

**PERSONALITY TRAITS IN THE ATLANTIC SPOTTED DOLPHIN (*STENELLA
FRONTALIS*): SYNDROMES AND PREDICTORS OF NEOPHILIA**

by

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The Charles E. Schmidt College of Science
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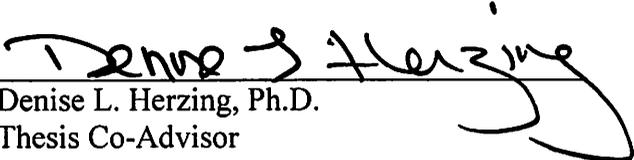
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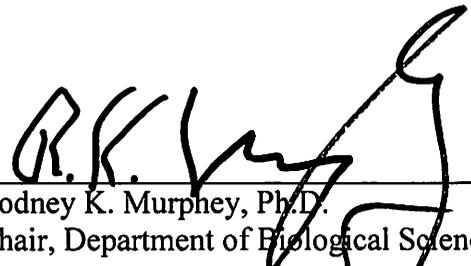
This thesis was prepared under the direction of the candidate's thesis co-advisors, Dr. Denise L. Herzing and Dr. Kate Detwiler, Department of Biological Sciences, and has been approved by the members of his supervisory committee. It was submitted to the faculty of the Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

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Personality is defined as inter-individual variation of behavioral traits while maintaining intra-individual stability. The focus of this study was to observe distinct personality trait categories, establish baseline personality trait phenotypes for the juvenile population, and compare the personality phenotypes between different categories, such as sex or generation. Three personality traits were studied—sociability, curiosity, and boldness—based on the percentage of time individuals spent with conspecifics, human researchers, and their mothers, respectively. The surveyed individuals significantly varied positively and negatively from the means of each trait, and no significant difference for any trait was found between males and females, or across time periods. A moderately strong correlation was discovered between two personality traits, boldness and curiosity, suggesting a personality syndrome. The second primary goal was to use the aforementioned baseline to determine if personality traits can be used to predict

neophilic behavior specific to human-dolphin communication research. Six of the study subjects were more prone than their peers to engage with the two-way work, and these individuals were more bold—spent less time with their mothers—than the other subjects. This suggests that boldness has some predictive capabilities towards this type of neophilia.

DEDICATION

To Robin and Sofi: my two favorite ladies, my sanity, and my home.

**PERSONALITY TRAITS IN THE ATLANTIC SPOTTED DOLPHIN (*STENELLA
FRONTALIS*): SYNDROMES AND PREDICTORS OF NEOPHILIA**

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INTRODUCTION

Personality

Personality is defined as consistent individual variation of behavioral responses to external stimuli, while maintaining intra-individual stability (Biro & Stamps, 2008; Stamps, 2007). The study of animal personality is a relatively new field, yet robust studies have shown both inter-individual variation and intra-individual stability (“personality”) across an extremely wide variety of taxa. A few basic personality traits are well agreed upon: (1) boldness, (2) curiosity towards novelty (neophilia), and (3) sociability (Bergman & Kitchen, 2009; Massen, Antonides, Arnold, Bionda, & Koski, 2013; Reale, Reader, Sol, McDougal, & Dingemanse, 2007).

Boldness is generally defined as a willingness to take risks, and has been measured in pumpkinseed sunfish (Coleman & Wilson, 1998), tropical poeciliids (Brown, Jones, & Braithwaite, 2005), Iberian rock lizards (Lopez, Hawlena, Polo, Amo, & Martin, 2005), dumpling squid (Sinn, Gosling, & Moltshaniwskyj, 2008), and many others, including numerous non-human primates such as baboons (Carter, Marshall, Heinsohn, & Cowlshaw, 2012) and grey mouse lemurs (Dammhahn & Ameling, 2012). Neophilia is defined as a willingness to engage with, or curiosity towards, novel objects for extended periods of time (Bergman & Kitchen, 2009). This trait has been measured across many taxa as well, such as the common octopus (Kuba, Meisel, Byrne, Griebel, & Mather, 2003), the Lake Tanganyika cichlid (Bergmüller & Taborsky, 2007), and the lake frog (Wilson & Krause, 2012), and across a wide variety of mammals, including grey seals

(Twiss & Culloch, 2012), voles (Herde & Eccard, 2013), and baboons and geladas (Bergman & Kitchen, 2009). Sociability has not been studied in as wide a breadth of taxonomic groups as boldness and curiosity, yet is still prevalent among social species, such as cowbirds (Kohn, King, Pott, & West, 2013), rhesus macaques (Capitanio, 2002), and chimpanzees (Koski, 2011).

These personality continua are neither one-sided nor binary. The other end of the “boldness” spectrum is “shyness,” with the most bold and most shy individuals representing the two extremes of the boldness continuum. An individual is not strictly bold or shy; though an individual may tend toward one extreme of the spectrum or the other (Réale et al., 2007; Wilson, Clark, Coleman, & Dearstyne, 1994), the traits are also expressed in moderation (Réale et al., 2007). A tropical poeciliid may be extremely bold (and willing to undertake great predatory risk), extremely shy (very timid and completely averse to taking risks), or somewhere in between—but all poeciliids will fit somewhere along this continuum (Brown et al., 2005).

Personality Syndromes

Consistent correlations and covariations among traits, called behavioral or personality syndromes (Sih, Bell, & Johnson, 2004), have also been reported. In species such as the social spider (Pruitt, Grinsted, & Settepani, 2013) and rhesus macaques (Brent et al., 2013), bold individuals have a robust tendency to be aggressive as well.

Correlations between boldness and neophilia (curiosity towards novel objects) have been reported in three- and nine-spined sticklebacks (Webster, Ward, & Hart, 2009), lemurs (Dammhahn & Almeling, 2012), and chimpanzees (Massen et al., 2013). Chimpanzees

also develop friendships, and will group with non-kin who exhibit similar levels of sociability and boldness (Massen and Koski, 2014). Lion-tailed macaques display syndromes of boldness, curiosity, and sociability (Rouff, Sussman, & Strube, 2005). Sometimes these traits do *not* correlate: a study by Carter, Marshall, Heinsohn, & Cowlshaw (2012) found that in baboons, boldness (towards a threat stimulus) and neophilia (towards novel foods) do *not* represent a behavioral syndrome. While both sociability and neophilia were measured in crested macaques, they were not correlated (Neumann, Agil, Widdig, & Engelhardt 2013).

Personality in Cetaceans

Very little work with personality has been done on one of the more social and cognitively-advanced families: Delphinidae. Several species within this family have been extensively studied in terms of their social intelligence, such as (1) maternal teaching in Atlantic spotted dolphins (*Stenella frontalis*) and bottlenose dolphins (*Tursiops truncatus*) (Bender, Herzing, & Bjorklund, 2008; Sargeant & Mann, 2009); (2) cultural transmission of information in resident killer whales (*Orcinus orca*) (Yurk, Barrett-Lennard, Ford, & Matkin, 2001); and (3) cognitive functioning (including joint attention and referential communication) in bottlenose dolphins (Xitco, Gory, & Kuczaj, 2004). Yet few studies have measured the different personality continua of cetaceans. Two notable exceptions are Highfill and Kuczaj (2007), and Birgersson (2010). These studies looked at personality in bottlenose dolphins (*Tursiops truncatus*) through the “five-factor model,” measuring experience, conscientiousness, extroversion, agreeableness, and neuroticism. However, these studies were qualitatively rated by

subjective observers (i.e., trainers), and correlated personality traits (syndromes) were not explored. At the time of publication, no other study has quantitatively measured individual personality traits or personality syndromes in a wild delphinid species.

Study Population

Since 1985, the Wild Dolphin Project (WDP), led by Dr. Denise Herzing, has been studying a wild, human-habituated group of resident Atlantic spotted dolphins (*Stenella frontalis*) on the Little Bahama Bank (LBB) off the northern coast of Grand Bahama Island. This population of dolphins offers a unique opportunity to study underwater behavior and personality traits. The 31-year study has yielded information on sex, age, maternal relationships, and paternal relationships via molecular analysis of fecal sampling, (Green, 2008). Beyond the studies of life-history (Herzing, 1997), the WDP has also conducted long-term studies on behavior and development (Miles & Herzing, 2003; Bender et al., 2008), social learning (Herzing, 2005), social structure (Welsh, 2007; Elliser, 2010), and communication and vocalizations (Au & Herzing, 2003; Herzing, 1996; Herzing 2004; Lammers et al., 2003). The dolphins tend to prefer associations with their kin—primarily their mother (Herzing & Brunnick, 1997)—but create many non-kin coalitions (Welsh & Herzing, 2008), indicative of their fission-fusion society (Elliser & Herzing, 2012).

Candidates for Personality Research

The Wild Dolphin Project is primarily observational and non-experimental, with over 30 years of video footage. This extensive catalogue of dolphin behavior is ideal for

measuring basic personality traits, such as boldness, sociability, and curiosity towards humans. Some traits, such as neophilia, are more difficult to measure. Although dolphins are generally curious animals, observing a dolphin coming across novel objects at this particular study site is too rare an event to produce sufficient data (Herzing, unpublished data). However, neophilic behavior has been observed in this population in another context.

Due to the unique nature of interactions and curiosity shown by this community of dolphins towards humans over the decades, one of the goals of the WDP is to create an interface to directly explore and study their cognition and ability to communicate with humans. Dolphins were exposed to a two-way human/dolphin interface in 1997-2000, and 2013-present (Herzing et al. 2012; Herzing, unpublished data). Researchers labeled ‘play’ objects (such as scarves and sargassum) with visual and/or acoustic symbols, and the humans modeled play behavior to the dolphins by requesting items from each other using symbols, sounds, and pointing. Three females from the 1990s (Caroh, LittleHali, and Tink) and three females from the 2010s (Meridian, Nereide, and Tristan), were more engaged with these trials than their peers, indicating a curiosity towards novelty—or neophilia. These six individuals will be referred to as neophilic juvenile dolphins, or NJDs.

The Significance of Personality Syndrome Research

Knowing which juvenile Atlantic spotted dolphins are neophilic—thus prone to engage with the two-way communication research—would be beneficial to the Wild Dolphin Project, but neophilia is not otherwise easily measured. However, one of the

traits that is readily observable in this population—boldness—is a fairly common syndrome of neophilia (Dammhahn & Almeling, 2012; Massen et al., 2013). If boldness is correlated with neophilic behavior in Atlantic spotted dolphins, this syndrome may have a predictive capability: bold individuals would be more prone to engage with the two-way communication project.

Research has shown that personality can predict behavior. In horses, high levels of extroversion (measured subjectively) predicted both the time it would take to complete a handling test (walking across a foreign blue tarp on the ground) and neophilia (willingness to investigate novel objects) (Ijichi, Collins, Creighton, & Elwood, 2013). Neuroticism predicted how reactive an individual was to sudden visual stimuli, such as an umbrella opening in close proximity to the horse. In dogs, van der Borg, Netto, and Planta (1991) qualitatively tested four separate problem-related personalities: aggressiveness, fearfulness, obedience, and anxiousness, measured via behavioral responses to different stimuli. These behavioral tests of the dogs were better predictors of problematic behaviors than the subjective opinions of the staff at the shelter. In both of these studies, personality predicted future behavioral responses.

Research Objectives

This study aimed to better understand (1) the observable personality traits of juvenile Atlantic spotted dolphins of Little Bahama Bank, and (2) the relation between these personality traits and neophilic behavior. Each of these distinct primary questions had its own set of hypotheses. The first primary question was to discover the personality baseline of this population of dolphins: determining where individuals lie on the three

continua of boldness, sociability, and curiosity towards humans, whether or not different groups vary according to sex or generation, and searching for correlations between the three distinct personality traits to identify consistent personality syndromes. The second primary question asked if it was possible to use these quantitatively measured personality traits to predict behavior, specifically neophilia. Including the six neophilic juvenile dolphins (NJDs) allowed for a comparison between neophilic and non-neophilic individuals, in search for any personality phenotypes that are unique to—and thus predict—neophilic behavior towards two-way communication research.

METHODS

Study Site

The study site for the Wild Dolphin Project is on the Little Bahama Bank (LBB) off the northern coast of Grand Bahama Island, 64 km from the east coast of Florida. LBB is an unprotected shallow sand bank ranging from 6-16 m in depth, with significantly greater depths surrounding the bank—the western border drops to over 500 m deep in the Gulf Stream. The bank has a white sandy bottom with scattered areas of rock, reef, and patches of sea grass, with an average visibility of 30 m, ideal for underwater photography and videography.

Study Population

The WDP has identified and catalogued over 200 individual resident Atlantic spotted dolphins that live on LBB. This species is categorized by four distinct age classes: calves are known as two-toned (1-3 years), juveniles are speckled (4-8), young adults are mottled (9-15), and adults are fused (16+), based on the pigmentation of the individual (Herzing, 1997; modified from Perrin et al., 1987). Female gestation lasts about 12 months, with an average birth interval at 3 years. Calves are weaned at 3-4 years, coinciding with the following birth (Herzing, 1997). Unweaned calves spend the majority of their lives at their mother's side, and the bond between mother and calf represents the strongest association of Atlantic spotted dolphins (Herzing & Brunnick, 1997). The calves leave their mother's side to play and otherwise engage with their

peers, as well as check out novel objects, humans, etc., but spend significant amounts of time at their mother's side (Miles & Herzing, 2003). Calves tend to swim in close proximity to their mothers for two reasons: first, because of the aforementioned strength of their bond, but also for protection—for an open-water species, there is nothing to hide behind besides a larger individual (Connor et al., 1998).

The Wild Dolphin Project Database

The WDP has been collecting video during the summer months (May – September) since 1985. Underwater video was collected using a variety of video cameras (e.g. 8mm high def) with attached hydrophones to document the underwater behavior and sound (Herzing, 1996). In addition to the researcher(s) collecting video, other researchers entered the water with underwater cameras to take photo-identification shots. The combination of video and photography has allowed the WDP to successfully identify and record the life-history of individuals since the project began. Observations for this study were exclusively from video-recorded encounters over the past 31 years.

The WDP's video database is integrated with an encounter database, complete with written details of every encounter filmed. This database includes information on the individuals present, the group size, the behaviors observed, and the relationships of the animals (such as mother-calf), as well as all data of the physical environment of the encounter (such as latitude/longitude, depth, water temperature, cloud cover, sea state, swell, and wind direction).

Video Sample Size

Individual 1-4 year-old two-toned dolphins were observed in the presence of their mothers. Across the 31 years of video within the WDP database, there are 100 total individuals with more than 15 total encounters during their sub-adult (two-toned and speckled) years (range: 15-167 encounters). Research was split into two time periods, looking at 10 juveniles that were born before the onset of the two-way communication work that began in 1997 (range: 1991-1995), and nine juveniles born in the late 2000s (range: 2007-2010). This restraint was in place to keep data from being too skewed, should unforeseen circumstances in a certain time period affect the personalities of either generation of research subjects. In addition, splitting the years into pre- and post-1997 allowed for a comparison of the three NJDs of each time period (1990s and 2000s) to their less-neophilic contemporary peers.

Six females (Caroh, LittleHali, Tink, Heaven, Rosebud, and Rosepetal) and four males (Geo, Latitude, Leo, and Mel) were included as subjects from the 1990s, and four females (Meridian, Nereide, Tristan, and Pointless) and five males (Achilles, Copper, Leucadia, Nematocyst, and Val) were included as subjects from the 2000s. The original plan was to have five males and five females from each time period, but ultimately individuals had to be chosen due to the viability of the research footage—clarity of the video and time an individual spent in-frame. This study focused on the aforementioned 19 individuals based on the amount of their high-quality footage.

Behavioral Ethogram

Three separate personality traits were observed in each individual, measured by the time spent in differing bold, curious, or social “states.” Boldness was measured by the amount of time the juvenile spent with its mother. Two-tones spend a significant amount of time in close proximity to their mother, as this represents their strongest social bond (Herzing & Brunnick, 1997). The inter-individual variation of time spent with, or apart from, mothers is an indicator of shyness or boldness, respectively. A two-toned dolphin spending significantly more time than its conspecifics in close proximity to its mother is described as shy, not unlike a small child afraid to leave the safety of her mother. Boldness in this study—how willing an individual is to stray from its protective mother’s side—was a measure of the calf’s willingness to take risks. The boldness ethogram measured (B_1) percentage of observed time spent more than 1 body-length away from the mother. (Table 1)

To measure sociability, the same criteria was used as boldness, but with conspecifics instead of an individual’s mother: the percentage of observed time spent within 1 body length of non-maternal conspecifics (S_1). Behavior was coded as “non-social” when subjects were alone, or when the only conspecific within 1 body length was the individual’s mother.

Curiosity towards humans was measured by (C_1) the percentage of observed time spent near humans, again within one body length. In many cases this was the researcher filming the encounter, but could be any other human in the water. While exact distances of proximity were estimated during coding, intra- and inter-observer reliability testing adquetly controlled for subjectivity. (Table 2)

After measuring the behaviors, each individual's personality-specific data set (personality phenotype) was compared to the rest of the population. In other words, the percentages of time a subject spent at least one body length away from its mother, a conspecific, or a human, were compared to the data of the other subjects. This comparison allowed for a characterization of each individual for each of the three traits. For example, the measure of boldness characterized each individual as bold, shy, or neutral (i.e., not statistically different from the mean). (Table 3)

Video Analysis

Video was imported from the WDP video database into the program BORIS (Behavioral Observation Research Interactive Software), an open-source event-logging software for behavioral observation (created by Olivier Friard and Marco Gamba at the University of Torino, Italy). For each video, the individual's behavior was scored via the primary ethogram (Table 1), which was programmed into BORIS. Individuals were observed with continuous focal sampling, noting "start" and "stop" events for the behavior listed in the ethogram. Many clips had multiple individuals relevant to the study, and in those cases each individual was focally scored independently.

All video clips came from the first four years of an individual's life, and all clips with the relevant subject "in frame" for at least 30 seconds were included in the study. For each clip, all three personality traits were measured. Subjects were included in the study if there was at least 840 total seconds of footage (range: 868-2084), or 14 minutes. To control for developmental variations of behavior, footage was selected from distinct

ages, with at least 420 seconds (7 minutes) from the individual's first two years of life (range: 434-1633), and at least 420 from the second two years (range: 420-1138).

Hypotheses Tested

Primary Question 1:

What is the personality baseline of the juvenile resident Atlantic spotted dolphins at Little Bahama Bank across the personality continua of boldness, sociability, and curiosity towards humans?

Hypothesis 1:

H₀: There is no significant variation in any of the three personality types measured in juvenile Atlantic spotted dolphins.

H₁: There is significant variation in at least one of the three personality types measured in juvenile Atlantic spotted dolphins.

Hypothesis 2:

H₀: There are no significant variations between males and females across any of the three personality types measured in juvenile Atlantic spotted dolphins.

H₁: There is at least one significant variation between males and females across any of the three personality types measured in juvenile Atlantic spotted dolphins.

Hypothesis 3:

H₀: There are no significant variation between individuals from the 1990s and the 2000s across any of the three personality types measured in juvenile Atlantic spotted dolphins.

H₁: There is at least one significant variation between individuals from the 1990s and the 2000s across any of the three personality types measured in juvenile Atlantic spotted dolphins.

Hypothesis 4:

H₀: There are no significant correlations between distinct personality traits in the population.

H₁: There is at least one significant correlation between distinct personality traits in the population.

Primary Question 2:

Can boldness, sociability, or curiosity towards humans predict neophilic behavior?

Hypothesis 5:

H₀: There are no significant variations between any of the three individual personality traits of the NJDs, compared to the juvenile dolphin baseline.

H₁: There is significant variation between at least one individual personality trait of the NJDs, compared to the juvenile dolphin baseline.

Hypothesis 6:

H₀: There are no significant variations between the interindividually consistent syndromes of personality traits of the NJDs, and the juvenile dolphin baseline.

H₁: There are significant variations between the interindividually consistent syndromes of personality traits of the NJDs, and the juvenile dolphin baseline.

Statistical Analysis

Video length and overall time for each individual varied, but was standardized through data collection, as all measurements were percentages of time an individual spent in a various state. All data for each of the three personality traits was not normal (Shapiro Wilk $p < .001$), and non-parametric statistical tests were run in SPSS.

Hypothesis 1 (variation of individual dolphins from the mean) was tested with the One-

sample Wilcoxon Signed Rank test. Hypotheses 2, 3, and 5 (variation between males versus females, 1990s versus 2000s individuals, and the NJDs versus the baseline population, respectively), were tested with the Mann-Whitney U test. Hypothesis 4 (correlations between distinct personality traits) was tested for Pearson correlations.

Intra- and Inter-observer reliability tests

To strengthen the results, 26.3% of the subjects (n=5, Caroh, LittleHali, Meridian, Nematocyst, and Tink) were scored multiple times to ensure intra-observer and inter-observer reliability. A total of 27.2% of those subjects' encounters were scored twice by the primary observer for intra-observer tests. A randomly chosen different set of 25.9% of their encounters were scored by a second trained observer for the inter-observer tests. To determine inter- and intra-observer reliability, an interrater reliability (Kappa) test was run using SPSS, allowing a 1-second tolerance window. Kappa correlation values of greater than 0.70 were considered good levels of agreement. Inter- and intra-observer reliabilities for all individuals were found to be greater than Kappa = .078 ($p < 0.010$). (Table 2)

RESULTS

Primary Question 1 — Personality Baseline

Interindividual Variation of Sociability, Curiosity, and Boldness

Significant variation from the group means were discovered in all three traits. For sociability, the mean percentage of time spent in close proximity to a conspecific was 37.56% (n=19). Three dolphins were significantly more social (i.e. spent a greater percentage of time with non-maternal conspecifics) than this mean, and four were significantly less social. For curiosity, the mean percentage of time spent in close proximity to a human was 33.50% (n=19). Three dolphins were significantly more curious (i.e. spent a greater percentage of time in proximity to humans) than this mean, and four were significantly less curious. Lastly, for boldness, the mean percentage of time spent *not* in close proximity to one's mother was 35.57% (n=18). Two dolphins were significantly more bold (spent a greater percentage of time away from their mother) than this mean, and four were significantly more shy. One individual, Tink, was not included in boldness/shyness measures, as no clips could be found of her with her mother. Overall, 10 of 19 subjects exhibited variation from at least one personality mean (all p values < 0.05), two individuals exhibited variation across two personality traits, and four individuals varied from the mean across all three traits. (See: Table 3; Figure 1.)

Variation Between Sexes

There was no significant variation of males versus females for sociability with conspecifics ($p=0.842$), curiosity towards humans ($p=0.400$), or boldness/shyness ($p=0.258$). (Table 4)

Variation Between Generations

There was no significant variation between 1990s subjects and 2000s subjects for sociability ($p=0.661$), curiosity ($p=0.065$), or boldness ($p=0.436$). There was no statistically significant sex-specific or generation-specific variation across across any of the three personality traits for this population. (Table 4)

Syndromes, or Correlations of Personality Traits

There was no correlation between boldness and sociability (Pearson's coefficient of -0.397 , $p(\text{two-tailed})=.103$, $n=18$) or curiosity and sociability (Pearson's coefficient of 0.029 , $p(\text{two-tailed})=.907$, $n=19$). There was a significant correlation, or syndrome, between boldness and curiosity towards humans (Pearson's coefficient of 0.496 , $p(\text{two-tailed})=.036$, $n=18$). This coefficient states that for each percentage point increase of boldness, there is an expected correlated 0.496 percent increase of curiosity towards humans. In terms of observed behavior, for each unit of time an individual spends away from its mother, it is expected to spend 0.496 more units of time in proximity to humans. (See: Table 5)

Primary Question 2 – Personality Traits Predicting Neophilia

Consistent Personality Traits Among the Neophilic Juvenile Dolphins

There was significant variation between the NJDs and the baseline population for only one of the three measured personality traits: boldness. The five measured NJDs (Caroh, LittleHali, Meridian, Nereide, and Tristan) spent 45.64% of their time away from their mothers, whereas their non-neophilic peers spent on average only 31.70% of their time away from their mothers ($p=0.046$). In other words, the neophilic individuals were significantly more bold than the baseline population. (Table 4)

Consistent Syndromes Among the Neophilic Juvenile Dolphins

No NJD-specific syndromes or combinations of personality traits were found, and thus cannot significantly vary from the juvenile dolphin baselines in this respect.

DISCUSSION

Primary Question 1 – Personality Trait Baseline

The interindividual variability for all three of the traits measured—sociability, curiosity, and boldness—is consistent with the growing body of quantitative personality research. Subjects varied from the baseline means for all three traits both positively and negatively. This variation of personality phenotypes describes the personality baseline of juvenile resident Atlantic spotted dolphins on Little Bahama Bank—the first primary question. The average juvenile from this population of Atlantic spotted dolphin spends 37.56% of its time exhibiting sociability, 33.50% of its time exhibiting curiosity towards humans, and 35.57% of its time exhibiting boldness. However, these baselines serve only as averages, as at least 33% of the subjects varied (sometimes greatly) from these means (36.8% of subjects varied from the baseline mean of both sociability and curiosity, and 33.3% from the mean of boldness). (See: Figure 1.)

While there was a significant amount of interindividual variability, these variations were not found across sex or generations. Male juveniles were not significantly more or less sociable, curious, or bold than their female counterparts, and subjects from the 1990s did not vary from subjects in the 2000s. The wide variety of interindividual variability offers its own set of unique implications, which will be discussed in subsequent sections.

Primary Question 1 – Syndrome of Boldness and Curiosity

Subjects exhibited a moderately strong significant correlation between two traits: boldness and curiosity (Pearson's correlation=0.496). The discovery of this syndrome augments the description of the personality baseline of this population, consistent with the other personality research. Correlations between personality traits are relatively common across many taxa, from chimpanzees to stickleback fish. A syndrome of boldness and curiosity has also been found in lion-tailed macaques (Rouff et al., 2005).

The correlation between boldness and curiosity towards humans makes sense for this population, given the in-water interactions observed between juveniles, mothers, and humans. It is important to note that these two traits are not mutually exclusive: boldness and curiosity can be measured independently from each other. All dolphins—mothers and calves alike—have exceptional speed and maneuverability in the water, allowing *them* to choose whether or not to be in proximity to a human. This highlights a potential drawback of this study's ethogram: a very shy and non-curious calf would prefer to both stay by her mother and avoid humans. If her mother approaches a human, her desire to keep her distance from the human could be overridden by her need (as a shy individual) to remain by her mother's side, thus inflating her curiosity score.

The ethogram was specifically tailored to account for this. The measurement for all three behaviors—"within one body length of a individual"—was explicitly chosen for curious behavior, because it allows a calf to choose whether or not to be near a human regardless of its mother's proximity to a human. For example, if a calf was simply being shy (and closely following its mother), it would still have the option of swimming on the "no-human" side of its mother (outside of the one body length from the human), while

remaining by *her* side. In other words, this ethogram specifically allows for a subject to follow its mother as *she* swims in proximity to humans, but still maintain its personal distance (and remain non-curious). This was a relatively common occurrence during coding—many individuals that ended up classified as less-curious or less-bold would often “hide” on the other side of their mother if she came close to a researcher.

Since boldness and curiosity towards humans are not mutually exclusive, their correlation suggests an interesting implication. Even though these dolphins have been well-habituated to the presence of humans, 21.1% of juveniles are still significantly less curious towards humans (Table 3). One possible explanation for this statistic is that the less curious juveniles are simply less interested in humans. However, this study shows that curiosity towards humans is correlated with boldness, which is characterized as being significantly more prone to leave the safety of a mother’s side. This correlation suggests that as an individual exhibits more bold behavior—a willingness to take risks—they are concurrently more willing to swim in close proximity to humans. Due to this observed correlation, it is possible that the inverse is also true: the less curious individuals consider proximity to humans to be less safe, and thus avoid them more often.

Primary Question 1 – Syndrome of Boldness and Sociability

While boldness is correlated with curiosity, it was not significantly correlated with sociability. *Stenella frontalis* is a highly socialized species, and individuals spend much of their time near their podmates (Herzing, 1997). The juveniles of this population, bold or shy, are going to see and potentially interact with many non-maternal conspecifics. Some conspecifics may be relatively unknown, or may represent a threat,

but all of the data collected involved primarily or exclusively members of the Little Bahama Bank population. If LBB conspecifics represent less of an unknown—and seem more safe—than a human, social behavior (spending time near a conspecific) would be exhibited by both bold and shy individuals, though the bolder individuals would be more willing to leave their mother's side to pursue social behavior. While a willingness to take risks (boldness) is an indicator of more curious behavior (spending more time near a human), boldness would likely be *less* of an indicator of more social behavior.

The only statistically significant syndrome of boldness is curiosity towards humans. However, if at the onset of this study it was predicted that the bold individuals were even slightly more prone to be more sociable (as just discussed), a 1-tailed significance value would have been used for the Pearson's correlations instead of a 2-tailed. Had that been the case, the syndrome between boldness and sociability would have approached significance with a 1-tailed p value of 0.052, and a Pearson's correlation of -0.397 (which is weaker than the 0.496 correlation of boldness and curiosity). While this interpretation of the data only *approaches* significance, it suggests that while there may be correlation between boldness and sociability, it still would have been a weaker correlation than boldness and curiosity (-0.397 and 0.496, respectively). (Table 5)

Primary Question 1 – Syndromes exhibited by individuals

The statistical significance of the syndrome between boldness and curiosity comes from the Pearson's correlation, and this statistic is supported if we look at all of the individuals who significantly varied from the means of curiosity or boldness (Table 6). Of the seven individuals who significantly varied from the mean of curiosity, four

displayed the expected level of boldness: Rosebud, Rosepetal, and Nematocyst were less curious *and* less bold, whereas Meridian was *more* curious and *more* bold. Additionally, LittleHali was more curious but not statistically more bold, however she was a neophilic juvenile dolphin (NJD), the category that *is* significantly more bold than the average (see next section). Looking in the other direction, of the seven individuals who significantly varied from the mean of boldness, four displayed the expected level of curiosity (Rosebud, Rosepetal, Nematocyst, and Meridian). On the other hand, only one individual who significantly varied from the means of curiosity or boldness displayed an *unexpected* level of the correlated trait: Achilles was less bold and more curious, counter to what the syndrome predicts. This comparison of syndromes exhibited by individuals (from Table 6) offers no statistical significance, but it congruent with the statistical analysis of this syndrome from Hypothesis 4.

Collectively, these first four hypotheses offer strong descriptive data of varied personalities within the juvenile population of the Atlantic spotted dolphins on Little Bahama Bank. They exhibit various levels of sociability, curiosity towards humans, and boldness; the males are not significantly different from females, nor are 1990s individuals different from 2000s individuals; and there is a moderately strong correlation (syndrome) between the traits of boldness and curiosity towards humans. The descriptive portion of this project represents one of the first studies of its kind: at the time of publication, there have been no published quantitative studies on personality of non-captive members of a species within the family Delphinidae. The larger implications personality traits within a delphinid species will be considered at the end of this discussion.

The Predictive Capability of Syndromes

It is unfortunate that so little personality work has been done on delphinids, because a well-understood behavioral syndrome can be a useful tool. An increased understanding of a species' behavioral syndromes can lead to a capability for prediction, which can be highly beneficial for certain types of studies. For example, due to the discovered syndrome between neophilia and boldness in chimpanzees (Massen et al., 2013), one would—under normal circumstances—expect bold chimpanzees to be neophilic, and vice versa. However, certain personality traits are more difficult to study than others, especially if we consider the setting of the research. Free-ranging observational studies are more limited in terms of the ways they can interact with the research subjects, whereas captive or experimental studies are not held to the same constraints. One might expect some personality traits such as neophilia to be easier to study in an experimental setting, even more so if on captive animals. Researchers can design elegant experiments in which subjects come across a novel object, and observe their reactions. Purely observational studies, on the other hand, do not often have this luxury of environmental manipulation. Researchers attempting to study a hard-to-observe personality trait within the confines of a non-experimental study may have few options.

However, if a species has a robust syndrome between a more difficult-to-measure personality trait—such as neophilia—and any of a host of those easier to observe—such as boldness, curiosity towards humans, or sociability—you could predict how neophilic an individual is based on its personality phenotype. Behavioral syndromes can be beneficial to many studies of behavior and personality, but using syndromes as predictors

for harder-to-observe behaviors or personality traits can be extraordinarily useful to non-experimental observational studies of free-ranging species. The Wild Dolphin Project is one such study: neophilia is difficult to measure, but crucial for two-way communication research.

Primary Question 2 – Neophilic Juvenile Dolphins

While the results and answers to the first primary question—a descriptive personality baseline—are noteworthy on their own, they set the stage for the other primary focus of this study: to discover if any of these readily observed personality traits can be used to predict neophilic behavior towards two-way communication interfaces. This second primary question asks, can personality traits such as boldness, sociability, or curiosity towards humans be used as predictors of neophilic behavior? The short answer is yes, they can.

To answer this second primary question, personality phenotypes of individuals known to significantly engage with the two-way communication research were described. Data was gathered on six of these neophilic juvenile dolphins (NJDs): Caroh, LittleHali, Tink from the 1990s; Meridian, Nereide, and Tristan from the 2000s. When comparing data from these individuals against baseline averages, the NJDs were statistically no different in terms of sociability or curiosity towards humans, but were significantly more bold than the baseline population: spending 45.64% of time away from their mother, versus 31.70% for the baseline. (This comparison had to exclude the sixth NJD, Tink, because her mother was unknown in the population.)

The five measured NJDs may be collectively more bold than the rest of the population, but not all of the five NJDs who were measured for boldness were individually more bold than the average. Of the collective 18 subjects measured, only two individuals in total were significantly more bold than the average: Meridian, an NJD from the 2000s, and Copper, a male from the 2000s who is not an NJD, but the son of an NJD from the 1990s: Caroh. Though outside the scope of this particular study, research has shown that personality traits such as boldness and sociability will be passed down from mother to offspring in rhesus macaques (Brent et al., 2013). It is possible that Copper inherited his boldness from his NJD-boldness-prone mother, Caroh.

An individual may be significantly bold without being a potential NJD, as there are other factors at play. For example, Copper is bold and not an NJD, but he is a male, and males are, thus far, less likely to engage with two-way communication devices (Herzing et al., 2012; Herzing, unpublished data). Conversely, an individual may be an NJD without explicitly expressing individual boldness, such as Caroh and LittleHali. This fact—that only one NJD was individually classified as “bold”—highlights a limitation of the study. This research focused only on an individual’s first four years of life, with a priority on the first three. With a sample size of more years, or more encounters within the first 3-4 years, individual NJD phenotypes may move closer to the NJD averages. Instead of hard-and-fast rules such as “boldness always predicts neophilia,” or “only bold individuals will become NJDs” we ought instead to consider boldness as a more fluid predictor of neophilia. While there is a significant correlation between boldness and the neophilia expressed by the NJDs, this correlation is not absolute.

Primary Question 2 – Implied Syndrome of Boldness and Neophilia

The six NJDs in this study are so classified because of their greater frequency interacting with novel two-way communication devices—they are collectively more neophilic than the baseline juvenile population. Collectively, NJDs are also significantly more bold than the baseline, spending 45.64% of their time away from their mothers compared to the 31.70% of their peers. This correlation suggests a syndrome between boldness and neophilia, despite only being able to measure neophilia indirectly within the confines of this study.

Boldness and neophilia are often correlated as syndromes across the growing body of personality research, exhibited in three- and nine-stickleback fish (Webster et al., 2009), chimpanzees (Massen et al., 2013), and lemurs (Dammhahn & Ameling, 2012). In some studies these personality traits are even described interchangeably: lake frog tadpoles (Wilson & Krause, 2012) and lion-tailed macaques (Rouff et al., 2005). In these studies, individuals that were more willing to take risks (i.e. display boldness) were also more willing to observe, interact with, or approach novel objects (i.e., display neophilia). In this context, the Atlantic spotted dolphins join the wide variety of taxa, from stickleback fish and tadpoles to chimpanzees, lemurs, and macaques, displaying a syndrome between risk-taking and interacting with novel objects.

Larger Implications

The primary goal of this study was to establish a personality baseline for the Atlantic spotted dolphin on the Little Bahama Bank, in service of determining what personality traits could best predict individuals prone to neophilia towards two-way

communication research. Having discussed both aspects of this goal in depth, it is worth considering these descriptive results within the larger context of how we view and treat dolphins as a non-human species—specifically, the oft-discussed case for cetacean or delphinid personhood. In the context of non-humans, “personhood” specifically refers to basic legal protection of the rights to life, liberty, and well-being. Many authors, scientists, and philosophers have considered this topic in great detail, from the discussion of the cognitive and communicative differences and similarities between delphinids and humans (Herzing & White, 1998; DeGrazia, 1997; Marino, 2013), to claims that delphinids ought to be awarded at least the basic rights to be free of undue harm and pursue their own interests (Singer, 1977). Discussing all of the factors in support of granting personhood to delphinids is not feasible here, but some of the more common elements are as follows.

Many members of the family Delphinidae appear to possess culture, defined as a social transmission of information (rather than genetic) between conspecifics through a form of social learning (Mundinger, 1980). The social transmission of information has been observed in killer whales, *Orcinus orca* (Abramson et al., 2012; Rendall & Whitehead, 2001; Yurk et al., 2002) bottlenose dolphins (Sargeant & Mann, 2009), and Atlantic spotted dolphins (Herzing, 2005; Bender et al., 2008). These members of Delphinidae also exhibit complex social interactions (Conner et al., 1998, Yurk et al., 2002, Herzing, 2005, Bender et al., 2008) indicative of their advanced cognitive functioning (Simmonds, 2006). Other indicators of advanced cognitive capabilities include bottlenose dolphins exhibiting imitation and mimicry (Reiss & McCowan, 1993), self awareness (Reiss & Marino, 2001), and object-specific referential communication

(Xitco et al., 2004). Atlantic spotted dolphins display an awareness of others as they modify their behavior while teaching (Bender et al., 2008), and use referential communication for individual conspecifics via signature whistles (Herzing, 1996). This list is not comprehensive, but represents a sample of traits supporting claims for delphinid personhood.

To illustrate this, consider the following. Imagine an otherwise undescribed mammalian species that (a) maintains many complex social relationships, (b) exhibits curiosity towards novel experiences and learns from them through imitation and mimicry, (c) specifically modifies its behavior to teach its offspring and conspecifics novel behaviors, (d) exhibits social transmission of information, or culture, (e) has a complex communication system that differentiates between disparate objects, as well as distinct members of its community, (f) learns multiple region- or cultural-specific dialects of communication, and (g) displays advanced cognition in the form of self awareness and an awareness of others. Perhaps this mammalian species lacks an *observable* civilization or language, but its culture and complex communication system are at least prototypical to those ends. If this was a description of a newly discovered Indigenous culture of *Homo sapien sapiens*, one would be hard-pressed to claim that its individuals were not deserving of personhood status.

One may argue the primary difference between a newly-discovered Indigenous culture (granted personhood) and the above description of a non-human mammal (no personhood), is that the latter only describes the group's collective traits, and omits any description of the variety of unique individuals within the population. Thus, if individuals of this species also exhibited a wide variety of personality traits—bold

individuals who seek novelty, shy individuals who prefer to spend time alone, sociable individuals who are playful—it becomes even more difficult to distinguish our hypothetical mammalian species from an Indigenous culture. In other words, we may ask, *how* is this species different from a human, and most pressingly, are any remaining differences so expansive that this species is exempt from personhood and the most basic of rights?

The discovery of quantitatively measured personality in the Atlantic spotted dolphin certainly does not make the case in and of itself for the personhood of delphinids. What this study does do, however, is add further support to the growing body of evidence that the line that separates humans and delphinids (as well as the great apes, the family Corvidae, and others yet to be discovered) is not as distinct as the most anthropocentric among us tend to believe. This study was limited to just one age class of one population of one species within the family Delphinidae, but given the ongoing discoveries of personality across many, many taxa, one may expect researchers are capable of studying and describing personality traits within many other delphinid species.

Conclusion

The first primary goal of this study was to establish a baseline of personality traits exhibited by juvenile Atlantic spotted dolphins on Little Bahama Bank. To describe this baseline, three personality traits were studied—sociability, curiosity, and boldness—based on the percentage of time individuals spent with conspecifics, human researchers, and their mothers. The surveyed individuals significantly varied positively and negatively from the means of each trait, and no significant difference for any trait was

found between males and females, or across time periods. A moderately strong correlation was also discovered between two personality traits, boldness and curiosity, suggesting a personality syndrome.

The second primary goal was to use the aforementioned baseline to determine if personality traits can be used to predict neophilic behavior specific to two-way communication research. Six of the study subjects (the NJDs) were more prone than their peers to engage with the two-way work. These NJDs were statistically more bold—spent less time with their mothers—than the other subjects. This suggests that boldness has some predictive capabilities towards this type of neophilia. Lastly, these collective findings of individual expressions of personality offer support toward the case for delphinid personhood.

The findings of this study highlight the lack of personality studies on delphinids, indicating the need for future research both on Atlantic spotted dolphins and other delphinid species. Future research into different traits and/or age classes would greatly augment our understanding of the personality phenotypes of this species, such as which personality traits are stable across a subject's lifetime, or whether or not certain traits or syndromes confer improved chances at reproduction or survival. Studies with exclusively focal-target data sampling would allow researchers to pursue more in-depth lines of inquiry as well, such as if any environmental or experiential factors influence personality phenotypes within a population. Personality research is also needed in other delphinid species, as our current understanding of personality variation within this family is almost non-existent. These topics of future research would provide greater

insight into the growing body of personality research in general, and specifically the family Delphinidae.

APPENDIX

Table 1 – Ethogram

Personality trait	Measurement
Boldness	B ₁ – Percentage of time more than 1 body length away from mother.
Sociability	S ₁ – Percentage of time spent within 1 body length of non-maternal conspecific
Curiosity	C ₁ – Percentage of observed time spent within 1 body length of a human

Table 2 – Intra- and Inter-Reliability Analysis

Reliability Tested	Tolerance Window	Kappa value	Significance
Intra-observer: Caroh	1 second	0.98	<0.001
Intra-observer: LittleHali	1 second	0.98	<0.001
Intra-observer: Meridian	1 second	0.95	<0.001
Intra-observer: Nematocyst	1 second	0.97	<0.001
Intra-observer: Tink	1 second	0.96	0.006
Inter-observer: Caroh	1 second	0.94	<0.001
Inter-observer: LittleHali	1 second	0.86	<0.001
Inter-observer: Meridian	1 second	0.85	0.008
Inter-observer: Nematocyst	1 second	0.79	0.004
Inter-observer: Tink	1 second	0.96	<0.001

Kappa values higher than 0.70 are considered strong reliability, values higher than 0.80 are considered outstanding (Landis & Koch, 1977).

Table 3 – Individual Variation from the Means

Subject	Born	n	sociability	p		curiosity	p		boldness	p	
Caroh*	1992	26	34.32	0.849		29.63	0.316		34.32	0.970	
LittleHali*	1993	26	59.29	0.006	more	43.31	0.026	more	32.17	0.292	
Tink*	1994	21	66.37	0.004	more	31.47	0.715		--	--	
Heaven	1995	23	42.45	0.329		30.47	0.484		48.20	0.234	
Rosebud	1991	24	7.40	0.000	less	22.58	0.005	less	11.19	0.019	less
Rosepetal	1994	25	7.32	0.000	less	26.92	0.025	less	23.36	0.021	less
Geo	1991	20	38.98	0.277		27.72	0.204		31.24	0.350	
Latitude	1991	22	36.90	0.883		30.80	0.591		42.98	0.505	
Leo	1991	20	21.72	0.010	less	32.11	0.341		22.60	0.166	
Mel	1992	23	40.39	0.903		33.27	0.503		44.30	0.300	
Meridian*	2008	35	44.65	0.173		47.51	0.021	more	66.70	0.000	more
Nereide*	2009	23	35.90	0.831		38.82	0.503		45.01	0.328	
Tristan*	2009	25	32.74	0.182		33.61	0.078		49.99	0.716	
Pointless	2009	22	40.10	0.935		22.76	0.031	less	33.36	0.615	
Achilles	2008	21	19.90	0.066	less	48.01	0.054	more	22.20	0.030	less
Copper	2007	33	46.60	0.199		45.47	0.375		56.18	0.031	more
Leucadia	2008	26	33.92	0.636		43.58	0.101		32.17	0.620	
Nematocyst	2010	32	59.60	0.013	more	9.11	0.000	less	17.08	0.041	less
Val	2009	28	45.11	0.295		39.35	2.740		27.22	0.361	
Overall:		475	37.56%			33.50%			35.57%		

Grey cells are female, white are male. Names with * are NJDs. Bold names varied from at least one mean. n is the number of encounters. Bold data and p-values are significantly different from means, adjacent column states whether they exhibit more or less of a trait.

Table 4 – Hypotheses 2, 3, and 5

Hypothesis Tested	p values (tested with Mann-Whitney U)		
	Sociability	Curiosity	Boldness
H2 – Male versus Female	0.842	0.400	0.258
H3 – 1990s versus 2000s	0.661	0.065	0.436
H5 – NJDs versus Base	0.416	0.282	0.046 *significant

No statistically significant differences for any of the three personality traits between males and females, or 1990 versus 2000 individuals.

Table 5 – Syndromes

Syndromes across population	Pearson’s coefficient	Significance. (2-tailed)	N
Boldness & Curiosity	0.496	0.036 *significant	18
Boldness & Sociability	0.397	0.103	18
Curiosity & Sociability	0.029	0.907	19

Syndromes across NJDs			
Boldness & Curiosity	0.510	0.380	5
Boldness & Sociability	-0.207	0.739	5
Curiosity & Sociability	0.141	0.789	6

Boldness and curiosity are correlated across the greater juvenile population; no other correlations found.

Table 6 –Syndromes of Boldness and Curiosity Exhibited by Individuals

Individual exhibiting sig. variation from mean	Boldness	Curiosity	Syndrome?
<u>LittleHali</u>	**	Curious	Yes**
<u>Rosebud</u>	Shy	Non-curious	Yes
<u>Rosepetal</u>	Shy	Non-curious	Yes
<u>Meridian</u>	Bold	Curious	Yes
Pointless	--	Non-curious	--
Achilles	Shy	Curious	No
Copper	Bold	--	--
<u>Nematocyst</u>	Shy	Non-curious	Yes

** NJD lacking individual significant variation from mean.

Underlined names exhibit the syndrome, bold text represents traits that vary above baseline. '--' does not vary from mean.

Figure 1 – Individual Variation from Personality Means

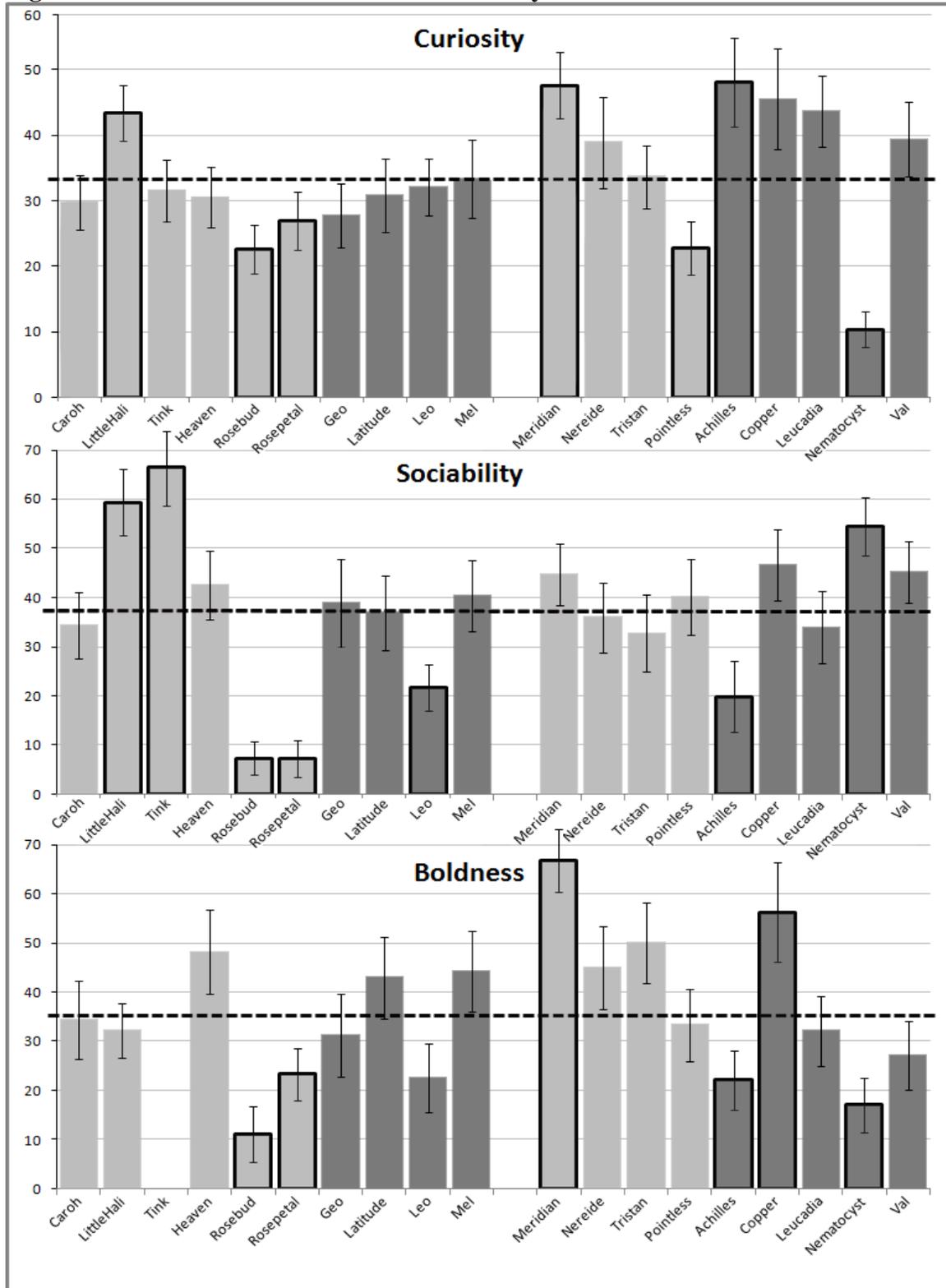


Figure 1. The dotted line represents the population mean for each measured trait. Female subjects are light grey, male subjects are dark grey. Individuals with bold outlined bars varied significantly from the mean.

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