



RESEARCH

Signs of generalized anxiety and compulsive disorders in chimpanzees

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Abstract Fear and anxiety have been studied extensively in humans and other animals. However, far less attention has been focused on the clinical and ethical implications of nonhuman animals' susceptibility to psychological disorders. Behavioral signs of psychopathology in nonhuman animals, including our closest phylogenetic relatives, are rarely described as clinical syndromes. In this study, we drew on approaches described in child psychiatry, veterinary medicine, and primatology, to identify behavioral clusters in chimpanzees comparable with human anxiety disorders, such as generalized anxiety disorder and obsessive–compulsive disorder.

In phase 1 of this study, we accessed published case reports of 20 chimpanzees subjected to maternal separation, social isolation, experimentation, or similar experiences. We tested the inter-rater reliability of the *Diagnostic and Statistical Manual of Mental Disorders* (fourth edition; DSM-IV) criteria for generalized anxiety disorder and obsessive–compulsive disorder when applied to chimpanzees in these case studies. Additionally, based on the DSM-IV, veterinary approaches, and ethograms, we defined behaviorally anchored alternative criteria, which proved more reliable than the DSM-IV criteria in phase 1. In phase 2, the new behaviorally anchored criteria were applied to chimpanzees living in wild sites in Africa ($n = 196$) and those with previous histories of experimentation, orphanage, illegal seizure, or violent human conflict ($n = 168$) living in sanctuaries. In phase 2, 18% of chimpanzees

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living in sanctuaries met the set of behaviorally anchored criteria for generalized anxiety disorder, compared with 0.5% of those in the wild ($P = 0.036$), and 19% of chimpanzees in sanctuaries met the set of behaviorally anchored criteria for obsessive–compulsive disorder, compared with 0% of those in the wild ($P = 0.071$).

Chimpanzees display behavioral clusters similar to anxiety disorders described in humans, underscoring the importance of ethical considerations regarding their use in experimentation and other captive settings.

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Introduction

Fear and anxiety have been studied for decades in humans, nonhuman primates, and other animals. The relationships between captive confinement and poor physical and psychological health effects have been the foundation for many attempts to develop nonhuman animal models of human psychopathology (Vellucci, 1990; Coplan et al., 1995; Lang et al., 2000; Barros and Tomaz, 2002; Nelson and Winslow, 2009). However, far less attention has been focused on nonhuman animals' susceptibility to psychological disorders, the factors that contribute to their development, and relevant clinical and ethical implications.

Nonhuman animals share similarities with humans in genetic and environmental risk factors for psychopathology, and the brain structures associated with fear and chronic anxiety disorders are shared across a wide range of animals (Stevens and Price, 2000; Fabrega, 2004; Brüne, 2008). Fear operates in a less organized subcortical neural circuit than pain (Charney and Deutch, 1996; Coplan and Lydiard, 1998; Panksepp, 2004). The amygdala, along with other regions of the brain, mediates anxiety, fear, rage, and associated protective behaviors, and it plays a role in activating panic, phobias, and anxiety (Gregory, 2004). In humans and other animals, shared risk factors for anxiety states include interruptions of early childhood development, loss of autonomy, captivity, and threats to one's physical safety, among others (Suomi et al., 1981; Engdahl et al., 1993; Coplan et al., 1995; Barros and Tomaz, 2002; Carll, 2007; Nelson and Winslow, 2009).

Nonhuman primates are used in fear and anxiety experiments, based on the rationale that they are close to humans in phylogenetic proximity and that they display similar physiological and behavioral responses to anxiety-induced situations (Barros and Tomaz, 2002). For example, stereotypies, including overgrooming behaviors and other repetitive or ritualistic movements, postures, or utterances, are commonly observed in captive nonhuman primates (Reinhardt et al., 2004). Some stereotyped behaviors are considered displacement activities, in that these and other behaviors reflect anxious states that can further escalate into self-directed or external aggression. Displacement behaviors are thought to emerge when an individual experiences emotional arousal owing to conflicting motivations, and some authors have pointed out that displacement behaviors are a good measure of anxiety levels (Maestripieri et al., 1992). Animal

welfare studies have used displacement and self-directed behaviors as indicators of anxiety associated with the environment, captivity, or other manipulations. Some researchers have assessed the effects of welfare interventions by measuring reductions in displacement activities. These behaviors, and the escalation of these behaviors, may reflect a need to regulate one's arousal state (Maestripieri et al., 1992; Troisi, 2008).

Other authors have pointed out that stereotypic behaviors observed in nonhuman primates reared in captivity are reminiscent of obsessive–compulsive disorder and posttraumatic symptoms observed in humans (Hugo et al., 2003; Brüne, 2006). Some stereotypies in nonhuman primates have been shown to decrease in response to selective serotonin reuptake inhibitors, which have also been used to successfully treat symptoms of obsessive–compulsive disorder and posttraumatic stress disorder (PTSD) in humans (Hugo et al., 2003; Brüne, 2006). Despite similarities among humans, nonhuman primates, and other animals, behavioral signs of psychopathology in animals are frequently described as individual traits rather than clinical syndromes as they are in human patients, although a recent study has highlighted the unexpectedly high prevalence of abnormal behaviors in captive chimpanzees as well as welfare implications arising from these observations (Birkett and Newton-Fisher, 2011).

Elsewhere, we reported on our findings that previously traumatized chimpanzees demonstrate persistent abnormal objective symptoms and that these symptoms cluster into syndromes that are similar to the *Diagnostic and Statistical Manual of Mental Disorders* (fourth edition; DSM-IV) criteria for PTSD and depression (Ferdowsian et al., 2011). Although our previous study focused on developing criteria for depression and PTSD in chimpanzees, we noted a number of observed abnormal behaviors did not fit within the scope of the criteria for PTSD or depression. We noted that these behaviors were more consistent with symptoms of generalized anxiety disorder or obsessive–compulsive disorder. However, as noted previously (Scheeringa et al., 2003; Ferdowsian et al., 2011), the DSM-IV is a limited tool for the diagnosis of anxiety disorders in individuals unable to communicate verbally. This is especially relevant to the DSM-IV diagnosis of generalized anxiety disorder and obsessive–compulsive disorder, which rely heavily on subjective report. To test this hypothesis, and in an attempt to better understand the nature of anxiety disorders in chimpanzees, we used a combination of approaches described in child psychiatry, veterinary medicine, and primatology.

Specifically, we applied the formal diagnostic criteria for generalized anxiety disorder and obsessive–compulsive disorder to chimpanzees to address 2 fundamental questions: (a) Do traumatized chimpanzees develop symptoms expressed in the form of generalized anxiety disorder and obsessive–compulsive disorder? (b) If they do, are DSM-IV diagnostic criteria for these disorders adequate to describe these disorders in chimpanzees? In the first part of the study, we hypothesized that behavioral disorders in chimpanzees would fit 1 of the following 3 mutually exclusive possibilities: (a) a number of traumatized chimpanzees would reliably meet DSM-IV criteria for generalized anxiety disorder or obsessive–compulsive disorder; (b) traumatized chimpanzees would manifest few or only transient symptoms; (c) traumatized chimpanzees would develop many of the symptoms/signs of psychiatric disorders but would not reliably meet DSM-IV criteria. If hypothesis (a) was supported, we would conclude that generalized anxiety disorder and obsessive–compulsive disorder occur in chimpanzees in forms similar to those described in human adults. If hypothesis (b) was supported, we would conclude that the disorders of interest do not occur in chimpanzees. Finally, if hypothesis (c) was supported by our findings, we would conclude that disorders similar to those occurring in humans occur in chimpanzees, but that the diagnostic criteria and perhaps the definitions of syndromes need revising to be appropriate for this species. For the second part of the study, we hypothesized that there would be differences between the wild and sanctuary populations in the prevalence of constellations (clusters) of abnormal behaviors. As Overall reported in her study, identification of a diagnosis using definitional criteria represents an algorithmic approach that clusters behaviors of individuals that are more similar to each other. This approach does not imply that individuals are equally affected (Overall, 2005).

Methods

The methods for the overall study have also been previously described (Ferdowsian et al., 2011). While addressing the fundamental questions described earlier in the text, we also aimed to (a) understand the nature and epidemiology of psychiatric conditions among great apes, and (b) quantify the prevalence among chimpanzees of behavior clusters that are comparable with human psychiatric disorders. We followed methods similar to those reported by Scheeringa (2003) for the development of alternative criteria for PTSD in nonverbal infants and children. We also used ethograms used in primatology, and we drew from a veterinary approach previously described by Overall, which accounts for necessary and sufficient conditions in behavioral diagnoses of nonhuman animals (Table 3; Overall, 2000).

The study was conducted in 2 phases. Phase 1 was conducted to determine whether there was a supported rationale for developing behaviorally anchored criteria that could

serve as adequate alternatives to the DSM-IV criteria for the assessment of psychiatric disorders in chimpanzees. In phase 1, we applied DSM-IV diagnostic criteria (Tables 1 and 2) to published case reports of traumatized chimpanzees, and we designated behaviorally anchored criteria (Tables 1 and 3) for these disorders to compare them with the DSM-IV criteria, using measures of inter-rater reliability. In phase 2, we applied the new behaviorally anchored diagnostic criteria to data collected on chimpanzees currently living in sanctuaries as a result of previous use in laboratory research, illegal trade and seizure, or being orphaned, as well as a sample of chimpanzees living in the wild. We hypothesized that there would be differences in the prevalence of patterns of abnormal behavior between the wild and sanctuary populations.

Phase 1

The case reports for phase 1 were published in previous scientific reports; to obtain them, we searched “PrimateLit,” a database funded by the National Institutes of Health including all primate literature from 1940 to the present (our search was completed by September 30, 2009). We did a global search using the umbrella term “nonadaptive,” and limited our search to the genus *Pan*. The search returned 384 results that met our initial criteria. Articles were screened to exclude conference abstracts, books, and formats other than journal articles (240 items). After 9 items were removed because they were not in English, the remaining 135 articles were screened to determine whether they met the following criteria:

1. They reported original data on ≥ 1 individually identifiable chimpanzees (i.e., they were not group-level comparisons, population proportions, etc.).
2. They reported in detail on behaviors that are recognized as pathological in animals (e.g., stereotypic locomotion, hair plucking, self-mutilation) and humans.
3. Information in the article or title suggested that there had been some potentially adverse or traumatic experience such as maternal separation, being orphaned, chronic close confinement, experimentation, social isolation, or a similar experience.

Using these inclusion criteria, we found that 20 cases in 12 published articles provided adequate detail for a review. Most of these articles included details for >1 individual; in certain cases, >1 article was about the same individual(s) at different times or with a focus on different details.

To develop the behaviorally anchored set of criteria, we elicited the written and verbal advice of experts in primatology, ethology, psychology, and psychiatry and constructed an expanded checklist of symptoms designed to account for chimpanzee/human differences. These experts reviewed, critiqued, and helped revise the symptom checklist. The checklist included symptoms used for the behaviorally anchored criteria. Based on careful review of inventories of chimpanzee behavior (ethograms) from wild, sanctuary, and

Table 1 Comparison between the 2 sets of criteria for generalized anxiety disorder: DSM-IV (phase 1) and the behaviorally anchored set for chimpanzees (phases 1 and 2)

DSM-IV criteria ^a	Proposed behaviorally anchored criteria for chimpanzees
A. Excessive anxiety and worry (apprehensive expectation), occurring more days than not for at least 6 months, about a number of events and activities (such as work or school performance).	A. Appears excessively anxious compared with other chimpanzees, for at least 6 months.
B. The person finds it difficult to control the worry.	B. Demonstrates difficulty controlling anxiety, as evidenced by displacement activities, including excessive scratching, excessive yawning, overgrooming, self-directed behaviors (e.g., self-clutching, sucking on fingers or toes), or difficulty calming down after arousal or excessive outbursts.
C. The anxiety and worry are associated with at least 3 of the following symptoms (with at least some of the symptoms present for more days than not for the past 6 months). Only 1 item is required in children	C. At least 3 signs of persistent hyperarousal for at least 6 months
a. Restlessness or feeling keyed up or on edge.	a. Appears restless, keyed up, or on edge.
b. Being easily fatigued.	b. Difficulty concentrating.
c. Difficulty concentrating or mind going blank.	c. Easily irritated or angered.
d. Irritability.	d. Sleep disturbance as evidenced by difficulty falling asleep or awake or easily awakened during evening observations.
e. Muscle tension.	e. Extremely watchful or on guard.
f. Sleep disturbance (difficulty falling or staying asleep, or restless unsatisfying sleep).	
D. Not another axis I disorder.	D. The behaviors cause interference with daily activities.
E. Anxiety, worry, or physical symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.	E. The disturbance is not due to the direct physiological effects of a substance or general medical condition.
F. The disturbance is not due to the direct physiological effects of a substance or general medical condition.	

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zoo settings, we matched behaviors previously documented among chimpanzees in those settings to specific DSM-IV diagnostic criteria for mood and anxiety disorders. Appropriate changes to the wording of questions in the DSM-IV were also made. Recognizing the limits of using the DSM-IV criteria for the diagnosis of obsessive–compulsive disorder in chimpanzees, and the strengths of a veterinary approach reported by Overall, we also extended Overall's published methods for diagnosing obsessive–compulsive disorder in animals to identify new criteria specific to chimpanzees (Table 3). These criteria resemble human diagnostic criteria in that they emphasize the importance of abnormal repetitive behaviors that interfere with normal functioning. Our goal was to make the expanded checklist of symptoms, and therefore the new proposed criteria for generalized anxiety disorder and obsessive–compulsive disorder in chimpanzees, behaviorally anchored.

Three raters who were aware of the purpose of the study rated all 20 cases independently. Each of the raters was a primatologist familiar with normal and abnormal chimpanzee behaviors. Inter-rater reliability was assessed by calculating Fleiss kappa (K) and the percentage agreement for each item.

We asked the 3 raters to apply the 11 items in the DSM-IV comprising the criteria for generalized anxiety disorder and the 10 items in the DSM-IV comprising the criteria for

obsessive–compulsive disorder to each of the 20 cases. We also asked the raters to apply the expanded checklist of symptoms to each case study. The frequency with which the items were reported in the case studies, the reliability coefficients, and consultations with experts were all used to determine whether to keep, eliminate, or modify items, to create a set of behaviors that might be indicative of generalized anxiety disorder and obsessive–compulsive disorder for use in the phase 2 of the study.

Phase 2

As previously described (Ferdowsian et al., 2011), the expanded symptom checklist, followed by the new behaviorally anchored criteria for generalized anxiety disorder and obsessive–compulsive disorder identified through our analysis in phase 1, was applied to chimpanzees at 8 sites (3 wild sites [$n = 196$] and 5 sanctuary sites [$n = 168$], including 2 African sanctuary sites and 3 sanctuary sites in North America, Asia, and Europe that housed chimpanzees formerly used in laboratory research). The 5 sanctuary sites were combined for the purposes of this study. The study included heterogeneous populations of various ages and both sexes. Chimpanzees in African sanctuaries had histories that included illegal trade, being orphaned, or

Table 2 DSM-IV criteria for obsessive-compulsive disorderDSM-IV criteria^a

A. Either obsessions or compulsions

Obsessions as defined by (1), (2), (3), and (4)

1. Recurrent and persistent thoughts, impulses, or images that are experienced at some time during the disturbance, as intrusive and inappropriate and that cause marked anxiety or distress.
2. The thoughts, impulses, or images are not simply excessive worries about real-life problems.
3. The person attempts to ignore or suppress such thoughts, impulses, or images, or to neutralize them with some other thought or action.
4. The person recognizes that the obsessional thoughts, impulses, or images are a product of his or her own mind (not imposed from without as in thought insertion).

Compulsions as defined by (1) and (2)

1. Repetitive behaviors (e.g., hand washing, ordering, checking) or mental acts (e.g., praying, counting, repeating words).
 2. The behaviors or mental acts are aimed at preventing or reducing distress or preventing some dreaded event or situation; however, these behaviors or mental acts either are not connected in a realistic way with what they are designed to neutralize or prevent or are clearly excessive.
- B. At some point during the course of the disorder, the person has recognized that the obsessions or compulsions are excessive or unreasonable. Note: This does not apply to children.
- C. The obsessions or compulsions cause marked distress, are time-consuming (take >1 h/d), or significantly interfere with the person's normal routine, occupational (or academic) functioning, or usual social activities or relationships.
- D. If another axis I disorder is present, the content of the obsessions or compulsions is not restricted to it (e.g., preoccupation with food in the presence of an eating disorder, hair pulling in the presence of trichotillomania, concern with appearance in the presence of body dysmorphic disorder, preoccupation with drugs in the presence of a substance use disorder, preoccupation with having a serious illness in the presence of hypochondriasis, preoccupation with sexual urges or fantasies in the presence of a paraphilia, or guilty ruminations in the presence of major depressive disorder).
- E. The disturbance is not due to the direct physiological effects of a substance (e.g., a drug of abuse, a medication) or a general medical condition.

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violent human conflict. Chimpanzees previously used in laboratory research had been used in medical experiments. These chimpanzees had been exposed to various degrees and periods of sustained confinement, disruption of primary attachments, removal from social groups, repeated phlebotomy, capture, anesthetic injections through syringe or dart guns, invasive procedures, induced diseases, or chronic isolation. A small number of the chimpanzees living in the wild had histories of injuries resulting from snares, spears, or similar objects.

Using the expanded checklist of symptoms, caregivers at the sanctuaries provided information about chimpanzees based on their past observations of the chimpanzees' persistent behaviors during the time in which the raters knew these individuals. We used parallel methods to assess wild chimpanzees. Trained individuals working at selected field sites with chimpanzees were asked to complete the surveys for specific individuals. Observers were matched to specific chimpanzees based on their knowledge of the chimpanzees, as determined by the site supervisors. In each of the 8 settings, 3 observers completed a survey for each chimpanzee, for a total of 3 surveys per chimpanzee. Responses were made independently. This approach capitalized on the intimate knowledge and long-term experience of the people who were the most familiar with individual chimpanzees

while minimizing the impact on each chimpanzee. Although this method did not rely on direct observations, it provided for a larger sample size than would be possible otherwise. We used this approach to calculate the prevalence of patterns of behaviors comprising the behaviorally anchored criteria for generalized anxiety disorder and obsessive-compulsive disorder. The wild and sanctuary populations were compared. Differences were tested for statistical significance using a Mann-Whitney *U* test. Statistical analysis was performed using Statistical Package for Social Sciences, version 18.0, and an α of 0.05 was used for all tests.

Study approvals and ethics statement

Approval for the study was provided by the governing body of each site participating in the study and by the Uganda National Council for Science and Technology, the Uganda Wildlife Authority, and the National Council for Science and Technology under the Ministry of Higher Education, Science and Technology in the Republic of Kenya. Exemption for institutional review board approval was determined by an independent external institutional review board because the study did not involve research on human subjects. The study relied on long-term experience of the people who were most familiar with the chimpanzees and did not directly impact the

Table 3 Criteria for the assessment of obsessive–compulsive disorder in animals, including proposed alternative criteria for assessment in chimpanzees

Overall criteria (Overall, 2005)	Proposed behaviorally anchored criteria for chimpanzees
Necessary condition Repetitive, stereotypic motor, locomotory, grooming, ingestive, or hallucinogenic behaviors that occur out of context to their “normal” occurrence, or in a frequency or duration that is in excess of that required to accomplish the ostensible goal.	Repetitive, stereotypic motor, locomotory, grooming, ingestive behaviors, including overgrooming, repetitive pacing, vocalizations or other behaviors, or regurgitation and reingestion, which cause interference with daily activities.
Sufficient condition As for necessary condition, in a manner that interferes with the animals’ ability to otherwise function in his or her social environment.	

chimpanzees. No pain or suffering was inflicted. Chimpanzees involved lived in the wild or in sanctuaries.

Results

Phase 1

Generalized anxiety disorder

In phase 1, 1 of the 20 chimpanzees satisfied DSM-IV criteria for generalized anxiety disorder (Table 1) according to 1 rater. The other 2 raters found that none of the chimpanzees satisfied the criteria. Using the alternative behaviorally anchored criteria for generalized anxiety disorder (Table 1), 3 chimpanzees satisfied criteria according to all 3 raters; 1 other chimpanzee satisfied criteria according to 2 raters; and 4 more chimpanzees satisfied criteria according to 1 rater. Measures of inter-rater reliability were higher using the alternative behaviorally anchored criteria for generalized anxiety disorder, compared with the DSM-IV criteria. Percentage agreement among the 3 raters for each of the 11 items for the DSM-IV criteria ranged from 23% to 58% (median = 37%), whereas the inter-rater reliability K values for the 3 raters ranged from -0.224 to 0.200 (median = -0.027). Percentage agreement on the diagnosis of generalized anxiety disorder, using the DSM-IV, was 97%, with a corresponding K value of -0.017 . In contrast, percentage agreement among the 3 raters for each of the items in the behaviorally anchored criteria for generalized anxiety disorder ranged from 67% to 100% (median = 82%), and inter-rater reliability K values ranged from 0.167 to 0.733 (median = 0.411). Percentage agreement for the diagnosis of generalized anxiety disorder using behaviorally anchored criteria (Table 1) was 83% ($K = 0.556$).

Obsessive–compulsive disorder

All raters agreed that none of the chimpanzees met DSM-IV criteria for obsessive–compulsive disorder (100% agreement, $K = \text{undefined}$). However, the raters reported that 18 of the 20 chimpanzees demonstrated abnormal

repetitive behaviors, as are commonly observed in obsessive–compulsive disorder. The chimpanzees identified in the case studies displayed repetitive, stereotypic motor, locomotory, grooming, or ingestive behaviors, as described in Overall’s necessary condition for obsessive–compulsive disorder in animals. Specifically, the chimpanzees displayed repetitive pacing, repetitive vocalizations, or other repetitive behaviors, overgrooming behaviors, or regurgitation and reingestion. According to raters, chimpanzees in the case studies displayed an average of 1.8 of 5 abnormal repetitive behaviors, or 36% of 100 possible total behaviors in a sample of 20 chimpanzees. The published case studies did not include enough information for raters to determine whether the chimpanzees demonstrated functional impairment. Therefore, the case studies did not permit full assessment of whether these chimpanzees met Overall’s sufficient condition for obsessive–compulsive disorder or the proposed behaviorally anchored criteria for the assessment of obsessive–compulsive disorder in chimpanzees (Table 3).

Phase 2

Generalized anxiety disorder

In phase 2, significantly more chimpanzees in sanctuaries ($n = 168$) than in the wild ($n = 196$) showed behavioral clusters that were consistent with a diagnosis of generalized anxiety disorder according to our set of behaviorally anchored criteria. Using the behaviorally anchored criteria for generalized anxiety disorder (Table 1), 18% ($n = 31$ of 168) of chimpanzees in sanctuaries satisfied the criteria, compared with 0.5% ($n = 1$ of 196) of chimpanzees in the wild (Figure 1; $P = 0.036$).

Obsessive–compulsive disorder

Using the behaviorally anchored criteria for obsessive–compulsive disorder (Table 3), 19% ($n = 32$ of 168) of chimpanzees living in sanctuaries satisfied the criteria, compared with 0% ($n = 0$ of 196) living in the wild (Figure 2; $P = 0.071$). Chimpanzees in sanctuaries demonstrated an average of 1.48 of these behaviors (30% of 840

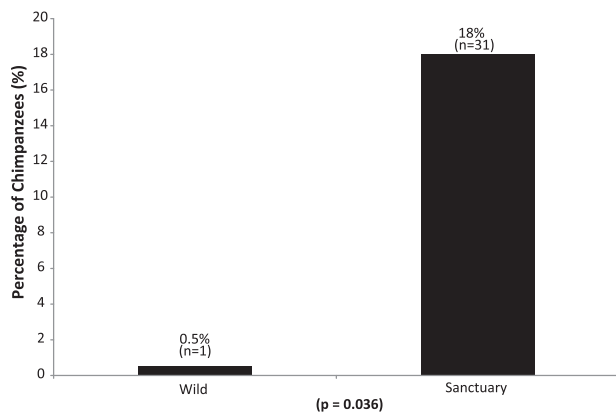


Figure 1 Prevalence of generalized anxiety disorder, according to the behaviorally anchored criteria, for chimpanzees living in the wild and in sanctuaries (phase 2).

total possible behaviors), compared with an average of 0.22 abnormal behaviors per wild chimpanzee (4% of 980 total possible behaviors).

Discussion

Similar to previous reports (Brüne et al., 2006; Bradshaw et al., 2008; Ferdowsian et al., 2011), and a recent study in a substantial number of captive chimpanzees (Birkett and Newton-Fisher, 2011), our findings suggest that chimpanzees can exhibit persistent symptoms similar to those observed in human psychiatric disorders. Specifically, our results demonstrate that chimpanzees previously exposed to varying levels of captivity and traumatic events more commonly met behaviorally anchored criteria for generalized anxiety disorder and obsessive–compulsive disorder, compared with chimpanzees living in the wild.

Although an “anxious phenotype” has been described by some authors (Cameron et al., 2004; Suomi, 2006; Kalin et al., 2007; Fox et al., 2008), there have been few attempts to place these findings within a broader clinical and ethical context. Furthermore, efforts to induce fear and anxiety states using experimental laboratory procedures are confounded by extended cage confinement, conditions intrinsic to laboratory captivity, and other environmental and social factors. When behavioral signs of psychopathology are studied or viewed in this narrow way, experimental laboratory approaches avoid acknowledging the interests and experiences of individual animals and sidestep important ethical and clinical issues (Asquith, 1984; Bradshaw and Finlay, 2005). Definitions of necessary and sufficient conditions for anxiety disorders in nonhuman animals are important to identify potential risk factors for psychopathology and severity of distress, and to follow responses to various clinical interventions (Overall, 1997, 2004, 2005).

It is possible that the disorders and symptoms observed in chimpanzees and other animals may represent a continuum of disorders, rather than discrete disorders. In humans,

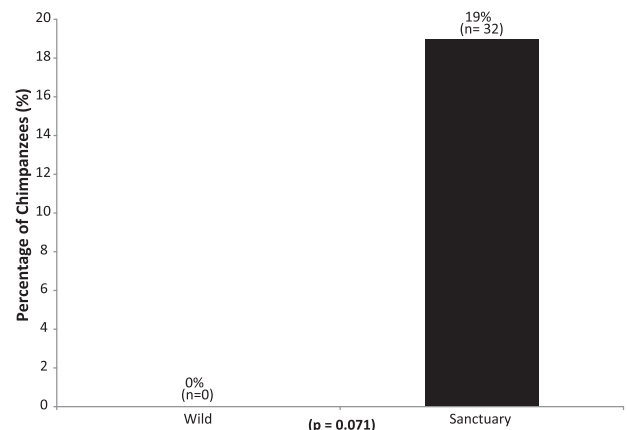


Figure 2 Prevalence of obsessive–compulsive disorder, according to the behaviorally anchored criteria, for chimpanzees living in the wild and in sanctuaries (phase 2).

depression and anxiety disorders commonly occur comorbidly, highlighting the strengths and weaknesses of current diagnostic systems (Feinstein, 1970; Pallanti et al., 2002). Anxiety often precedes depression and may be explained by biological, ethological, and cognitive mechanisms. For example, infant primates separated from their mothers have shown protest behaviors followed by despair (Bowlby, 1980). Long-term captivity, up to months or years, can result in a range of reactions along the spectrum of anxiety and depressive disorders (Carll, 2007). Similar to generalized anxiety disorder, obsessive–compulsive disorder can be observed as a maladaptive harm-avoidance strategy (Stein and Bouwer, 1997), where the defense is directed against potential threats that lie in the future (Brüne, 2006). As such, a firm diagnosis of obsessive–compulsive disorder in chimpanzees—in the absence of verbal report—is difficult to ascertain, although comparative studies suggest that chimpanzees may have the ability to travel mentally in time (Suddendorf and Whiten, 2001). Arguably, however, the stereotyped behaviors observed in chimpanzees phenotypically resemble repetitive behaviors observed in humans with sensory deprivation, stress, frustration, boredom, and mental retardation (Rojahn et al., 1997), such that, alternatively, a diagnosis of stereotypic movement disorder according to DSM-IV may be justified.

Our study had limitations. Although humans can observe and describe chimpanzees’ behaviors using established behavioral descriptions, we cannot fully understand the experiences of other animals. Therefore, we extended methods that had been used in similar situations, such as with humans unable to articulate their experiences and with other veterinary populations. Although it is impossible to understand any individual’s motivation, particularly those with whom we cannot communicate, many anxiety and repetitive behaviors are observable. The sets of behaviorally anchored criteria for generalized anxiety disorder and obsessive–compulsive disorder in chimpanzees were tested and selected based on multiple factors, including the frequency with which items were

reported in the case studies, each item's face validity and reliability coefficients, and consultation with experts. Because there is no gold standard for the assessment of anxiety disorders in chimpanzees, it was not possible to establish the external validity of the criteria we developed.

In phase 1, behavioral ratings were made from published studies and case reports. These reports may have contained biases that could have influenced the raters. Information about duration was generally unavailable. However, none of the reports explicitly described obsessive-compulsive disorder or generalized anxiety disorder in chimpanzees, eliminating the potential for bias toward an already established diagnosis.

In phase 2, we examined duration, but the study design was not longitudinal and therefore relied on the recall of the raters. Direct observations were not made. Our primary aim was to search for particular patterns of abnormal behavior, which could inform future work. Future studies might include behavioral observation and other validation efforts. In some cases, duration was not reported, thereby increasing the possibility of false-negative findings. This study did not permit full assessment of the severity of symptomatology. Although common in laboratory chimpanzees and the chimpanzees in our study who previously lived in laboratories, we did not include behaviors such as scatolia (feces smearing) in this analysis, although it has been described in humans with obsessive-compulsive disorder (Zeitlin and Polivy, 1995) and prisoners of war kept in solitary confinement, as well as children with developmental disabilities and patients with dementia.

Strengths of the study include a large sample size with females and males represented in phase 2, as well as reports of trained observers who knew the chimpanzees for an extended period. The clusters of behaviors, as revised, had face validity in that they resembled symptoms for anxiety disorders listed in the DSM-IV.

Conclusions

Our study's findings underscore the association of psychopathology with conditions of confinement, physical harm, and isolation. Similar to the findings reported for humans, our findings may be a result of more generalized conditions, such as captivity, and the loss of autonomy and social bonds that are critical to the psychological well-being of chimpanzees (Brüne et al., 2004; Reimers et al., 2007). This study suggests that chimpanzees can exhibit behavioral clusters similar to generalized anxiety disorder and obsessive-compulsive disorder as a result of potentially traumatic experiences.

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