

A Chimpanzee (*Pan troglodytes*) Model of Triarchic Psychopathy Constructs: Development and Initial Validation

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Abstract

The current work sought to operationalize constructs of the triarchic model of psychopathy in chimpanzees (*Pan troglodytes*), a species well suited for investigations of basic biobehavioral dispositions relevant to psychopathology. Across three studies, we generated validity evidence for scale measures of the triarchic model constructs in a large sample ($N = 238$) of socially housed chimpanzees. Using a consensus-based rating approach, we first identified candidate items for the chimpanzee triarchic (CHMP-Tri) scales from an existing primate personality instrument and refined these into scales. In Study 2, we collected data for these scales from human informants ($N = 301$) and examined their convergent and divergent relations with scales from another triarchic inventory developed for human use. In Study 3, we undertook validation work examining associations between CHMP-Tri scales and task measures of approach-avoidance behavior ($N = 73$) and ability to delay gratification ($N = 55$). Current findings provide support for a chimpanzee model of core dispositions relevant to psychopathy and other forms of psychopathology.

Keywords

psychopathy, triarchic model, chimpanzees, personality, animal models

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Psychopathic personality (psychopathy), as described in Hervey Cleckley's (1941) classic book *The Mask of Sanity*, entails a severe disturbance in behavioral control, social relations, and emotional experience concealed by an outward appearance of normalcy. Psychopathy is a multifaceted construct (e.g., Patrick, Fowles, & Krueger, 2009) that is not exclusive to criminal populations (e.g., Lykken, 1995; Schneider, 1958; Skeem & Cooke, 2010), but which has traditionally been studied predominantly in adult forensic samples. However, this situation has changed in recent years, as researchers have moved toward conceptualizing and assessing psychopathy in younger samples (Salekin, 2006) and adults from the community at large (see Hall & Benning, 2006; Lilienfeld, 1994). This work

has contributed to a view of psychopathic tendencies as grounded in basic biobehavioral dispositions that vary continuously within the human population and potentially in other species as well.

In service of reconciling competing conceptions of psychopathy, recent theoretical and empirical work has sought to more accurately capture the dimensions of the construct (Patrick, 2006), through the elucidation of its component traits (e.g., Lilienfeld & Widows, 2005;

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Marcus, Fulton, & Edens, 2013; Patrick et al., 2009; Poythress & Hall, 2011). Developed for this purpose, the triarchic model (Patrick et al., 2009) characterizes psychopathy as a configuration of three dimensional trait constructs with distinct biological referents: *boldness*, *meanness*, and *disinhibition*. Empirical support for this model derives from several sources. For example, research demonstrates that the triarchic dispositional constructs are represented to varying degrees in multiple well-validated assessment instruments for psychopathy (Patrick & Drislane, in press) and that these constructs reflect configurations of five factor model (FFM) personality traits, such as low agreeableness and low conscientiousness, known to be associated with psychopathy (Poy, Segarra, Esteller, Lopez, & Molto, 2014).

Furthermore, recent research demonstrates that scale measures of the triarchic model constructs can be developed using items from extant instruments through a consensus-based rating approach (Drislane, Brislin, et al., 2014; Drislane, Patrick, & Arsal, 2014; Hall et al., 2014), allowing for investigation of these constructs in preexisting data sets. The current research extends work along these lines by seeking to establish scale measures of the triarchic constructs in a nonhuman primate species, chimpanzees (*Pan troglodytes*). Notably, nonhuman animals and specifically chimpanzees have increasingly become the focus of research on the biological and comparative foundation of personality (e.g., Freeman et al., 2013; Freeman & Gosling, 2010). For instance, recent factor analytic research has reported evidence for a robust five-factor solution largely paralleling the FFM reliably found in human samples, with the potential addition of a sixth dimension, dominance (Freeman et al., 2013; King & Figueredo, 1997). Likewise, previous studies have shown that chimpanzee personality is hierarchical in nature and that at least some portion of variability in personality is heritable and potentially linked to specific genetic polymorphisms (Adams, King, & Weiss, 2012; Hopkins, Donaldson, & Young, 2012; Latzman, Hecht, Freeman, Schapiro, & Hopkins, 2014; Latzman, Hopkins, Keebaugh, & Young, 2014).

Of specific interest in the current study was the extent to which biobehavioral dispositions relevant to psychopathy can be conceptualized and quantified in chimpanzees along thematic lines specified by the triarchic conceptual framework. Comparative data on the triarchic model would provide a basis for investigating phylogenetic and neurobiological aspects of this theoretical model of psychopathy. Furthermore, pragmatically, the development of triarchic model scales in nonhuman primates may be beneficial to behavioral management staff as a means for assessing potential compatibility of individuals being introduced into new social groups.

Triarchic Model

The triarchic model was developed to reconcile alternative conceptions of psychopathy (Patrick et al., 2009). The model characterizes the phenotypic components of this multidimensional construct within a biobehavioral framework. Specifically, the triarchic model frames psychopathy in terms of three dimensional constructs: disinhibition and meanness (callous aggression) are anchor dimensions of the externalizing spectrum of psychopathology (Krueger, Markon, Patrick, Benning, & Kramer, 2007), whereas boldness reflects more adaptive aspects of psychopathy (e.g., social efficacy, stress immunity, venturesomeness) that can be viewed in turn as facets of fear/fearlessness (Kramer, Patrick, Krueger, & Gasperi, 2012). More specifically, disinhibition corresponds directly to externalizing proneness and reflects a phenotypic propensity toward impulse control problems entailing a lack of planfulness and foresight, impaired regulation of affect and urges, insistence on immediate gratification, and deficient behavioral restraint. Meanness corresponds to a distinct subdimension of the externalizing spectrum, labeled callous aggression, that encompasses attributes including deficient empathy, disdain for and lack of close attachments with others, rebelliousness, excitement seeking, exploitativeness, and empowerment through cruelty (Krueger et al., 2007). Last, boldness encompasses low levels of fear/avoidance (Kramer et al., 2012), manifested as high self-assurance and social efficacy, a capacity to remain calm in situations involving threat and recover quickly from stressful events, and a tolerance for unfamiliarity and danger—that is, a relatively benign expression of genotypic fearlessness marked by social dominance, emotional resilience, and adaptive risk taking (Lilienfeld et al., 2012).

It is important that, contrary to models that potentially conflate psychopathy in part with antisociality/criminality by overemphasizing indicants of antisocial behavior (e.g., Skeem & Cooke, 2010; but see Hare & Neumann, 2010, for a contrasting view), the triarchic model allows for an examination of not only the maladaptive disinhibitory and callous aspects of psychopathy but also its ostensibly more adaptive aspects, such as fearless dominance (Lilienfeld et al., 2012). To operationalize these constructs in both forensic and community samples, Patrick (2010) developed the self-report based Triarchic Psychopathy Measure (TriPM; for alternative operationalizations, see Drislane, Brislin, et al., 2014, and Hall et al., 2014). The TriPM contains scales for indexing disinhibition, boldness, and meanness that show theory-consistent patterns of associations with psychopathy-relevant criterion measures. From the vantage point of the current research, the triarchic model of psychopathy, with an emphasis on both consequential negative and adaptive behaviors, provides

an opportunity to consider this model of psychopathy within an evolutionary framework.

In humans, the TriPM scales also display associations with FFM personality traits that are consistent with theoretical expectations. Specifically, disinhibition correlates substantially with low conscientiousness and to a lesser degree with low agreeableness, and meanness correlates substantially with low agreeableness and more modestly with low conscientiousness. In sharp contrast, boldness relates uniquely to low neuroticism, high extraversion, and high openness, while also showing some association with low agreeableness (Poy et al., 2014). These associations of the triarchic constructs as indexed by the TriPM with FFM personality traits dovetail with work connecting psychopathic tendencies to traits represented in the FFM (Lilienfeld, Watts, Francis Smith, Berg, & Latzman, in press; Miller & Lynam, 2003). This evidence, together with recent studies demonstrating the effectiveness of a consensus-based rating approach to operationalizing the triarchic constructs using items from established inventories of psychopathy (Drislane, Brislin, et al., 2014; Hall et al., 2014) and general personality (Brislin, Drislane, Smith, Edens, & Patrick, in press), led us to predict that effective scale measures of these constructs could be derived from an FFM-oriented rating measure developed for use with chimpanzees.

Effective operationalization of these constructs in chimpanzees would provide evidence for the evolutionary and neurobiological basis of the triarchic model dimensions and lay the foundation for further programmatic research with this novel population. Indeed, a notable point regarding the triarchic model constructs is that they are developed explicitly within a neurobiological context (Patrick et al., 2009). An analysis of psychopathy in terms of neurobehavioral dispositions is timely given the National Institute of Mental Health's (NIMH) research domain criteria (RDoC; Cuthbert & Insel, 2013; Insel et al., 2010) initiative, which aims to elucidate the neurobiological bases of mental illness and reframe conceptions of psychopathology around constructs with specific brain referents. The RDoC research framework includes constructs, conceptualized as fundamental units of analysis, that in turn are grouped into major domains of functioning. With regard to triarchic constructs, clear counterparts exist within the RDoC framework: disinhibition links to the construct of "response inhibition" within the Cognitive Systems domain, boldness links to the construct of "acute threat" in the Negative Valence Systems domain, and meanness links to the construct of "attachment formation and maintenance" in the Social Systems domain. The dimensional constructs of the triarchic model can thus be viewed as trait-dispositional counterparts to these RDoC constructs.

Chimpanzees: A Model Species for the Study of Psychopathic Personality Traits

RDoC explicitly encourages investigators to utilize animal models to investigate constructs within the various specified domains. Chimpanzees are particularly well suited as an animal model for the examination of these constructs. As noted earlier, it is now widely accepted that humans and chimpanzees share many emotional processes, providing the foundation for an unparalleled animal model of human emotion (Phillips et al., 2014). As such, chimpanzee models are uniquely positioned to provide access to highly complex processes associated with basic phenotypic traits, largely free from the typical sociocultural confounds inherent in human studies (E. E. Nelson & Winslow, 2009).

In addition to sharing an extremely high percentage of genes with humans, chimpanzees likewise live in complex social environments that require sophisticated social cognition and behavior to recruit social support, form social alliances, and recognize displays of emotion (de Waal, 1996). Moreover, although many primates engage in reconciliation following agonistic encounters, only chimpanzees (and perhaps other great apes) exhibit what de Waal (1996) describes as "consolation." Consolation occurs when a third party member of a social group of chimpanzees hugs, grooms, or otherwise touches the loser of a physical altercation, as if to console them. Similarly, chimpanzees share food even with non-kin, suggesting a high degree of prosociality—which de Waal (2008) suggests may similarly be the foundation for altruism and empathy in humans. Other complex socioemotional and communicative traits that distinguish chimpanzees from other nonhuman primate species include self-awareness, empathy, theory of mind and related constructs, extended delay of gratification, long-term planning, and rudimentary linguistic skills (Beran, Savage-Rumbaugh, Pate, & Rumbaugh, 1999; Call & Tomasello, 2008; Gallup, 1970; Lyn, 2012; Povinelli, Reaux, Bierschwale, Allain, & Simon, 1997). Many of these social and cognitive abilities reflect behavioral traits likely to be related to the triarchic model dimensions. For instance, ability to delay of gratification (reflecting the RDoC construct of response inhibition) is a presumed behavioral manifestation of the triarchic disinhibition dimension. Taken together, such observations underscore the value of research with chimpanzees in advancing our understanding of evolutionary and biobehavioral processes associated with psychopathic and other personality traits.

Potentially most important, a comparative approach using chimpanzees (or other primates) allows for a relatively straightforward analysis of biological processes

contributing to the complex trait dimensions of the triarchic model. Specifically, although biological factors are presumed to account for some variability in psychopathic traits in humans, it is likely that sociocultural influences, including parenting and peer modeling, also play important roles (Lykken, 1995). Almost from birth, social systems and cultural institutions impose expectations on how humans should behave and react in terms of inhibiting impulses, engaging in prosocial behavior (e.g., “share your candy”), and expressing empathy (e.g., “say you’re sorry”). Because systematic social and cultural pressures of such types are largely absent in chimpanzees, interindividual variation in psychopathic traits in apes can be presumed to reflect largely biological mechanisms.

In the only previously published study to examine the relevance of the psychopathy construct to chimpanzees, Lilienfeld, Gershon, Duke, Marino, and de Waal (1999) developed a provisional 34-item caregiver-reported chimpanzee psychopathy measure by “translating” the criteria of Cleckley (1941) and other authors into chimpanzee-relevant personality referents. Broadly consistent with findings in the human psychopathy literature, this measure correlated positively with measures of extraversion and agreeableness and with relevant observation-based ratings of bluff displays, daring behaviors, teasing, ill-temper and aggressiveness, and sexual activity. Although the Lilienfeld et al. study provided provisional evidence for the applicability of psychopathy to chimpanzees, their work focused exclusively on psychopathy total scores and did not attempt to delineate symptom subdimensions and evaluate their correlates. The focus on total psychopathy scores carries limitations in light of burgeoning evidence demonstrating that subdimensions (or facets) of psychopathy, including those specified by the triarchic model, often demonstrate strikingly different external correlates, many of which bear important implications for the etiology of psychopathy (Skeem, Polaschek, Patrick, & Lilienfeld, 2011).

Current Investigation

Leveraging caregiver-report data for items of a well-validated chimpanzee inventory of personality (Freeman et al., 2013), we sought to develop and undertake an initial validation of scale measures for indexing the constructs of the triarchic psychopathy model in a relatively large sample of socially housed captive chimpanzees. To be clear, the goal of this research was not to determine whether chimpanzees have psychopathy in the manifest polythetic dichotomous sense of the term, nor was it to derive ways for characterizing certain chimpanzees as “psychopaths” in a clinical sense, as has been done by some investigators studying other forms of “psychopathology” in chimpanzees (e.g., Bradshaw, Capaldo,

Lindner, & Grow, 2008; Ferdowsian et al., 2011). Rather, our goal was to evaluate the triarchic model from a comparative and evolutionary standpoint.

Three studies were undertaken. In Study 1, we utilized an established consensus-based approach (Drislane, Brislin, et al., 2014; Hall et al., 2014) to develop chimpanzee triarchic (CHMP-Tri) scales using personality items from Freeman et al.’s (2013) inventory, which are scored by caretakers on the basis of everyday in situ observations. Next, in Study 2, we used human informant-rating data to evaluate the correspondence of the CHMP-Tri scales to counterpart operationalizations in humans, in terms of selective relations with counterpart scales of the TriPM. Last, in Study 3, we validated the CHMP-Tri scales in a subset of chimpanzees by examining associations with individual variation on task-based assessments of approach-avoidance behavior under conditions of uncertainty and delay of gratification (DG). We expected to find unique associations for differing triarchic dispositions with these behavioral indicators. Specifically, based on conceptual descriptions of the triarchic constructs (Patrick et al., 2009) and evidence from prior empirical work, we expected boldness to be uniquely associated with approach under uncertain conditions (e.g., Ross, Benning, Patrick, Thompson, & Thurston, 2008) and disinhibition to be uniquely associated with DG (e.g., Newman, Kosson, & Patterson, 1992; Unikel & Blanchard, 1973).

Study 1

Method

Subjects. Chimpanzees were members of two colonies of apes housed at the Yerkes National Primate Research Center (YNPRC) in Atlanta, Georgia, and at the University of Texas MD Anderson Cancer Center (UTMDACC) in Bastrop, Texas. Personality ratings were available for 95 adult and subadult chimpanzees at YNPRC, including 68 females and 27 males ranging in age from 9 to 53 years ($M_{\text{age}} = 24.79$, $SD = 10.90$). Ratings were available for 143 adult and subadult chimpanzees at UTMDACC including 74 females and 69 males ranging in age from 8 to 51 years ($M_{\text{age}} = 28.58$, $SD = 10.60$). All aspects of the research complied with the American Psychological Association’s (2012) *Guidelines for Ethical Conduct in the Care and Use of Nonhuman Animals in Research*, followed the Institute of Medicine guidelines for research with chimpanzees, and were conducted with the approval of the local Institutional Animal Care and Use Committee.

All chimpanzees were housed in social groups ranging from 2 to 16 individuals, in indoor–outdoor enclosures 24 hr per day. During the winter seasons, the indoor facilities are heated. Lighting in the outdoor facility followed the typical seasonal cyclic change in sunrise and sunset.

The chimpanzees were fed two to five meals daily, consisting of fruits, vegetables, and commercially produced primate chow. Environmental enrichment devices and opportunities were provided to the chimpanzees on a daily basis. At no time were the subjects deprived of food or water.

Measure of personality traits. Through consideration of both the existing human personality literature as well as those traits that may be specific to chimpanzees, Freeman and colleagues (2013) used a combined top-down and bottom-up approach to develop a 41-item personality questionnaire. Each item consisted of a single trait accompanied by a behavioral definition and a Likert-type scale ranging from 1 (*least descriptive of the chimpanzee*) to 7 (*most descriptive of the chimpanzee*). Strong evidence was reported for five factors: Reactivity/unpredictability, Dominance, Extraversion, Openness, and Agreeableness. Reliability has been shown to be adequate both in terms of interrater reliability and internal consistency, and the factors have been found to demonstrate good external validity (Freeman et al., 2013). For example, these scales have been found to evidence strong convergent and discriminant validity with other previously validated scales and with various in vivo behaviors (Hopper et al., 2014; Reamer et al., 2014).

Using this instrument, chimpanzees were rated by colony staff members who had worked with the animals for an extended period and who reported having “enough experience for an accurate rating” (Freeman et al., 2013, p. 1044). With the exception of one of the YNPRC animals, two to three independent raters rated each chimpanzee, and ratings were averaged for all analyses. Consistent with previously published data on interrater reliabilities for personality ratings in chimpanzees (Freeman et al., 2013; Weiss, King, & Hopkins, 2007), mean interrater reliability using ICC (3,k) across all items was .66 and .60 for the YNPRC and UTMDACC colonies, respectively.

Data analytic approach

Scale construction. Construction of the CHMP-Tri scales (Boldness, Meanness, Disinhibition) occurred in three phases. First, in a development phase, candidate personality items were selected for inclusion in scales based on consensus ratings of each. Following identification of initial candidate items, the CHMP-Tri scales underwent a refinement phase and then a final psychometric evaluation phase.

Development phase and candidate item scale construction. Ten raters (5 Ph.D.-level experts in psychopathy, 2 Ph.D.-level primatologists, and 3 clinical psychology graduate students) were provided with a Construct Defi-

nition Form that included narrative descriptions of the phenotypic constructs described in the triarchic model of psychopathy (Patrick et al., 2009): *boldness*, *meanness*, and *disinhibition*.¹ The raters used a secure online system to rate each of the chimpanzee personality items for their relevance to each of the triarchic model constructs. Two of the items, “Depressed” and “Aggressive,” were reserved as criterion indicators (see the discussion later). For each of the other 39 items, raters indicated the degree to which the content of the item related to one of the triarchic phenotypes using a selection of five choices: unrelated to the trait, strongly represents *high* levels of the trait, somewhat represents *high* levels of the trait, somewhat represents *low* levels of the trait, and strongly represents *low* levels of the trait. This rating process was completed a total of three times, as each item was rated separately for boldness, meanness, and disinhibition.

The level of agreement across raters for each item was evaluated to identify candidate items for CHMP-Tri scales for each construct. Items that were rated as *strongly* related to a triarchic phenotype by the majority of raters (at least 5 of 10) and *somewhat* related to a construct by the remaining raters were selected as initial scale indicators. Items that had been rated as strongly indexing the low pole of a construct by the majority of raters were reverse coded prior to being included as scale indicators. In total, 11 initial candidate items were identified for boldness, 11 items for meanness, and 8 for disinhibition.

Scale refinement phase. The CHMP-Tri scales were then refined through an iterative process, taking into account several considerations. First, items were evaluated for adjusted item-total correlations with other candidate items within their target scales. Items with weak item-total correlations were deleted from target scales if their omission improved scale homogeneity, as indexed by Cronbach’s alpha. In addition, candidate items were evaluated for their associations with nontarget scales. One of the aims when constructing the CHMP-Tri scales was to index the triarchic model traits as distinctively as possible; as such, candidate items were deleted from target scales if their removal reduced cross-correlations of the target scale with the other CHMP-Tri scales. The content of candidate items was also evaluated at this stage of scale refinement to ensure balanced representation of distinctive elements of each construct (e.g., inclusion of items reflecting social, affective, and behavioral-venture-someness aspects of boldness).

Next, to replace nonoptimally performing initial candidate items, some of the remaining chimpanzee personality items were evaluated for possible inclusion in the scales. Given the small pool of possible items, the level of rating consensus was relaxed at this stage of scale refinement. Nevertheless, replacement items were

required to be rated as relevant by a majority of the five psychopathy experts. These replacement items were evaluated for their internal properties within scales (i.e., item-total correlations, cross-scale correlations) in a manner similar to the initial candidate items. The effect of adding or dropping a particular item was evaluated individually during this stage of scale development to maintain emphasis on the initial items rated as most relevant to each trait across all raters. Again, these replacement items were retained only if they improved content coverage of a given construct, correlated more highly with the target scale than with other nontarget scales, and increased the homogeneity of the target scale. Based on these procedures, final versions of the CHMP-Tri scales emerged as follows: Boldness, six items (four reverse keyed); Disinhibition, seven items (one reverse keyed); and Meanness, five items (two reverse keyed). The items of the final scales, and their behavioral definitions (which served as referents for caretaker ratings), are shown in Table 1.

Final scale evaluation and external validation. Following scale construction, the final content and psychometric properties of the CHMP-Tri scales were evaluated. In addition, the construct validity of the CHMP-Tri scales was investigated by evaluating associations of these scales with separate observation-based single-item ratings of clinically relevant tendencies exhibited by chimpanzees—namely, proclivities toward depression (i.e., “Often appears isolated, withdrawn, sullen, brooding, and inactive; does not seek out social contact, and tends to be unresponsive to social interactions of other chimpanzees”) and physically aggressive (i.e., “Often initiates fights or other menacing and agonistic encounters with other chimpanzees”) behaviors. Although not represented directly in the item content of the final CHMP-Tri scales, these criterion variables were expected to show clear differential associations with scores on the three scales (Drislane, Patrick, et al., 2014; Venables & Patrick, 2012).

Results

Scale content evaluation and psychometric properties. Despite a rather small base set of items (39) to draw from and the cross-species translational nature of the current work, the content of the final CHMP-Tri scales appears largely consistent with the conceptual framework described by Patrick and colleagues (2009; see Table 1). The final CHMP-Boldness scale indexes fearless and resilient tendencies in the domains of social behavior (Dominant, Dependent [reversed]), emotional sensitivity (Anxious [reversed], Fearful [reversed]), and venturesome experience-seeking (Bold, Timid [reversed]). In contrast,

CHMP-Disinhibition assesses unrestrained-externalizing tendencies through items indexing impulsivity (Impulsive, Inventive/Spontaneous), emotional dysregulation (Irritable, Excitable, Calm [reversed]), and disruptive or inappropriate social behavior (Socially Inept/Intrusive, Jealous/Attention-Seeking). Finally, the CHMP-Meanness scale includes items assessing lack of empathic (Kind/Considerate [reversed]) or affiliative tendencies (Affectionate/Friendly [reversed]), antagonistic social strategies (Manipulative, Bullying), and selfishness (Stingy).

The final CHMP-Tri scales displayed intercorrelations largely consistent with the triarchic theoretical model (Patrick et al., 2009) and observed patterns of correlations among other manifest operationalizations of these traits in humans (Drislane, Brislin, et al., 2014; Hall et al., 2014). Specifically, CHMP-Meanness and Disinhibition were moderately positively correlated ($r = .48, p < .001$), as were CHMP-Boldness and Meanness ($r = .42, p < .001$). In contrast, the CHMP-Boldness and Disinhibition scales exhibited only a weak, nonsignificant positive correlation ($r = .11, p > .05$). Considering the impact of scale length on reliability, internal consistencies were respectable for the six-item CHMP-Boldness and seven-item Disinhibition scales ($\alpha = .82$ and $.77$, respectively), and somewhat lower, as expected, for the five-item CHMP-Meanness scale ($\alpha = .67$). Given the well-known limitations of Cronbach's alpha as an index of scale homogeneity (e.g., Sijsma, 2009), we also computed mean interitem correlations. Mean interitem correlations across the three scales were $.43, .32$, and $.29$ for Boldness, Disinhibition, and Meanness, respectively, all within the recommended target range (i.e., $.15-.50$; Briggs & Cheek, 1986; Clark & Watson, 1995).

Correlations between CHMP-Tri scales and observer ratings of aggressive and depressive tendencies

In addition to satisfactory psychometric properties, preliminary analyses of relations with clinically relevant criterion variables provided evidence for construct validity of the scales, underscoring the effectiveness of the item-to-scale mappings. Consistent with findings from research with human participants, the three CHMP-Tri scales evidence differential associations in expected directions with separate observation-based ratings of Depressed and Aggressive tendencies exhibited by chimpanzee subjects. Whereas depressive tendencies were associated robustly—in a *negative* direction—with Boldness ($r = -.35, p < .001$), tendencies toward physical aggressiveness showed strong positive correlations with Disinhibition in particular ($r = .70, p < .001$), and to a somewhat lesser extent, Meanness ($r = .53, p < .001$). The stronger association of physical aggressive tendencies with Disinhibition,

Table 1. List of Items Composing Each CHMP-Tri Scale

CHMP-Tri scale	Item label	Item description
Boldness ($\alpha = .82$)	Dominant	Is able to displace, threaten, or take food from other chimpanzees. May express high status by decisively intervening in social interactions.
	Dependent (-)	Often relies on other chimpanzees for leadership, reassurance, touching, embracing, and other forms of social support.
	Anxious (-)	Hesitant, indecisive, tentative, jittery.
	Fearful (-)	Reacts excessively to real or imagined threats by displaying behaviors such as screaming, grimacing, running away, or other signs of anxiety or distress.
	Bold	Daring, not restrained or tentative. Not timid, shy, or coy.
	Timid (-)	Lacks confidence, is easily alarmed, and is hesitant to venture into new social or non social situations.
Disinhibition ($\alpha = .77$)	Impulsive	Often displays some spontaneous or sudden behavior that could not have been anticipated.
	Inventive/spontaneous	More likely than others to engage in novel behaviors. E.g., using new devices or materials in their enclosure.
	Irritable	Often seems in a bad mood or is impatient and easily provoked to anger or exasperation and consequent agonistic behavior.
	Excitable	Easily aroused to an emotional state. Becomes highly aroused by situations that would cause less arousal in most chimpanzees.
	Calm (-)	Equable, restful. Reacts to others in an even, calm way. Is not easily disturbed or agitated.
	Socially inept/intrusive Jealous/attention seeking	Acts inappropriately in a social setting. Often troubled by others who are in a desirable or advantageous situation such as having food, a choice location, or access to social groups. May attempt to disrupt activities or make noise to get attention.
Meanness ($\alpha = .67$)	Kind/considerate (-)	Often consoles others in distress to provide reassurance.
	Affectionate/friendly (-)	Seems to have a warm attachment or closeness with other chimpanzees. This may entail frequently grooming, touching, embracing, or lying next to others.
	Bullying Manipulative	Overbearing and intimidating toward younger or lower ranking chimpanzees. Is adept at forming social relationships for its own advantage, especially using alliances and friendships to increase its social standing. Chimpanzee seems able and willing to use others.
	Stingy	Is excessively desirous or covetous of food, favored locations, or other resources in enclosure. Is unwilling to share these resources with others.

Note: α = Cronbach's alpha; CHMP-Tri = Chimpanzee Triarchic scales. Items ending in (-) are reverse keyed.

which coincides with findings from human work (cf. Krueger et al., 2007), is particularly notable given the lack of direct coverage of aggressive tendencies in this CHMP-Tri scale.

Discussion

Study 1 was aimed at developing and undertaking an initial validation of scale measures of the triarchic psychopathy constructs for use with chimpanzees. CHMP-Tri scales were developed through a three-stage process, resulting in a set of scales that appear to measure distinct psychopathy-relevant dispositions with expectable patterns of interrelations consistent with the triarchic model

formulation (Patrick et al., 2009). Furthermore, CHMP-Tri scales showed expected associations with depressive and aggressive tendencies as indexed by observer (caretaker) ratings. These initial findings provide provisional support for the CHMP-Tri scales as a basis for operationalizing psychopathy-relevant dimensions in chimpanzees, with the potential to advance our understanding of evolutionary and biobehavioral processes associated with this form of personality pathology.

In humans, there is now a sizeable literature on the TriPM operationalization of the triarchic model. In addition to demonstrating clear support for the TriPM as a means for assessing the triarchic model dimensions, this literature has also highlighted explicit linkages to structural models of

the externalizing spectrum of psychopathology (Krueger et al., 2007) and dispositional fear/fearlessness (Kramer et al., 2012; for a review, see Patrick & Drislane, in press). As such, the TriPM represents a key referent for the CHMP-Tri operationalization developed in Study 1, and a concrete basis for connecting the CHMP-Tri scales to constructs of response inhibition and acute threat in the RDoC framework (L. D. Nelson, Strickland, Krueger, Arbsi, & Patrick, 2014; Patrick, Venables, Hicks, Nelson, & Kramer, 2013; Yancey, Vaidyanathan, & Patrick, in press).

To evaluate the correspondence of the CHMP-Tri scale measures to the established TriPM operationalization of the triarchic model constructs, we next examined convergent and discriminant associations between the newly created CHMP-Tri scales and counterpart scales of the TriPM in a human sample, using an informant-rating approach. Consistent with the translational aims of our research, this study provided for direct evaluation of correspondence between the CHMP-Tri and TriPM scale operationalizations of the triarchic model constructs—an examination of how the CHMP-Tri scales, developed using data from chimpanzees, perform psychometrically within a human participant sample.

Study 2

Method

Participants. Participants consisted of 301 adults recruited through Amazon's Mechanical Turk (MTurk; www.mturk.com), an open online marketplace that provides access to participants for web-based data collection. Research indicates that studies conducted using MTurk produce results broadly similar to those yielded by traditional data collection methods (Buhrmester, Kwang, & Gosling, 2011; Goodman, Cryder, & Cheema, 2013). Participants were asked to "report on an individual they know well" (e.g., spouse/partner, friend, family member) and were compensated monetarily for their participation. Most informants were female (63.7%) and White (80.6%). Individuals on whom informants reported ($M_{age} = 36.99 \pm 14.42$) were about evenly split between males and females (52.5% males, 47.5% females), with 40.5% of targets being the informant's spouse/partner, 36.0% a friend, and 21.6% a family member. All study procedures were approved by the university's Institutional Review Board.

Measures

CHMP-Tri scales. Informants rated target individuals on the same set of personality items used by chimpanzee caregivers in Study 1, using the same 7-point rating format. Scores on the three CHMP-Tri scales were computed

as sums of constituent items for each, as shown in Table 1. Internal consistencies (Cronbach's alphas) for the six-item Boldness and seven-item Disinhibition scales within this sample (.64 and .62, respectively) were somewhat lower than those in the Study 1 chimpanzee sample, whereas internal consistency for the five-item Meanness scale was somewhat higher (.82). Mean interitem correlations across the three scales were .23, .19, and .48 for Boldness, Disinhibition, and Meanness, respectively. Although somewhat different from Study 1, all average interitem correlations fell within the recommended target range (Briggs & Cheek, 1986; Clark & Watson, 1995).

TriPM scales. Participants also rated target individuals using an informant version of the TriPM (Patrick, 2010). Specifically, TriPM items were formatted so that informants reported on the same known target person using a 4-point Likert-type scale denoting the extent to which each TriPM item statement applied to that individual. Consistent with previous findings using the original self-report version of the TriPM, internal consistencies (Cronbach's alphas) in the current sample were .80 for the 19-item Boldness scale, .95 for the 19-item Meanness scale, and .95 for the 20-item Disinhibition scale. Mean interitem correlations across the three scales were .17, .50, and .49 for Boldness, Meanness, and Disinhibition, respectively.

Analyses. Convergent and discriminant patterns of associations between CHMP-Tri and TriPM scales were evaluated in differing ways. First, bivariate (zero-order) correlations among and between CHMP-Tri and TriPM scales were computed. Next, to evaluate correspondence between variance unique to each CHMP-Tri scale and its TriPM counterpart, regression models were performed in which scores on the three TriPM scales were included as predictors with one or another of the CHMP-Tri scales as the criterion. Last, paralleling validity analyses in Study 1, bivariate correlations between CHMP-Tri scales and single-item indicators of "Aggressiveness" and "Depressed" were examined.

Results: Associations among CHMP-Tri and TriPM scales

Correlations among subscales of the CHMP-Tri and TriPM scales are shown in Table 2. Consistent with findings for chimpanzees in Study 1, the strongest correlation among CHMP-Tri scales was between CHMP-Tri Meanness and Disinhibition ($r = .55, p < .001$). Contrary to findings in Study 1, however, CHMP-Tri Boldness showed significant negative associations with both CHMP-Tri Disinhibition and Meanness ($r_s = -.38$ and $-.31$, respectively, $p_s < .001$). With regard to associations among TriPM scales, a

Table 2. Correlations Among TriPM Scales and CHMP-Tri Scales in Humans

Scale	1	2	3	4	5	6
1. TriPM Bold	<i>.80</i>					
2. TriPM Mean	-.14	<i>.95</i>				
3. TriPM Disinh	-.31	.81	<i>.95</i>			
4. CHMP-Tri Bold	.63	-.22	-.33	<i>.64</i>		
5. CHMP-Tri Mean	-.25	.72	.57	-.31	<i>.82</i>	
6. CHMP-Tri Disinh	-.34	.48	.57	-.38	.55	<i>.62</i>

Note: $N = 301$. Bold = Boldness; CHMP-Tri = Chimpanzee Triarchic scales; Disinh = Disinhibition; Mean = Meanness; TriPM = Triarchic Psychopathy Measure. Correlations $\geq |.11|$ are significant at $p < .05$; $\geq |.15|$, at $p < .01$; $\geq |.19|$, at $p < .001$. Convergent correlations are shown in boldface. Internal consistencies (Cronbach's alphas) are shown in italics along the diagonal.

strong relationship was evident between TriPM Meanness and Disinhibition ($r = .81$, $p < .001$) and, as was the case for counterpart CHMP-Tri scales in this human sample, TriPM Boldness showed significant negative associations with TriPM Meanness and Disinhibition ($r_s = -.31$ and $-.14$, $p_s < .001$ and $< .05$, respectively).

With regard to convergent associations between CHMP-Tri and TriPM scales, as shown in Table 2, in all but one case, the highest observed r_s were between counterpart scales of the two instruments, providing evidence of convergence between these alternative triarchic construct operationalizations. The lone exception was the similar-magnitude associations for the CHMP-Tri Disinhibition and CHMP-Tri Meanness scales with TriPM Disinhibition. To examine convergent associations between scale-specific variance in each CHMP-Tri scale and its TriPM counterpart, accounting for shared variance across TriPM scales, linear regression models were performed predicting scores on each CHMP-Tri scales from the three TriPM scales together. As shown in Table 3, the strongest predictive relationship (i.e., beta coefficient magnitude) in each model was for the counterpart TriPM scale. Table 3 also shows values of multiple R and R^2 for these regression models.²

Consistent with results for chimpanzees in Study 1, examination of relations with informant-rated criterion variables provided further evidence for the validity of the CHMP-Tri scales in this human sample, underscoring the strength and comparability of the associations between species. Specifically, the three CHMP-Tri scales evidenced differential associations in expected and consistent directions with separate ratings of Aggressive and Depressed tendencies on the part of individuals who served as targets for informant ratings. Although Depressed was again associated most robustly (in a negative direction) with CHMP-Tri Boldness ($r = -.59$, $p < .001$), Aggressive showed comparably strong positive associations with CHMP-Tri Disinhibition and Meanness scores ($r_s = .46$, $.50$, $p_s < .001$).

Discussion

Study 2 further validated the CHMP-Tri scale measures of the triarchic model constructs by evaluating their correspondence with counterpart operationalizations provided by the TriPM in a human sample. Along with examining convergence between the two sets of triarchic scales, Study 2 demonstrated that the CHMP-Tri scales evidenced expected differential associations with criterion ratings of proclivities toward depression and physical aggression. In sum, results from Study 2 highlight the broad applicability of the CHMP-Tri model of psychopathic personality by establishing the criterion-related validity of CHMP-Tri scale measures in a sample of humans. To further validate CHMP-Tri dimensions, we next examined associations between CHMP-Tri scales and behavioral measures of approach-avoidance behavior and DG ability in subsets of chimpanzees from Study 1.

Study 3

Method

Participants. Chimpanzee participants for this study comprised a subset of members of the two colonies of apes included in Study 1. Approach-avoidance behavior data were available for 73 chimpanzees housed at UTM-DACC, and DG data were available for 55 chimpanzees residing at YNPRC. CHMP-Tri scale scores for these participants were computed as described in Study 1.

Task-behavioral criterion measures

Approach-avoidance behavior. Approach-avoidance behavior in response to the presentation of a novel stimulus, a human mannequin, was examined in a subsample of 73 chimpanzees from the UTMDACC colony. For each chimpanzee, the total number of interactions with the mannequin was recorded as an indicator of approach behavior. To account for positive skewness and to account for data containing the minimum score of 0 (i.e.,

Table 3. Predicting CHMP-Tri Scale Scores From Tri-PM Scale Scores in Humans

Predictor	CHMP-Tri Boldness		CHMP-Tri Meanness		CHMP-Tri Disinhibition	
	β	t	β	t	β	t
TriPM Boldness	.59	12.50**	-.19	-4.42**	-.19	-3.87**
TriPM Meanness	-.03	-0.35	.82	11.97**	.11	1.36
TriPM Disinhibition	-.13	-1.60	-.15	2.13*	.42	5.03***
$R (R^2)$.65 (.42)		.74 (.55)		.60 (.36)	

Note: $N = 301$. CHMP-Tri = Chimpanzee Triarchic scales; TriPM = Triarchic Psychopathy Measure. The strongest association in each model is shown in boldface.

* $p < .05$. ** $p < .01$. *** $p < .001$.

zero interactions with the mannequin), these scores were log 10 transformed after adding a constant of 1 to each (Howell, 2007). The transformed scores approximated a normal distribution and no longer violated assumptions of normality.

Delay of gratification. DG behaviors were examined in a subsample of 55 chimpanzees from the YNPRC colony. Similar to procedures employed in prior work by Beran and colleagues (Beran et al., 1999; Beran et al., 2014), a transparent PVC pipe blocked at one end with butcher paper was inserted halfway into the subject ape's cage at an angle to allow grapes to be inserted and rolled to the end of the pipe without falling into the cage. In full view of the chimpanzee subject, the experimenter then began placing grapes into the opposite end of the pipe at a rate of about 1 every 2 to 3 s until either (a) all the grapes were placed in the pipe or (b) the subject took possession of the pipe. If the subject took the pipe before all the grapes had been placed inside of it, the experimenter walked away and took the remaining grapes—leaving for 5 min before returning to start a new trial. If a subject waited until all the grapes had been placed in the pipe before pulling the tube into the cage, the subject received all the grapes and the next trial was initiated immediately after the ape finished eating the grapes and returned the PVC pipe to the experimenter.

In sum, on trials in which the ape participant took possession of the pipe before all grapes had been delivered, the participant was permitted to eat the grapes present in the pipe, but did not have an opportunity to perform another trial for 5 min. After initial training phases during which all animals were required to perform up to a standard level before completing, the chimpanzees received 10 trials per test session, which started with 5 grapes per trial. Once the subject had been successful in 5 out of 6 consecutive trials or 5 trials in a row within a test session (i.e., waited for all grapes to be transferred), the number of grapes was increased in increments of 5, up to a level of 20. The number of trials required for the subject to

reach criterion and wait for 20 grapes was evaluated over three sessions. The mean across the three testing sessions was used as the primary dependent measure, such that higher values reflected poorer DG abilities (i.e., more test trials on average to reach criterion).

Data analyses. Relationships for each CHMP-Tri scale with the two behavioral task variables were evaluated using simple bivariate correlations. In addition, relationships for the three scales were examined in the context of regression models including scores on all three together as predictors of each task variable. These regression analyses provided information about comparative levels of prediction for each triarchic scale measure after controlling for overlap (i.e., variance in common) with the other triarchic scales (see Table 2), which can operate to suppress or otherwise distort relationships with criterion measures (e.g., Hicks & Patrick, 2006).

Results

Associations with approach-avoidance behavior. Simple bivariate correlations and multiple regression models were used to investigate associations between CHMP-Tri scale scores and individual variability in approach behavior to a salient novel stimulus (human-like mannequin). At the bivariate level, CHMP-Tri Boldness was significantly positively associated with approach behavior ($r = .32, p < .01$). Neither CHMP-Tri Meanness ($r = .18, p > .13$) nor CHMP-Tri Disinhibition ($r = .13, p > .27$) emerged as a significant predictor of approach behaviors. When considered simultaneously in a multiple regression analysis (i.e., accounting for overlap among the CHMP-Tri scales), consistent with bivariate associations, only CHMP-Tri Boldness ($\beta = .37, t = 2.60, p < .05$) emerged as a significant unique predictor of total interactions, indicating a stronger approach orientation. Predictive associations for CHMP-Tri Meanness and Disinhibition in this analysis were negligible ($\beta s = -.11$ and $.16, t s = -0.64$ and 1.14 , respectively, $p s > .25$).

Associations with delay of gratification. Simple bivariate correlations and multiple regression models were used to test for associations between CHMP-Tri scale scores and interindividual variability in DG task performance, coded such that higher scores were indicative of lesser DG. At the bivariate level, none of the CHMP-Tri scales significantly predicted DG task scores: CHMP-Tri Disinhibition showed a nonsignificant positive relationship with scores on this task, $r = .18$ ($p = .19$), whereas associations for Boldness and Meanness were weakly negative and negligible, respectively ($r_s = -.10$ and $-.01$, $p_s > .46$). When considered simultaneously in a multiple regression analysis, a near-significant predictive relationship emerged for variance unique to Disinhibition ($\beta = .31$, $t = 1.97$, $p = .05$), with variance unique to Boldness showing an enhanced (but still nonsignificant; $\beta = -.27$, $t = -1.67$, $p = .10$) predictive association, and Meanness again exhibiting a negligible association ($\beta = .08$, $t = 0.53$, $p > .59$).

Discussion

Results of Study 3 provide additional support for the validity of the CHMP-Tri scales in terms of expected associations with overt behavioral indicators. Specifically, after accounting for shared variance among CHMP-Tri scales, CHMP-Tri Boldness was found to be uniquely associated with approach behavior. In addition, CHMP-Tri Disinhibition showed a unique predictive relationship with interindividual variation in DG ability.

General Discussion

In a three-stage process, we developed and generated initial evidence of validity for a model of psychopathic personality organized around the constructs of the triarchic conceptualization (Patrick et al., 2009) in a relatively large sample of socially housed captive chimpanzees. Our findings extend previous work (i.e., Lilienfeld et al., 1999) in demonstrating the applicability of the psychopathy construct to chimpanzees, but go beyond these results in demonstrating that the subdimensions of psychopathy, as delineated in the triarchic model, exhibit markedly different correlates that are broadly consistent with theoretical expectations. Using an established consensus-based rating approach to identifying construct-relevant indicators (Drislane, Brislin, et al., 2014; Hall et al., 2014), we began by identifying candidate items for CHMP-Tri scales from an existing primate personality instrument and refined the scales through within- and across-scale analyses. In Study 2, we collected data for the CHMP-Tri scales from human informants, and examined patterns of convergent and divergent relations with scales from another triarchic model inventory developed

for human use, the TriPM (Patrick, 2010). This study provided information regarding the ability of the CHMP-Tri scales to effectively index triarchic facets of psychopathy in humans. Finally, in Study 3, we reported findings from preliminary validation work examining associations between CHMP-Tri scales and behavioral tasks indexing approach-avoidance behavior and ability to delay gratification.

Consistent with previous research findings (Drislane, Brislin, et al., 2014; Drislane, Patrick, et al., 2014; Hall et al., 2014), the current results suggest that the triarchic constructs can be effectively operationalized using items from existing multitrait inventories. Specifically, we succeeded in creating brief triarchic construct scales from items of an established personality inventory for chimpanzees (Freeman et al., 2013). In doing so, the current study extended existing literature by demonstrating that the triarchic model of psychopathy can be meaningfully explicated in chimpanzees, a species that is uniquely poised for comparative research on human personality. The availability of scale measures of the triarchic model constructs for this species sets the stage for specialized research to be undertaken with existing nonhuman primate data sets that can advance our understanding of psychopathy in novel ways. Furthermore, in addition to advancing our understanding of human psychopathology, the development of these scales may be useful to behavioral management staff working in research facilities or zoos for identifying individuals that may be compatible (or incompatible) when forming social groups.

The CHMP-Tri scales demonstrated promising psychometric properties, including satisfactory reliabilities and relations with criterion measures consistent with triarchic model theory (Patrick et al., 2009), and with findings for the TriPM operationalization of the model. Although lower than reliabilities for corresponding TriPM scales, internal consistencies for the CHMP-Tri scales were impressive considering their brevity (e.g., applying the Spearman-Brown prophecy formula [Brown, 1910; Spearman, 1910], projected reliabilities for CHMP-Boldness, Meanness, and Disinhibition scales of equal length to counterpart TriPM scales would be .85, .82, and .95, respectively). In addition, the CHMP-Tri scales exhibited criterion-related validity in terms of expected patterns of correlations with caretaker ratings of "Depressed" and "Aggressive." Boldness was negatively associated with ratings of depression, consistent with findings for the fearless-dominance component of self-reported psychopathy (Benning, Patrick, Blonigen, Hicks, & Iacono, 2005) and Cleckley's (1941) classic characterization of psychopathic individuals as largely lacking in anxious-depressive tendencies. In contrast, CHMP-Disinhibition and Meanness each showed positive associations with ratings of "Aggressive," consistent with findings for

operationalizations of disinhibitory-externalizing and callous-exploitative tendencies in the human child (Frick, Marsee, & Patrick, 2006) and adult psychopathy literatures (Krueger et al., 2007).

We further explored the validity of the CHMP-Tri scales in Study 2 by collecting data for these scales along with counterpart scales of the TriPM in a human sample of informants reporting on target individuals they knew well. Internal consistencies for these scales as applied to human targets fell in a similar range to values for chimpanzee participants in Study 1, with values somewhat higher for CHMP-Meanness and somewhat lower for CHMP-Boldness and Disinhibition. Intercorrelations among the CHMP-Tri scales in the human sample were also broadly consistent with those for the chimpanzee sample, although CHMP-Tri Boldness showed unexpected negative associations with both Meanness and Disinhibition. Nevertheless, atypical negative correlations were also evident for counterpart subscales of the TriPM, indicating that the basis of these unexpected inverse associations lay in either distinct aspects of human informant perceptions or idiosyncrasies of our human sample. Further consistent with these possibilities, the correlation between scores on the informant-based Disinhibition and Meanness scales of the TriPM ($r = .81$) was also markedly higher than that between self-report versions of these scales ($r_s \sim .4-.6$, depending on the sample; Patrick & Drislane, in press).

Regarding possible biases in informant perceptions, informants may have been less able to distinguish between tendencies toward disinhibition and meanness-callousness on the basis of observation, possibly as a function of the appreciable contribution of negative emotionality to both. Perhaps related to this, these results could be a reflection of a potential “horns and halo” effect, whereby target individuals were perceived as “all/mostly bad” or “all/mostly good,” leading to inverse associations between more versus less socially desirable attributes. Alternatively, this pattern of correlations might reflect broad positive or negative response biases on the part of informants. Further research using both informant- and self-report measures of triarchic constructs, operationalized in differing ways and collected from differing participant samples, will be needed to adjudicate among these possibilities.

Notwithstanding the apparent impact of such factors, correlations between counterpart scales for the two instruments (convergent validity coefficients) were impressive (i.e., .6-.7)—especially considering that r_s between CHMP-Tri scales and corresponding TriPM scales are constrained by the weaker internal consistency reliabilities of the former. Disattenuated r_s adjusting for the lower Cronbach’s alphas of the CHMP-Tri scales would be higher (i.e., .7-.9). Evidence for discriminant

validity (i.e., Campbell & Fiske, 1959) was also demonstrated, in that the CHMP-Tri scales correlated to a lesser degree with noncorresponding, conceptually distinct scales of the TriPM: In all instances but one, correlations of CHMP-Tri scales with noncorresponding scales of the TriPM were lower than corresponding scales by .15 or more. The lone instance in which lesser differentiation was evident was for CHMP-Tri Disinhibition with TriPM Meanness—that is, $r = .48$, versus .57 with TriPM Disinhibition. We attribute the weaker divergence in this case to the higher than expected correlation, as noted earlier, between the Disinhibition and Meanness scales of the TriPM in the participant sample for Study 2. As evidence for this explanation, the TriPM Disinhibition scale showed equivalent r_s with CHMP-Tri Meanness and Disinhibition scales (.57 in each case), which correlated only .48 with one another. These findings suggest that the elevated r between TriPM Disinhibition and Meanness scales likely reflects a bias in informant ratings of the former, toward inferring disinhibitory tendencies more on the basis of callous-aggressive behaviors. As a consequence of this tendency, scores on TriPM Disinhibition indexed tendencies intermediate between those indexed by the CHMP-Tri Disinhibition and Meanness scales, rather than tendencies more distinct to CHMP-Tri Disinhibition.

The foregoing interpretation gains credibility from the fact that the CHMP-Tri scales were developed to index the triarchic constructs in the informant-rating domain, whereas the TriPM scales were developed to index these constructs in the domain of self-report. From this perspective, it seems plausible that a greater shift occurred in how items of the TriPM scales were rated by informants than in how items of counterpart CHMP-Tri scales were rated. Further research will be needed to clarify ways in which ratings of particular items of the TriPM (and, by extension, other inventories of psychopathy or personality pathology) differ systematically across self-report and informant-rating domains, and the psychological bases of such differences.

Results from regression analyses using the three TriPM scales together as predictors of scores on each CHMP-Tri scale (Table 3) provided further evidence for the convergent and discriminant validity of the former. In each case, a unique predictive contribution to scores on the target CHMP-Tri scale was evident only for the counterpart scale of the TriPM. All told, findings from Study 2 provide evidence that the CHMP-Tri scales translate well across species and operate quite similarly to the established TriPM scales in a human sample, despite differences in the functioning of the TriPM scales in the informant versus self-report domain.

Further highlighting the validity of the CHMP-Tri scales, CHMP-Tri Boldness and Disinhibition evidenced

distinctive associations with individual variation in task-assessed behaviors in Study 3. Specifically, as expected based on the theoretical conception of boldness as reflecting low dispositional fear and a heightened threshold for the activation of the brain's defensive system (Patrick et al., 2009), CHMP-Tri Boldness was uniquely associated with higher levels of approach behavior to an unfamiliar, humanlike figure—a stimulus expected to appear threatening to most chimpanzees. This finding is, in turn, consistent with previous research showing TriPM Boldness to be associated with fearlessness and thrill-seeking in human samples (e.g., Sellbom & Phillips, 2013). Also consistent with the theoretical conception of disinhibition as reflecting present-centeredness and lack of behavioral restraint (Patrick et al., 2009), CHMP-Tri Disinhibition evidenced a near-significant association with DG score (i.e., reflecting weaker DG ability). This finding fits with previous research relating TriPM Disinhibition to measures of impulsivity, low control, and nonplanfulness (e.g., Drislane, Patrick, et al., 2014; Sellbom & Phillips, 2013). Together with findings from Studies 1 and 2, findings from these behavioral task procedures indicate that the CHMP-Tri scales demonstrate meaningful and expected associations with criterion variables of differing types.

The three studies presented here are marked by several limitations. First, both Studies 1 and 2 relied exclusively on informant-report, which may artificially inflate observed relations among and between scales, and observation-based ratings due to shared method variance. Nonetheless, the promising pattern of associations with criterion measures in other domains, including behavioral tasks, helps to assuage this concern. Moreover, our findings of convergent and discriminant validity for the triarchic scales clearly point to shared substantive content above and beyond method covariance. In addition, the use of a nonclinical MTurk sample in Study 2 may limit generalizability. Furthermore, an informant-report version of the TriPM has not previously been employed, pointing to a need for additional research on this version of the measure. In addition, sample sizes for the behavioral tasks in Study 3 were comparatively modest, and perhaps as a consequence, the relations between CHMP-Tri Disinhibition and DG ability in the smaller of the two task samples ($n = 55$) only approached significance. Although consistent with our a priori hypothesis, this result requires replication.

These limitations notwithstanding, in a three-stage process, the current study demonstrates that the triarchic model of psychopathy can be meaningfully represented in chimpanzees, an animal model uniquely well suited for multilevel neurobiological investigations of individual variation in dispositional traits. As such, the current work can serve as a basis for innovative research directed at

elucidating core processes underlying subdimensions of psychopathy across multiple levels of analysis (e.g., genetic, neurophysiological, task behavioral, social-interpersonal). Indeed, triarchic model constructs are explicitly neurobehavioral in that they have distinct referents in neurobiology and behavior (Patrick & Drislane, in press; Patrick, Durbin, & Moser, 2012; Patrick et al., 2009). Our findings are therefore particularly timely given the recently formulated NIMH RDoC framework, which calls for research focusing on biobehavioral constructs—including constructs with clear connections to boldness, meanness, and disinhibition (i.e., acute threat, attachment, and response inhibition, respectively)—of broad relevance to psychopathology. Evidence for the viability of triarchic model constructs as representations of RDoC constructs is provided by work demonstrating that boldness (or fear/fearlessness) and disinhibition predict various fear-based psychopathologies and externalizing conditions, respectively (L. D. Nelson et al., 2014; Patrick, Durbin, et al., 2012), and in turn electrophysiological biomarkers known to be associated with conditions of these types (Benning, Patrick, & Iacono, 2005; Patrick et al., 2013; Yancey et al., in press; Yancey, Venables, Hicks, & Patrick, 2013).

Results from the current work provide clear support for our primate-translational operationalization of the triarchic psychopathy conception and establish the foundation for an animal model of key neurobehavioral constructs, represented in the RDoC framework, that appear important to multiple forms of psychopathology. Furthermore, though there have been recent decisions to scale back some types of research with captive chimpanzees by National Institutes of Health (NIH), the types of future studies described here all fit well within the ethical framework of scientifically justifiable research with chimpanzees outlined by the Institute of Medicine (2011). In addition, NIH owns and currently supports more than 400 chimpanzees currently residing in research and sanctuary settings in the United States. It is quite concerning that NIH continues to financially support these apes and yet potentially limits their use in the types of noninvasive research projects described here, particularly when the scientific advancements and benefits that might come from these efforts are of significant translational value.

The rich array of data of various types available for the chimpanzee colonies examined in the current work (including caregiver ratings, coded behavior, task performance, neurophysiological measures, and genetic data) provides extensive opportunities for precisely the type of multisystems analysis of these key constructs explicitly encouraged by the RDoC initiative. More specifically, important next steps in this translational research program include evaluation of relations between the CHMP-Tri operationalizations and (a) individual variation in

observed behaviors assessed through systematic coding of well-defined behavioral ethograms, (b) variations in brain anatomy assessed from magnetic resonance imaging and diffusion tensor imaging, (c) genetic polymorphisms related to neurotransmitter system (e.g., dopaminergic) function and potentially in turn to distinct behavioral tendencies (e.g., prosocial and affiliative behavior), and (d) early-rearing experiences (e.g., mother- vs. nursery-reared) expected to exert either direct or interactive effects on later behavior, including pathologic tendencies. Current findings thus set the stage for further programmatic work reflecting an RDoC-consistent, multilevel research strategy directed at clarifying the nomological network of core biobehavioral constructs across multiple units of analysis—including informant report, coded behavior, lab-task performance, brain structure and connectivity, and genomic variation. Work along these lines has the potential to advance not only our understanding of the pathophysiology of psychopathy but also, as described earlier, processes contributing to core biobehavioral dispositions of relevance to multiple forms of psychopathology.

Author Contributions

R. D. Latzman, L. K. Hecht, C. J. Patrick, and W. D. Hopkins developed the study concept. All authors contributed to the study design. Testing and data collection were performed by R. D. Latzman, H. J. Freeman, S. J. Schapiro, and W. D. Hopkins. R. D. Latzman, L. E. Drislane, S. J. Brislin, and C. J. Patrick performed the data analysis and interpretation. R. D. Latzman, L. E. Drislane, and L. K. Hecht drafted the manuscript, and C. J. Patrick, S. O. Lilienfeld, and W. D. Hopkins provided critical revisions. All authors approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

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Notes

1. The Construct Definition Form can be found in the online supplement to Hall et al. (2014) at http://supp.apa.org/psycarticles/supplemental/a0035665/a0035665_supp.html.
2. Although R -squared provides an index of variance accounted for by a set of predictors, the maximum attainable value of

R^2 depends on the reliabilities of both the criterion and independent variables, rendering it relative as an index of variance accounted for. At the same time, its nonsquared counterpart, multiple R , provides a readily interpretable multivariate counterpart to bivariate r , reflecting omnibus prediction for all variates. Given these considerations, and in view of the lower reliabilities for the CHMP-Tri scales relative to the TriPM scales, we report values of both multiple R and R^2 in Table 3.

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