k)
1. Happy	.37	.97
2. Social interactions	.55	.98
3. Achieve goals	.35	.96
4. Be killer whale	.46	.98

671 Note: Item numbers and abbreviations refer sequentially to the four items described in

672 *Subjective Well-being Questionnaire* Section.

673 Table 3

674 *Factor loadings obtained for Killer whales welfare*

	Principal Component Analysis						Regularized Exploratory Factor					
	F1	F 2	F 3	F4	F5	F6	F 1	F 2	F 3	F4	F5	F6
5. Environment inspection	**.83**	.08	.02	.07	-.08	.00	**.81**	.02	.14	.00	-.10	.00
13. Enjoy environmental enrichment	**.72**	.01	.10	.03	.12	.20	**.67**	-.02	.20	-.01	.09	.19
17. Enclosure exploration	**.63**	.34	-.04	-.03	-.17	.09	**.61**	.32	.07	-.07	-.11	.05
19. Motionless behavior	**-.62**	-.04	.56	.09	-.08	.10	**-.67**	.00	.39	.28	-.16	.14
16. Attachment to objects	**-.62**	-.02	.48	.05	-.06	-.03	**-.64**	-.01	.32	.21	-.13	.00
23. Novelty acceptance	**.60**	.04	-.26	.19	-.04	-.06	**.61**	.01	-.19	.05	-.02	-.04
35. Adapts to routine	**.57**	-.03	.16	.04	-.08	-.08	**.46**	-.03	.16	.02	-.08	-.02
14. Likes changing enclosure	**.56**	.40	.00	.25	.04	.13	**.60**	.32	.06	.19	.05	.05
15. Likes changing group	**.47**	.32	-.18	.13	.12	.30	**.51**	.28	-.09	.05	.15	.18
28. Isolation	-.09	**-.80**	-.01	.23	.06	.14	-.12	**-.76**	-.15	.14	-.03	.31
29. Playful engagement	.19	**.74**	-.10	-.07	-.32	-.11	.24	**.72**	-.03	-.06	-.22	-.24
27. Avoids contact with conspecifics	.18	**-.64**	-.15	.23	.11	-.02	.15	**-.60**	-.20	.12	.05	.11
25. Active affiliative context	.12	**.62**	.05	-.08	-.23	.38	.16	**.65**	.10	-.05	-.12	.24
30. Demanded to play	.32	**.61**	.10	-.03	.05	-.27	.32	**.46**	.19	.01	.05	-.36
24. Social integration	.32	**.52**	.11	.23	.09	-.11	.35	**.38**	.11	.19	.07	-.17
26. Passive affiliative context	-.14	**.44**	-.09	.10	.19	-.31	-.04	.27	-.05	.09	.15	**-.33**
6. Abnormal behavio	-.28	-.17	**.67**	-.08	-.23	.13	-.38	-.12	**.54**	.05	-.31	.19
7. Stereotypical behavior	-.05	-.20	**.62**	-.15	-.13	-.03	-.18	-.16	**.50**	-.03	-.19	.05
22. Self-directed behavior	.14	.27	**.59**	-.25	.22	.01	.02	.19	**.61**	-.07	.15	-.04
8. Self-injury behavior	.07	.20	**.58**	-.10	.17	.08	-.01	.12	**.53**	.02	.07	.03
9. Species-typical behavior	.47	-.04	**-.54**	.21	.16	.16	.42	-.04	**-.46**	.02	.22	.14
4. Present injuries	.27	.09	.38	-.16	.05	-.04	.14	.06	**.36**	-.06	.01	-.03
1. Good physical condition	.15	-.04	-.27	**.74**	.08	-.13	.28	-.12	-.39	**.59**	.03	-.10
39. Good Welfare	.24	-.04	-.37	**.64**	-.11	.21	.37	-.02	-.41	**.44**	-.09	.23
3. Good health	-.04	-.21	-.12	**.62**	.05	-.34	.05	-.28	-.27	**.47**	-.02	-.22
38. Happy individual	.19	.22	-.24	**.52**	-.12	.42	.31	.25	-.32	**.35**	-.06	.35
2. Good feeding habit	-.25	-.19	28	**.50**	.41	.05	-.21	-.27	.11	**.48**	.27	.09
31. Normal sexual response	.36	-.17	-.21	**.49**	-.11	.43	.43	-.10	-.30	.31	-.09	**.47**
21. Frustration and stress	.16	-.01	-.21	-.02	**.71**	.18	.17	-.06	-.07	.01	**.69**	.13
12. Performs aggressive behaviors	.07	.01	-.39	-.11	**.59**	.18	.10	.00	-.22	-.09	**.60**	.10
11. Receives aggressive behaviors	.14	.34	-.11	-.04	**-.59**	.06	.17	.38	-.10	-.11	**-.46**	.01
10. Threatening/dominant displays	-.02	-.37	.21	-.03	**.56**	-.05	-.09	-.40	.21	.06	**43**	.01
36. Collaboration in Management	.16	-.15	-.02	.37	**-.52**	.16	.19	-.06	-.17	.21	**-.45**	.22
18. Breaching behavior	.05	.04	.00	.14	**.45**	-.02	.08	-.07	.02	.12	**.32**	-.05
32. Vocalize	.24	.33	-.22	.14	-.39	.38	.31	**.40**	-.21	.03	-.27	.28
34. Dependency on Humans	.07	-.19	-.06	.05	.06	**.67**	.08	-.08	-.07	-.01	.07	**.57**
20. Problem solving	.08	.04	-.06	.07	-.11	**-.47**	.06	.01	-.07	.04	-.08	**-.31**
37. Interacts Humans > Conspecifics	.30	-.37	.11	.19	-.12	**.45**	.25	-.25	.02	.10	-.12	**.49**
33. Seeks trainer attention	-.35	.03	.23	-.20	-.07	.37	**-.35**	.10	.19	-.10	-.05	.27

675 *Note*. First column indicates numbers and abbreviations of welfare items. Welfare items can be
676 consulted on supplementary materials.
677 *Note.* Boldface indicates salient loadings
678

Table 4

Correlations between P.C.A. and R.E.F.A. for the Welfare questionnaire

	P.C.A.					
	Confidence	Sociability	Abnormal	Over. welf.	Nervous.	Self-suffic.
R.E.F.A.						
Confidence	**.98**	.29	**-.59**	.21	-.09	.08
Sociability	.23	**.98**	-.06	-.30	-.35	.02
Abnormal	-.29	.12	**.95**	**-.68**	.05	-.14
Over. Welf.	-.22	-.28	-.16	**.91**	.05	-.10
Nervous.	.04	-.10	-.20	-.07	**.97**	-.05
Self-suffic.	-.00	**-.43**	-.09	.13	-.14	**.94**

Note: Over. welf. = Overall welfare; Nervous. = Nervousness; Self-suffic. = Self-sufficiency

Note: Boldface indicates salient loadings

Table 5

Factor intercorrelation matrix for the factor obtained for the Welfare questionnaire

Factor	Confidence	Sociability	Abnormal	Over. welf.	Nervous.	Self-suffic.
Confidence	-					
Sociability	.29	-				
Abnormal.	-.39	-.14	-			
Over. Welf.	.26	-.10	-.22	-		
Nervous.	-.03	-.11	.04	-.06	-	
Self-suffic.	.33	.12	-.20	.28	-.25	-

Note: Over. welf. = Overall welfare; Nervous. = Nervousness; Self-suffic. = Self-sufficiency

Table 6

Correlation between Personality and Welfare factors

	Extraversion	Conscien-Agree	Dominance	Careful
Confidence	**.82**	-.42	**.64**	-.43
95%CI	[.54, .99]	[.89, -.04]	[.43, 1.30]	[-4.18, -.27]
Sociability	.22	-.06	.26	**-.73**
95%CI	[-.15, .50]	[-.46, .34]	[-.17, .77]	[-4.46, -1.92]
Abnormal	-.31	.07	**-.60**	-.25
95%CI	[-.36, .05]	[-.21, .29]	[-.69, -.20]	[-1.85, .44]
Over. welf.	.20	-.12	.17	.44
95%CI	[-.05, .14]	[-.15, .08]	[-.08, .19]	[.07, 1.03]
Nervousness	.37	**-.55**	**-.57**	-.00
95%CI	[-.01, .30]	[-.42, -.09]	[.12, .51]	[-.91, .90]
Self-suffic.	-.15	-.15	-.20	.21
95%CI	[-.21, .10]	[-.25, .12]	[-.34, .11]	[-.42, 1.29]

Note: Over. welf. = Overall welfare; Self-suffic. = Self-sufficiency; Conscien-Agree. = Conscien-Agreeableness

Note. Boldface correlations are significant at $p<0.01$

Table 7

Correlation between personality factors and subjective well-being factor

	Extraversion	Conscien-Agree	Dominance	Careful
SWB	**.62**	-.31	**.61**	-.04
95%CI	[.02, .06]	[-.06, .01]	[.03, .09]	[-.17, .14]

Note: Conscien-Agree. = Conscien-Agreeableness

Note. Boldface correlations are significant at $p<0.01$

Table 8

Correlation between welfare factors and subjective well-being factor

	Confidence	Sociability	Abnormal	Over. welf.	Nervousness	Self-suffic.
SWB	**.71**	-.20	**-.73**	.46	**-.66**	.29
95%CI	[.03, .07]	[-.05, .02]	[-.13, -.06]	[.03, .25]	[.06, .17]	[-.02, .12]

Note: Over. welf. = Overall welfare; Self-suffic. = Self-sufficiency

Note: Boldface correlations are significant at $p<0.01$

Supplementary materials (Welfare questionnaire)

This questionnaire has thirty-nine questions, all relating to the welfare of the killer whales at your zoo. The following scale should be used to make your ratings.

1. Displays either total absence or negligible amounts of the trait or state.
2. Displays small amounts of the trait on infrequent occasions.
3. Displays somewhat less than average amounts of the trait.
4. Displays about average amounts of the trait.
5. Displays somewhat greater than average amounts of the trait.
6. Displays considerable amounts of the trait on frequent occasions.
7. Displays extremely large amounts of the trait.

Please give a rating for each item even if your judgment seems to be based on a purely subjective impression of the killer whale and you are somewhat unsure about it. Indicate your rating by placing a cross in the box underneath the chosen number.

Finally, do not discuss your rating of any particular killer whale with anyone else, because this restriction is necessary in order to obtain valid reliability coefficients for the traits.

Killer whale' name: …….

Rater' name: …….

Date: …….

1. The killer whale has a good physical condition and a healthy appearance (color, pigmentation/discoloration, fin shape, constitution/weight)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

2. The killer whale has good feeding habits (food intake quantity, variety of foods, accepts all meals or doses provided, accepts/rejects certain foods)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

3. The killer whale is in good health (no chronic illnesses or tendency to catch illnesses)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

4. The killer whale often shows visible physical injuries

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

5. The killer whale inspects the elements of its environment and enclosure

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

6. The killer whale shows abnormal and/or non-desirable behaviors

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

7. The killer whale shows stereotypies or frequent and repetitive behaviors [vomiting, pacing (circling swim), biting on gates and bars, tongue playing, bobbing up and down, others…]

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

8. The killer whale shows self-injury behavior

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

9. The killer whale shows species-typical behaviors

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

10. The killer whale often performs jaw-popping and shows other threatening or dominant displays towards other group members

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

11. The members of the group shows aggressive behaviors towards the killer whale

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

12. The killer whale shows aggressive behaviors towards other members of the group

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

13. The killer whale interacts and enjoys the environmental enrichment

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

14. The killer whale shows an interest in changing enclosure

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

15. The killer whale shows interest in changing the social configuration of the group

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

16. The killer whale has a special attachment to objects and struggles to separate from them

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

17. The killer whale explores and moves throughout the entire enclosure

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

18. The killer whale tends to breach

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

19. The killer whale tends to lay motionless at the bottom of the pool or floating at the surface (logging behavior)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

20. The killer whale is creative, proactive, and able to solve problems

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

21. The killer whale often gets frustrated and stressed out easily

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

22. The killer whale often performs self-directed behavior such as scratching (scratching against the wall)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

23. The killer whale accepts novelty well (new enrichments, new foods, new trainers)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

24. The killer whale is integrated into its social group

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

25. The killer whale is actively involved in affiliative context (proactive behavior)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

26. The killer whale is often passive in affiliative context (reactive behavior)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

755 27. The killer whale avoids any contact with members of its group

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

756 28. The killer whale tends to be isolated from other group members

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

757 29. The killer whale engages in playful interactions

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

758 30. The killer whale is usually solicited by other group members for playing

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

759 31. The killer whale shows normal sexual responses (no aberrations or lack of response)

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

760 32. The killer whale tends to vocalize

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

761 33. The killer whale seeks the attention of his/her trainer

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

762 34. The killer whale has a high dependence on humans

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

763 35. The killer whale adapts and accepts the routine of the zoo

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

764 36. The killer whale collaborates in trainer management

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

765 37. The killer whale often interacts more with humans than with other killer whales of its group

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

38. The killer whale is overall a happy individual

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most

39. The killer whale's welfare is overall good

	1	2	3	4	5	6	7	
Least	☐	☐	☐	☐	☐	☐	☐	Most