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An Evaluation of the Convergent Construct Validity of the Boldness Inventory of Psychopathy using a Five-Minute, 10% Carbon-Dioxide-Enriched Air Challenge

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An Evaluation of the Convergent Construct Validity of the Boldness Inventory of Psychopathy using a Five-Minute, 10% Carbon-Dioxide-Enriched Air Challenge

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by

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Abstract

Psychopathy is a constellation of maladaptive interpersonal, affective, and behavioral features, including grandiosity, manipulativeness, emotional detachment, and impulsivity (Hare, 2003). Fearlessness, immunity to stress, self-assurance, and social dominance are considered to be adaptive features of psychopathy. Patrick and colleagues (2009) sought to reconcile differences between opposing conceptualizations of psychopathy by formulating a triarchic model of the condition. One core construct in this model, *boldness,* captures an ability to remain calm in the face of threat, an appetite for dangerous or risky activities, and an increased tolerance for uncertainty and danger. Boldness is believed to originate from differences in the brain's defensive systems involved in the detection of threat and represents a phenotypic expression of fearlessness. Two principal problems in studies on psychopathy and fearlessness are the use of varying operationalizations of fear and an overreliance on non-laboratory-based methods to assess it. The current study examined boldness in relation to anticipatory anxiety and real-time fear in response to a CO_2-enriched air challenge. It was hypothesized that boldness scores would relate negatively to (a) anticipatory anxiety ratings before the breathing challenge, (b) fear ratings taken midway through the challenge procedure, and (c) mean heart-rate midway through the challenge. Additionally, it was hypothesized that total boldness scores would relate negatively to STAI and BIS scores, and would be unrelated to PHQ-9 scores. As predicted, boldness related negatively to behavioral inhibition and state anxiety, although it also was unexpectedly linked to depressive symptoms. However, boldness was unrelated to anticipatory anxiety, fear ratings, and mean heart rate. The current study suggests boldness, as measured by the Boldness Inventory, is unrelated to psychological or physiological response to the air breathing challenge. Reasons for the unanticipated pattern of findings are discussed.

Keywords: psychopathy, boldness, fearlessness, biological challenge, CO_2, psychophysiology

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Dedication

This project is dedicated to my daughter, S. You will always be my greatest achievement. We did it, Bug!

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Introduction

Psychopathy is characterized by interpersonal, affective, and behavioral features, including grandiosity, manipulativeness, emotional detachment, superficiality, and poor behavioral control (Hare, 2003). Individuals with psychopathic traits are often portrayed as chimerical entities, who possess the ability to manipulate others while experiencing little guilt or remorse for their actions. The study of psychopathy is complicated by myriad controversies, including debates regarding conceptualization and assessment. Most researchers agree that antisociality and impulsive behavior are hallmarks of the condition (Cleckley, 1976; Hare, 1996; Patrick & Drislane, 2015). Individuals with psychopathic traits exhibit poor behavioral control and planfulness, display a frequent disregard for social norms and rules, and engage in deviant, aggressive, and impulsive behaviors (Nelson & Foell, 2006). Also inherent in many definitions of psychopathy is a relative immunity to fear or anxiety, referred to here as fearlessness. Fearlessness is a longstanding aspect of psychopathy (Cleckley, 1976), and thought to be a defining feature of the broader, "adaptive" constructs of boldness and fearless dominance. These aspects are central to emergent conceptualizations of psychopathy (Lilienfeld et al., 2012; Patrick, Fowles, & Kreuger, 2009; Patrick, Venables, & Drislane, 2013). However, researchers disagree about the centrality of these constructs and their putative relationship to the psychopathic personality (Sleep, Weiss, Lynam, & Miller, 2019).

Fearlessness and Psychopathy: Historical Perspectives. Fearlessness has long been recognized as a component of psychopathy, dating back to Cleckley (1941; Derefinko, 2015). For instance, he wrote of one psychopath ("Max"):

> "He was by no means nervous, even in the lay sense, and showed no emotional instability... rather than an excess of anxiety, he showed the reverse, apparently finding little or nothing in his present situation or in all his past difficulties to cause worry or uneasiness" (p. 32).

Lykken (1957) was the first to attribute the phenotypic presentation of psychopathy to underlying deficits in emotional reactivity, demonstrating what he termed "fearlessness" via classical conditioning paradigms. In these studies, Lykken discovered that individuals high in psychopathic traits did not exhibit the expected anticipatory arousal (e.g., elevated skin conductance) from threat of punishment. He concluded that these subjects must lack an innate sense of fear and cited this deficit as a dispositional hallmark of the psychopathic personality. Gray (1987) characterized psychopathy as a condition marked by a hypoactive behavioral inhibition system (BIS), a motivational system theorized to detect signs of punishment or termination of reward. He attributed the abnormal fear response in psychopathy to under-activation of the BIS in response to cues of threat and punishment. Fearlessness was prominent in early conceptualizations of psychopathy, and this perspective remains influential.

Current Conceptual Debates. Most researchers agree psychopathy includes core (maladaptive) features of interpersonal antagonism and impulsivity. One ongoing debate in the literature is the extent to which "adaptive features" are critical for understanding psychopathy (Miller & Lynam, 2014; Hare & Neumann, 2010). Fearlessness, immunity to stress, self-assurance, and social dominance are considered to be adaptive features of psychopathy (Benning, Patrick, Blonigen, Hicks, & Iacono, 2005; Lilienfeld & Widows, 2005). When present in otherwise psychologically healthy individuals, these characteristics can bestow appreciable benefits (e.g., the ability to remain calm in stressful situations). However, adaptive traits, like charisma or self-assurance, when combined with the more menacing features of psychopathy, like callousness, create a deceptive appearance of healthy psychological adjustment. Although many conceptualizations of psychopathy include descriptions of adaptive characteristics, the significance and centrality of these features is subject to spirited empirical debate (Lilienfeld et

al., 2012; Miller and Lynam, 2014). While many perspectives, both historical and contemporary, contend that adaptive features are necessary, albeit not sufficient, components of psychopathy, a clear disconnect exists between these conceptualizations and current practice. This discrepancy is well-illustrated by Hare's Psychopathy Checklist-Revised (PCL-R), the most widely used assessment of psychopathy, which de-emphasizes adaptive indicators in favor of more overt markers of antisocial and criminal behavior (Hare, 2003). A desire to utilize behavioral indicators to predict important outcomes (e.g., recidivism) is understandable; however, experts have cautioned the field with respect to an overreliance on behaviorally-focused assessments of psychopathy (DeMatteo et al., 2020). Perhaps most importantly, the minimization of adaptive features runs counter to many historical conceptualizations of the construct and represents a shift away from fundamental writings on psychopathy.

Boldness and Fearless Dominance. Boldness and fearless dominance are two higher-order constructs that evidence significant conceptual and empirical overlap with one another and are argued by some scholars to be central to psychopathy. The fearless dominance construct first emerged in the development of the Psychopathic Personality Inventory (PPI; Lilienfeld & Andrews, 1996) and later in its revised version, the PPI-Revised (PPI-R; Lilienfeld & Widows, 2005), a measure designed to assess psychopathic personality traits in non-forensic samples. Benning and colleagues (2005) later revisited the factor structure of the PPI and found support for two factors, which they labeled *Fearless Dominance* (*PPI-I*) and *Impulsive Antisociality* (*PPI-II*). Notably, the PPI factors consistently evidence divergent associations with a number of external criteria. In general, scores on the PPI-I are positively related to adjustment and healthy psychological functioning (e.g., low trait anxiety, sociability), while scores on the PPI-II

demonstrate associations with markers of psychological maladjustment (e.g., impulsivity, substance use; Benning et al., 2005; Patrick et al., 2009).

Patrick and colleagues (2009) sought to reconcile differences between competing conceptualizations of psychopathy by formulating a triarchic model of the condition. The model is comprised of three core phenotypic constructs: *meanness*, which describes a dispositional lack of empathy, manipulativeness, and a tendency to exploit others for personal gain; *disinhibition*, which reflects a general propensity toward impulsivity, emotion dysregulation, and impaired behavioral restraint; and *boldness*, which captures the ability to remain calm in the face of threat, increased self-confidence and emotional resiliency, and a high tolerance for uncertainty and danger. Patrick and colleagues (2009) argue that boldness originates from differences in the brain's defensive systems involved in threat detection, and represents a behavioral expression of underlying fearlessness (Fowles & Dindo, 2009; Vaidyanathan, Patrick & Bernat, 2009). Theoretical models place fearlessness within the broader constructs of boldness and fearless dominance, and evidence testing this idea is amassing.

In this vein, Patrick and colleagues (2019) recently developed a multiscale questionnaire designed to advance the measurement of the boldness construct, and to clarify how the construct relates to psychopathic symptomatology. While the PPI serves as an excellent index of psychopathic traits in non-forensic samples, it emerged post-hoc out of an exploratory analysis of the PPI's facet scales (Lilienfeld & Widows, 2005). As a result, the PPI cannot be expected to include all fundamental features of the psychopathy construct. Additionally, inconsistent relationships among putatively analogous measures of psychopathy (e.g., PPI, PCL-R) suggest significant problems with the conceptualization and assessment of the psychopathy (Lilienfeld, Watts, Francis Smith, Berg, & Latzman, 2015).

The Boldness Inventory (BI; Patrick et al., 2019) allows for a fine-grained measurement of boldness as it relates to relevant clinical variables (e.g., anxiety, fear) and adaptive functioning, as well as to the construct of psychopathy as a whole. The measure differs from the broader Triarchic Measure of Psychopathy (TriPM; Patrick & Drislane, 2015) as it focuses exclusively on the boldness construct and assesses thematically distinct facets of boldness (e.g., valor, self-confidence). The Boldness Inventory was initially validated using data from a nonclinical sample, and subsequently validated using both nonclinical and clinical (i.e., offender) samples. Recent work suggests the new inventory provides a means for measuring various facets of boldness and examining their relations with both adaptive and maladaptive behavior and biological systems (Patrick et al., 2019). The scale demonstrates solid psychometric properties, including excellent internal consistency and reliability; however, additional work is needed to evaluate the measure's construct validity, specifically with regard to its ability to predict theoretically-relevant physiological and behavioral correlates (e.g., biological indicators of fear; Patrick et al., 2019). See Table 3 for scale reliabilities and example items.

Current Literature. While a number of studies of psychopathy and fearlessness exist, laboratory-based studies of boldness are few in number. Indeed, only one laboratory-based study of fearlessness that utilized a validated measure of boldness as a predictor (e.g., TriPM) was identified. Kyranides, Fanti, Sikki, and Patrick (2017) investigated associations between boldness and physiological reactivity to affective stimuli after controlling for relevant personality traits (e.g., callousness, narcissism). Researchers collected self-report data from a large sample of adolescents (N = 2,414). A subset of adolescents identified as high risk with respect to the development of psychopathic traits (N = 99) completed a series of questionnaires approximately four years later, and were invited to participate in a laboratory session. 88 of the 99 participants

participated in an experimental session designed to measure physiological responses (e.g., startle potentiation, heart rate) to affective (*erotic, violent,* and *neutral*) stimuli**.** Boldness related negatively to heart rate reactivity in response to violent stimuli. The authors posit that fearlessness may be explained by reduced heart rate reactivity to aversive stimuli, suggesting autonomic underarousal may be a critical biological indicator of fearlessness. Kyranides and colleagues (2017) also observed negative associations between boldness and self-reported anxiety and fear. These results are consistent with findings from previous studies examining the relation between boldness and self-reported fearlessness (Brislin, Drislane, Smith, Edens, & Patrick, 2015; Hall et al., 2014). Notably, most studies of boldness and self-reported fearlessness operationalize fearlessness via scores on measures of behavioral inhibition (BIS/BAS; Carver & White, 1994) and trait anxiety (STAI-T; Spielberger, 1983).

Extant laboratory-based studies of fearless dominance (Benning, Patrick, & Iacono, 2005; Dindo & Fowles, 2011; Dvorak-Bertsch, Curtin, Rubinstein, & Newman, 2009; Justus & Finn, 2007; Lopez, Poy, Patrick, & Molto, 2013; Vaidyanathan, Patrick, & Bernat, 2009) utilize picture-viewing tasks, in which participants view a series of unpleasant, threat-relevant, or aversive images. Broadly, results suggest negative correlations with psychophysiological indicators of fearlessness (e.g., startle reactivity, heart-rate), with small effect sizes ranging from r's of -.18 to -.29. For example, Benning, Patrick, and Iacono (2005) examined the links between fearless dominance and startle response and skin conductance during an affective picture-viewing task. Consistent with previous findings, high levels of fearless dominance were associated with deficits in fear-potentiated startle. Additionally, participants high in fearless dominance demonstrated reduced skin conductance specifically in response to aversive stimuli. Vaidyanathan, Patrick, and Bernat (2009) utilized a similar approach to investigate startle

response to neutral, pleasant, and aversive pictures in a sample of undergraduates ($N = 88$). Results were similar to those of Benning and colleagues (2005) and supported the relation between high levels of fearless dominance and deficits in startle potentiation in response to aversive stimuli. These findings accord with numerous studies that utilized a validated measure of fearless dominance to evaluate relations with self-reported indices of fearlessness, including self-reported anxiety (Justus & Finn, 2007; Dindo & Fowles, 2011), behavioral inhibition (Sellbom & Phillips, 2013; Uzieblo, Verschuere, Van den Bussche, & Crombez, 2010), harm avoidance (Dindo & Fowles, 2011; Justus & Finn, 2007), trait anxiety (Durand & Plata, 2017; Sorman et al., 2016), trait fear (Sellbom, Wygant, & Drislane, 2014), and phobias (Justus & Finn, 2007). Taken together, results of these studies suggest negative associations between fearless dominance and fearlessness; however, the varying operationalization of fearlessness poses conceptual and methodological problems for this literature.

Clarifying Emotion Terminology: Anxiety, Fear, and Worry. One of the foremost problems of studies on psychopathy and fearlessness is the use of varying operationalizations of fear and different methods used to assess it (Hoppenbrouwers, Bulten, & Brazil, 2016). The notion that individuals with psychopathy are "fearless" is popular, both with clinicians and with the public at large; however, the term "fear" is often ill-defined and frequently misunderstood. One issue in the extant psychopathy literature is that terms such as fear and anxiety are utilized interchangeably and often without reference to bodies of theoretical and empirical work aimed at clarifying their nature and assessment. Experts in the area typically characterize fear as a surge of physiological arousal in response to a clear and immediate threat and occurs in specific, aversive contexts in which an individual is motivated to escape an impeding threat (Grillon, 2008). In contrast, anxiety is associated with sustained arousal and can occur in the absence of an

identifiable trigger. Anxiety occurs in response to an uncertain or future-oriented threat, and corresponds to excitation of the nervous system when a threat is possible at a later time (Barlow, 2004). Extant research supports the notion that anxiety and fear are related, yet distinct, emotions across multiple levels (e.g., neurobiological; LeDoux, 2013). LeDoux further argues that the term fear has become synonymous with the involuntary, physiological experience of fear rather than the psychological phenomenon of fear. In contrast to this perspective, data suggest that the psychological (i.e., conscious) experience of fear is different than the system that detects and responds to threat. While many studies ostensibly measure the role of deficient fear responding in psychopathy, a closer examination reveals significant concerns regarding the operationalization and measurement of fear.

Sex Differences. Although males are more likely than females to be diagnosed with psychopathy, the condition is present in both sexes. Researchers argue that psychopathy is "expressed" differently across the sexes, and these differences are likely influenced by a combination of genetic, environmental, and societal factors (e.g., gender-role socialization; Preston et al., 2018; Verona & Vitale, 2018). In general, men score higher on measures of psychopathy, both globally and with respect to affective/interpersonal features. Some studies provide evidence that female psychopathy is characterized by higher levels of internalizing psychopathology (e.g., anxiety, self-harm), disinhibition, and substance use problems when compared to males (Sica et al., 2021). There is some evidence to suggest that the nomological network of the triarchic model is similar among males and females; however, additional research is needed to achieve a greater understanding of sex differences in psychopathy.

The Current Study. Although evidence regarding the relation between boldness and fearlessness is amassing, the current literature has several critical gaps. First, although

researchers continue to disagree about the centrality of boldness and its putative relationship to the psychopathic personality, it is clear that features of boldness have been emphasized in seminal writings on the condition (Cleckley, 1941). The measurement of boldness and its association with fearlessness has critical implications for the role of fear in psychopathy, and advancements in this domain will contribute to an increased understanding of the scope and boundaries of the condition. Next, in order to accurately discern the role of fearlessness in psychopathy, a distinction must be made not only between fear and related affective states like anxiety, but also between automatic threat responding and the conscious experience of fear. While a number of studies focus on the relation between fearless dominance and purported fear or anxiety, only one study to date utilized laboratory-based methods to specifically examine the relation between *boldness* and fearlessness. Additionally, the vast majority of published laboratory-based studies employ startle modulation tasks to index automatic responses of fear. No studies to date have used carbon-dioxide enriched air (CO_2) inhalations as a fear-relevant elicitation procedure. The administration of carbon-dioxide enriched air (CO_2) is one of the most powerful methods for investigating fearful and (anticipatory) anxious responding in experimental psychopathology (Zvolensky, Feldner, Eifert, & Stewart, 2001; Nillni, Berenz, Rohan, & Zvolensky, 2012; Vickers, Jarfarpour, Mofidi, Rafat, & Woznica, 2012). Increased levels of CO_2, also known as *hypercapnia*, results in abrupt physiological sensations, including increased heart-rate, hyperventilation, feelings of disorientation, and flushing of the skin (Barlow, 2004; Zvolensky et al., 2001). The inhalation of CO_2 increases respiration and autonomic functions, which in turn result in increased physiological sensations commonly associated with fear (Babson, Feldner, Trainor, & Smith, 2009). The administration of CO_2-enriched air produces involuntary, immediate, and systemic psychophysiological effects which typically diminish

quickly following a return to room air. Importantly, these effects can be carefully controlled by an experimenter by varying the dose, timing, and duration of CO_2 administration. The current study is the first in the literature to examine boldness in relation to self-reported, anticipatory anxiety as well as challenge-elicited fear and heart-rate using the CO_2 procedure.

Primary Aim and Hypotheses. The current study was designed to investigate these critical gaps in the literature and provide an evaluation of the convergent validity of the Boldness Inventory. Two overarching hypotheses guided this investigation:

1. To further enhance the nascent literature on the convergent and divergent validity of the Boldness Inventory, interrelations between total boldness scores and two well-established measures of fearlessness commonly used in the literature were examined (Brislin et al., 2015; Hall et al., 2014). It was hypothesized that total boldness scores would relate negatively to scores on self-report measures of trait anxiety (STAI-T: Spielberger, 1983) and behavioral inhibition sensitivity (BIS/BAS; Carver & White, 1994). Additionally, it was hypothesized that total boldness scores would demonstrate no relation to scores on a self-report measure of depressive symptoms (PHQ-9; Kroenke et al., 2001).
2. In response to a 5-minute, 10% CO_2-enriched air challenge, total boldness scores will relate negatively to:
    a. anticipatory anxiety ratings taken immediately before the challenge begins,
    b. fear ratings taken during the middle epoch (120-150s) of the challenge, and
    c. mean heart-rate measured during the middle epoch (120-150s) of the challenge

Method

Participants

Student and community participants (N =74) were recruited via the university digital newspaper and social media. Recruitment materials asked participants to contact researchers if they wanted to take part in the study. A two-pronged screening approach was utilized to determine participant eligibility. First, interested participants were contacted by telephone and read a brief explanation of the study. Next, participants were read a list of exclusionary criteria and asked to respond with either a "Yes" or "No" to indicate whether they would be *ineligible* for the study (without specifying why they were ineligible). See Table 1 for exclusionary criteria. Eligible participants were then contacted via Zoom for a separate, comprehensive evaluation of exclusionary criteria. A conservative screening approach was utilized in order to 1) decrease the probability of adverse events from the CO_2 procedure and 2) limit the effect of potential confounding variables on study findings (e.g., previous participation in a study involving CO_2).

See Table 2 for demographic characteristics of the sample. About half the sample identified as female (48.6%), and the majority of the sample was white (74.3%) and non-Latinx (86.5%). Participants ranged in age from 18 to 66 years, with a mean age of 27.19 years (SD = 10.48). Participants' level of education ranged from some college to possession of a graduate degree, with the majority of the sample being current college students. The majority of participants reported no lifetime history of anxiety treatment (83.8%), previous arrests (93.2%) or past convictions for criminal offenses (91.8%).

Descriptive Measures

Demographics

Relevant demographic information (e.g., age, sex, race, ethnicity) was assessed via a demographic questionnaire.

Assessment of Exclusion Criteria

Assessment of exclusionary criteria was determined using a well-established, semi-structured medical history interview (Babson et al., 2009; Feldner, Zvolensky, Stickle, Bonn-Miller, & Leen-Feldner, 2006). The primary investigator, who is a doctoral-level clinical psychologist with significant training, administered the medical history interviews.

Anxiety Sensitivity

The Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007) is an 18-item version of the original ASI (Reiss et al., 1985) in which participants indicate the degree to which they are concerned about potential negative consequences of anxiety symptoms (e.g., It scares me when my heart beats rapidly). Items are endorsed on a Likert-type scale (0 = *very little*) to 4 (*very much*). The ASI-3 has a three-factor model (i.e., physical cognitive, and social consequences of anxiety). The current study utilized the total ASI-3 score as it represents a global-order ASI factor, which demonstrated excellent reliability (α = .92). The ASI-3 also demonstrates excellent internal consistency among subscales, and its psychometric properties in the current study were consistent with prior work (Nillni et al., 2012; Wheaton, Deacon, McGrath, & Berman, 2012).

Behavioral Inhibition and Activation

The Behavioral Inhibition/Activation scale (BIS/BAS: Carver & White, 1994) is a 20-item self-report measure designed to assess two motivational systems (i.e., approach toward desired stimuli, avoidance of unpleasant stimuli) theorized to underlie behavior and affect. The behavioral inhibition system is believed to control the experience of anxiety, and results in inhibition of behavior that may lead to negative outcomes, particularly in aversive or unfamiliar contexts. Items are rated on a Likert-type scale from 1 (*very true of me*) to 4 (*very untrue of me*), with higher mean scores indicating greater levels of behavioral inhibition and/or activation. The

BIS/BAS subscales demonstrate acceptable internal consistency, good 12-month test-retest reliability, and both convergent and discriminant validity with measures of trait anxiety and novelty-seeking (Carver & White, 1994; Demianczyck, Jenkins, Henson, & Conner, 2004; Meyer, Johnson, & Winters, 2001). The internal consistency for the behavioral inhibition scale (BIS) was consistent with previous research (α = .78; Demianczyck et al., 2004).

Boldness

The Boldness Inventory (BI; Patrick et al., 2019) is a 130-item self-report measure designed to index boldness. Total scores are computed by summing all items, with higher scores indicating greater levels of boldness. The Boldness Inventory contains nine subscales designed to measure specific facets of the boldness construct. Although the scale is relatively new, the BI demonstrates good psychometric properties, including good convergent validity, excellent internal consistency, and discriminant validity with measures of disinhibitory and externalizing tendencies (α = .97 in the current study; Patrick et al., 2019). The nine individual facet scales also demonstrated excellent internal consistency, with alpha coefficients ranging from .88 to .94. See Table 3 for subscale reliabilities and example items.

Depression

The Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) is a 9-item measure of depressive symptoms. Responses are given on a scale from 0 (*not at all*) to 3 (*nearly every day*), and summed to reflect a total score ranging from 0 to 27. Higher scores indicate greater levels of depression. The PHQ-9 demonstrates excellent internal consistency, convergent validity, and test-test reliability (α = .80 in the current study; Kroenke et al., 2001).

Trait Anxiety

The State Anxiety Inventory-Trait (STAI-T; Spielberger, 1983) is a 20-item self-report measure designed to assess trait anxiety. Trait anxiety consists of feelings of tension, apprehension, and increased autonomic activity and is considered a stable personality trait. Statements are rated on a 4-point Likert scale from 1 (*almost never*) to 4 (*almost always*) with instructions to indicate how frequently participants experience certain statements ("I feel nervous and restless"). The STAI has been translated into many languages, including Spanish and Arabic, and demonstrates good psychometric properties, including excellent internal consistency across a broad range of participants and good 30-day test-retest reliability (α = .89 in the current study; Barnes, Harp, & Jung, 2002; Spielberger, 1983).

Challenge Assessment

Anticipatory Anxiety

After being outfitted with psychophysiological recording equipment but prior to a 30s pre-challenge baseline, participants provided a subjective units of distress scale rating to index their level of anticipatory anxiety (SUDS-A). The SUDS-A is a Likert-type scale ranging from 0 (*no anxiety*) to 100 (*extreme anxiety)* and is widely utilized to assess distress in response to affect-elicitation procedures, including CO_2 challenges (Babson et al., 2009; Zvolensky et al., 2014).

Fear

Fear was assessed using a Biopac TSD115 Series Variable Assessment Transducer. Participants provided a continuous assessment by turning a dial to indicate increases and decreases in fear during the challenge procedure. Mean fear ratings during the 30s epoch in the middle of the procedures (120-150s) were utilized for analyses. This epoch was selected because

it provided an emotion rating in response to a *current* threat, consistent with theoretical models of fear (Barlow, 2004; LeDoux, 2013). The mid-point of the challenge was selected in order to limit potential habituation effects that may occur during the latter portion of the procedure.

Physiological Assessment

Heart rate was continuously measured throughout the challenge procedures using a Biopac MP 150 system (Biopac Systems, Inc., Goleta, CA). Acqknowledge 4 software was used for data acquisition and reduction. Heart rate was measured via electrocardiogram (ECG) recording obtained with two pre-gelled Ag-AgCL disposable electrodes placed in a modified Lead II configuration. Mean heart-rate ratings during the 30s epoch in the middle of the procedures (120-150s) were utilized for analyses.

Post-Challenge Assessment

Panic Attack Symptoms

The Diagnostic Sensations Questionnaire (DSQ; Sanderson, Rapee, & Barlow, 1989) was administered to assess panic attack symptoms immediately following the challenge. Participants are asked to rate panic attack symptoms (e.g., breathlessness, fear of dying) on a 9-point Likert-type scale from 0 (*not at all*) to 8 (*very strongly felt*). The DSQ is frequently used in challenge research and demonstrates excellent internal consistency (Nillni et al., 2017; Zvolensky et al., 2011). Reliability coefficients in the current study were acceptable, with respect to total (α = .86) and individual cognitive (α = .77) and physical (α = .83) subscale scores.

Procedure

See Figure 1 for a graphical depiction of study procedures. Upon arrival to the laboratory, participants were provided with an overview of the study procedures, including risks and benefits of participation. The consent process included a description of the possible negative side effects

that may occur while breathing CO_2-enriched air, including: breathlessness, dizziness, dry mouth, feeling sweaty, and nervousness. Participants were informed that while these bodily sensations are harmless, they have the opportunity to discontinue participation at any time. Eligible participants then completed the baseline self-report, randomized to limit order effects.

Upon completion of self-report measures, participants completed three brief trainings. First, the researcher provided instructions on salivary cortisol collection (obtained as part of a secondary analysis). Next, participants completed an emotion training in order to teach them about the distinction between anxiety and fear (see Appendix A). After the emotion training, participants completed a brief series of questions designed to assess their understanding of the distinctions between anxiety and fear. The researcher asked participants to repeat the emotion training and assessment until mastery was achieved. Mastery of the material was operationalized as a score of 100 (i.e., all questions answered correctly) on the training assessment. All participants successfully completed the emotion training. Finally, participants were instructed to use the fear dial to continuously indicate their level of fear during the baseline and the challenge, and they were provided with a visual reminder of the emotion definitions. See Appendix A for emotion and fear training scripts.

Upon conclusion of these trainings, the researcher attached physiological monitoring electrodes and the CPAP mask. Participants were provided with a reminder of the emotion training, and completed a 5-minute baseline, where they sat quietly and acclimated to the laboratory setting. Following the baseline, participants received the following instructions:

> *"Shortly, you will begin breathing air that is higher than normal in carbon dioxide. As you read in the consent form, you may experience breathlessness or nervousness. While uncomfortable, these feelings will go away as soon as the challenge is over. The challenge is 5min. It is your right to stop the challenge – by removing your mask – but please do your best to complete the challenge."*

The researcher left the room to begin the challenge procedure, and participants immediately provided a SUDS rating to index anticipatory anxiety. The researcher observed participants through a two-way mirror and bi-directional intercom system. Next, participants received an automated delivery of one, 5-minute CO_2 enriched-air presentation. The physiologic stimulus was 10% CO_2-enriched air (10% CO_2, 21% O_2, 69% NO_2), which has been approved for human consumption. Participants were equipped with a continuous positive pressure Downs C-Pap Mask. Consistent with prior work, participants were administered a single 5-minute CO_2 presentation during the laboratory assessment (Babson et al., 2009; Zvolensky et al., 2014). Fear and heart rate were continuously assessed during the duration of the challenge. The DSQ was administered immediately following the challenge. Salivary samples were collected in 15min intervals for the next 60min, during which participants watched an affectively neutral documentary. Following completion of the study, participants were provided with a comprehensive debriefing, which included a detailed explanation of study objectives. Participants were given the opportunity to ask any remaining questions pertaining to the study. Next, all participants were offered a list of local mental health resources. Finally, participants were compensated for their participation. 44 participants received $20 for completing the study, and 1 participant received credit towards an introductory psychology course. The remaining participants (N = 30) received a $45 Amazon gift card. The differences in compensation were the result of a funding award received after data collection had commenced. Funding status was not associated with any of the major outcomes of the study.

Data Analytic Approach

The estimated sample size (N = 70) was selected based on an a priori power analysis conducted using G*Power 3 (Faul, Erfeldner, Lang, & Buchner, 2007) using the closest analog

to the current study (Dindo & Fowles, 2011). Broadly, effect sizes in laboratory-based studies of boldness and fearless dominance are generally small in magnitude, ranging from *r*'s of .18 to .29. Importantly, a conservative power analysis suggested that in order to detect a small-to-medium effect (power of 0.80, alpha of 0.05) in our analyses, a sample of at least 55 participants was needed. A total of 74 participants were matriculated in order to account for lost psychophysiological data (e.g., due to artifacts) and dropout due to distress caused by the breathing challenge. First, a manipulation check was conducted to ensure that the CO_2 challenge sufficiently elicited psychological and physiological arousal. Next, we evaluated descriptive findings to examine how the data accord with previous studies and examined intercorrelations among predictor and outcome variables. Finally, we then conducted three linear multiple regressions to examine the effects of boldness on anticipatory anxiety, mid-point fear ratings, and mean heart rate.

Results

A total of 12 participants (16.2%) dropped out of the challenge prior to the 120-150s epoch. Prior to data analysis, all psychophysiological data were screened for outliers due to extraneous factors (e.g., participant movement or artifacts), missing, or incomplete data. Psychophysiological data (which includes transducer-based fear ratings) for an additional 6 participants were unable to be analyzed for these reasons. Thus, these participants were excluded from the primary analyses involving mean fear and heart-rate during the challenge, leaving an analytic sample of 56 participants. In regard to anticipatory anxiety prior to the challenge, participants indicated relatively low SUDS-A ratings (M= 1.13, SD = 1.55), suggesting that overall baseline anxiety was low and without much variability.

Global ASI-3 ratings in the current study (M = 17.91, SD = 12.96) were higher than previous studies of similar populations (M = 13.83, SD = 10.79; Wheaton et al., 2012). Scores for the BIS, DSQ, and STAI were consistent with normed samples (Falkenbach et al., 2014; Nilni et al., 2012; Uzieblo et al., 2007; Wheaton et al., 2012). Scores on the TriPM were consistent, albeit slightly higher, compared to normed samples (Shou et al., 2017), and BI scores were consistent with Patrick and colleagues (2019).

Manipulation Check.

A manipulation check was conducted to ensure that the CO_2 challenge was effective. Specifically, paired samples *t*-tests were conducted between pre-challenge and challenge (120-150s) heart rate and fear ratings. As expected, heart rate and fear ratings significantly increased pre-to post-challenge (ps > .001). See Table 4.

Correlations Among the Boldness Inventory and Self-Report Measures.

Descriptive statistics and zero order correlations among study variables are presented in Table 5. With regard to convergent validity and as predicted, BI scores were negatively associated with both BIS (r = -.66, p <.01) and STAI scores (r = -.79, p < .01). As expected, however, BI ratings and TriPM-Boldness scores were positively correlated (r = .82, p < .001).

Correlations between the Boldness Inventory and additional criterion measures were also examined to assess the divergent validity of the emergent measure. In contrast to predictions, BI scores were negatively associated with PHQ-9 scores (r = -.36, p <.01). TriPM-Boldness scores significant evidenced a similar pattern with PHQ-9 scores, although the association was not significant (r = -.27, p =.054).

Regressions.

Three linear multiple regressions were conducted to examine the effects of boldness (BI scores) on anticipatory anxiety (SUDS-A), mid-point fear ratings, and mean heart rate, while controlling for baseline fear and heart rate. Scores on the BI did not predict SUDS-A (β = .10, p = .38), mid-point fear ratings (β = .03, p =.83), or mean heart rate (β = .02, p = .65). Details are provided in Table 6.

Next, the same analyses were conducted after removing the non-responders. Non-responders (N = 11) were classified as participants whose fear ratings evidenced no change during the challenge, suggesting that they may not have appropriately attended to the dial or did not indicate that they experienced any change in fear during the challenge. Table 7 details the intercorrelations among variables in this subsample. The overall pattern of findings was generally similar and results of the primary analyses remained non-significant after removing non-responders (N = 45; see Table 6).

Descriptive and Exploratory Analyses.

Descriptive statistics were computed in order to facilitate comparison of observed scores on the BI from the current sample to Patrick et al. (2019). These results are presented in Table 8. Across studies, males generally score higher on measures of psychopathy (Durand & Plata, 2017; Patrick et al., 2019; Sica et al., 2021). In the current study, total BI scores were higher in males compared females, and males score higher on the Tolerance of Uncertainty subscale (ps < .05). These findings are consistent with those reported by Patrick et al. (2019), as males scored higher on all BI subscales, except for Social Assurance and Dominance (ns). Although the Boldness Inventory purportedly indexes various facets of fearlessness, it is plausible that specific subscales are more representative of the construct than others. For example, the Valor subscale

assesses one's lack of fear and ability to perform in dangerous or troubling situations (e.g., "I stay calm, cool, and collected in scary situations), whereas the Optimism scale measures an individual's confidence in their abilities and capacity to cope with difficult experiences, rather than an ability to persevere in fearful situations (see Table 3). Thus, although each facet indexes an important aspect of the boldness construct, some may be more relevant than others.

With this backdrop, exploratory analyses were conducted to investigate potential relations among boldness facets and outcome variables. The Intrepidness, Resilience, Tolerance for Uncertainty, and Valor subscales were selected as they appear to most closely approximate the core features of boldness. Four multiple regressions were conducted to examine the effects of specific boldness facets on anticipatory anxiety, mid-point fear ratings, and mean heart rate among responders, while controlling for baseline fear and heart rate. Intrepidness, Resilience, Tolerance for Uncertainty, and Valor predicted baseline heart rate. Facet scale scores did not predict anticipatory anxiety, mid-point fear ratings, or mid-challenge heart rate. These results are presented in Table 9.

Discussion

The current study aimed to address several critical gaps in the literature on the fearlessness aspect of psychopathy. Inherent in most conceptual debates regarding the nature of psychopathy is whether "adaptive" characteristics (i.e., boldness) represent core features of the condition. These debates, and movement toward clarification of the psychopathy construct, are complicated by the use of various measurement tools to assess it. Many measures fail to sufficiently assess the adaptive features of psychopathy, which further limits our ability to clarify the scope and boundaries of the psychopathy construct as a whole, and the role of fearlessness specifically. In this context, we endeavored to evaluate the psychometric properties of a novel

measure of boldness in relation to measures of anxiety, behavioral inhibition sensitivity, and depressive symptoms. Additionally, many of the principal problems in studies of psychopathy and fearlessness stem from the use of varying operationalizations of fear and anxiety-related constructs, and an overreliance on non-laboratory-based methods of investigation. Thus, the current study sought to address these issues by an examining the relations between boldness and subjective as well as psychophysiological response to a laboratory-based, 5-minute, 10% CO_2-enriched air challenge.

It was hypothesized that BI scores would be negatively associated with self-reported behavioral inhibition sensitivity and trait anxiety. Support was obtained for both of these hypotheses, and negative associations between BI, BIS, and STAI scores were large in magnitude. These findings accord with previous studies, which demonstrate negative associations between measures of psychopathy, and both behavioral inhibition sensitivity, and trait anxiety (Brislin et al., 2015; Durand & Plata, 2017; Fanti et al., 2016). These associations are also fairly consistent across various populations, including community (Latzman et al., 2019) and undergraduate participants (Falkenbach et al., 2014), as well as incarcerated and forensic psychiatric samples (Brislin et al., 2015; Edens & McDermott, 2010). Intercorrelations among the BIS and related measures of internalizing tendencies (e.g., STAI, ASI) were also consistent with that of prior work (Segarra, Poy, Lopez, & Molto, 2014; Uzieblo et al., 2007).

As predicted, BI scores and TriPM-Boldness scores were positively correlated, which supports the convergent validity of the Boldness Inventory. To our knowledge, this is the first study to utilize the Boldness Inventory outside of the initial scale development study (Patrick et al., 2019). The current findings support the use of the inventory as a tool to articulate and understand the nature and correlates of psychopathy subcomponents. Future studies should

examine facets of boldness and their relations with both adaptive and maladaptive behavior and the physiological correlates of psychopathy.

With respect to divergent validity, it was hypothesized that scores on the Boldness Inventory would not be associated with depressive symptoms. Interestingly, there was a negative association between BI scores and scores on the PHQ-9. It is possible that particular facets drove this association. For example, greater levels of Optimism and Resilience may be negatively associated with depressive symptoms, given the associations between depression and these constructs (Hoorelbeke, Van Den Bergh, Wichers, & Koster, 2019). There is some evidence to suggest that fearlessness (as indexed by the PPI), may exert protective effects against depression and suicidality (Hunt, Bornovalova, Kimonis, Lilienfeld, & Poythress, 2015), particularly in individuals with elevated impulsivity (Miller, Hyatt, Maples-Keller, Carter, & Lynam, 2017). The negative link between BI and depression scores in the current study adds to a growing body of work which suggest unique associations, and possible protective effects, between boldness and various forms of internalizing psychopathology. Future research should further examine divergent validity of the Boldness Inventory using broad and representative samples across a variety of contexts, including correctional and forensic settings. Although an in-depth investigation of facet scores and clinical outcomes was not a primary focus of the current study, researchers should evaluate which specific boldness facets predict important clinical outcomes. This is particularly vital given studies that show that clinical predictions (e.g., depression, treatment compliance) can be improved by parsing psychopathy facets (Douglas et al., 2008; Skeem et al., 2011).

The second set of hypotheses aimed to extend previous laboratory-based studies of fearlessness by examining boldness in relation to psychological and physiological arousal

elicited by a CO_2-enriched air challenge. It was hypothesized that total BI scores would relate negatively to 1) anticipatory anxiety rating prior to the challenge procedure; 2) fear ratings taken during the middle epoch of the challenge (120-150s); and 3) mean heart rate measure during the middle epoch of the challenge. Support was not obtained for these hypotheses, regardless of whether participants were classified as "responders" (i.e., those who experienced increased fear during the challenge) or those who were not. It is possible that boldness as indexed by total scores on the BI is unrelated to anxious and fearful reactivity elicited by a CO_2-enriched air challenge. However, it is important not to over-interpret null findings, and there are a number of methodological factors that could have influenced this pattern of results.

First, with regard to anticipatory anxiety, participants reported unusually low levels of anticipatory anxiety prior to the challenge procedure. In addition to sample-related characteristics that may have influenced findings as discussed above, a number of other factors are important to consider. For instance, although pre-task anxiety ratings should have been high for a future threat, it is possible the emotion training directly influenced this finding in particular. The current study utilized an emotion training procedure to familiarize participants with the constructs (i.e., anxiety, fear) being assessed. This is relatively rare in experimental psychopathology research, and has not, to the best of our knowledge, been done in the context of CO_2 research. Education regarding the nature of an upcoming "threat" and the commonly experienced psychological and physical responses may have inadvertently prepared participants to better cope with challenge distress and discomfort. In support of the idea that the training influenced anxiety ratings, STAI scores, which reflect trait levels of anxiety, also were unrelated to pre-challenge anxiety ratings. Individuals high in anxiety sensitivity may have been particularly sensitive to the instructional set, which may have inadvertently influenced the challenge response. Future studies should

examine the potential effects of pre-challenge emotion training procedures on pre-and post-challenge emotion ratings. Finally, the current study was conducted in the midst of the COVID-19 pandemic, and mask mandates were strictly enforced in the study community. It is possible participants were less affected by the challenge procedure due to the nature of the pandemic. It will be important to replicate the current findings outside the context of a respiratory-related global pandemic.

In terms of fear ratings, no other study has utilized real-time fear ratings in the context of a CO_2-enriched air challenge, making it difficult to draw comparisons with prior work. One possibility is that participants were so overwhelmed by the biological challenge procedures that they failed to accurately report their current fear levels. This explanation is weakened by the fact that the observed pattern of results held even when "non-responders" were excluded. Second, the emotion training may again be at play. For example, it is possible that participants did not fully attend to the material, or conflated the distinctions between fear and anxiety, thereby resulting in inaccurate fear dial ratings. However, most participants passed the emotion-training assessment on the first attempt (N =50; 67.6%) and almost all participants passed the training after two attempts (N = 72; 97.3%). No participants repeated the assessment more than three times, and participants were required to answer all questions correctly in order to complete the CO_2-enriched air challenge. These data suggest participants understood the central tenants of the emotion training; however, the training itself may have influenced real-time fear ratings. For example, reference to the desire to flee as when a bunny encounters a fatal threat (i.e., gardener with a shovel) may have affected participants' conceptualization of fear. That is, most participants likely did not experience the challenge as a mortal threat, given it was occurring in a predictable, high-regulated environment (e.g., research setting). Indeed, participants were asked

to reflect on their challenge experiences during the debriefing process. Although anecdotal, several participants conceptualized the challenge as a "distressing," rather than fearful, experience. Relatedly, participants explicitly informed the researcher they felt less fearful during the challenge due to the thorough screening process, multiple descriptions of study procedures and possible side effects (e.g., shortness of breath), and awareness of rigorous Institutional Review Board procedures. Third, we did not assess whether participants utilized coping strategies during the challenge procedure (e.g., cognitive restructuring), and they were not instructed to refrain from use of these techniques during the challenge. During debriefing, several participants reported using a variety of techniques to moderate their fear during the procedure (e.g., cognitive restructuring), and it is possible these techniques were successful in modulating fearful reactivity to the challenge. Given prior suggesting that, when not given specific instructions, many participants engage in active coping when presented with air enriched by CO_2 (Levitt et al., 2004), studies may benefit from providing some kind of instruction for how to manage the arousal elicited by the challenge (e.g., observe your response). Finally, selecting data at the mid-point of the challenge may have influenced the findings. Fear ratings may have increased over the course of the challenge, and data from a later point in time may have produced different results.

Finally, with regard to heart-rate reactivity to the challenge, boldness was not related with this outcome. This stands at odds with a long line of research linking aspects of psychopathy to objective indices of threat response (Esteller, Poy, & Molto, 2016; Lopez, Poy, Patrick, & Molto, 2013; Kyranides, Fanti, Sikki, & Patrick, 2017). Indeed, although effect sizes are generally small in magnitude (*r*'s of .18 to .33), boldness appears uniquely related to deficits in fear reactivity attenuated psychophysiological response to threat is at the heart of most conceptualizations of

psychopathology. Similar reasons as those discussed above regarding may apply to the perplexing data pattern here. That is, boldness as assessed by the BI and the TriPM evidenced *positive* (albeit non-significant) associations with baseline heart rate. To evaluate the possibility that only certain aspects of the BI were related to challenge response, post-hoc exploratory analyses were conducted on the conceptually-relevant subscales of Intrepidness, Resilience, Tolerance of Uncertainty, and Valor. Findings showed these subscales were similarly unrelated to anticipatory anxiety or mid-challenge fear ratings or heart rate during the challenge, although the association between Resilience and challenge heart rate was approaching significance after controlling for baseline ($p = .054$). Replication and extension of these findings, particularly with a sample recruited under different conditions, is now needed to extend this body of work and continue interrogating the unique, predictive validity of boldness facets using a multi-method approach.

Finally, total BI scores were elevated in males compared to females, which accords with previous studies (Uzieblo et al., 2007). Further, gender differences are typically most prominent when examining the individual factors underlying psychopathy measures, with females scoring higher on scales that index the impulsive-antisocial factor (cf. fearlessness; Dalkner et al., 2018).

Limitations notwithstanding, the current study has several notable strengths, including the use of an empirically-driven emotion training and assessment. No prior laboratory-based studies of fearlessness have provided participants with education before a task. Further, this is the first study to examine the fearlessness aspect of psychopathy using a 5-minute, 10% CO_2-enriched air challenge, which is one of the most powerful methods for eliciting fearful and anxious responding (Zvolensky, Feldner, Eifert, & Stewart, 2001; Nillni, Berenz, Rohan, & Zvolensky, 2012). Collectively, the current study suggests boldness, as measured by the BI, is unrelated to

psychological or physiological response to the air breathing challenge. This is also the first study to our knowledge to demonstrate large, negative associations between the BI and measures of behavioral sensitivity and trait anxiety. Additional work is needed to forward our understanding of the role of boldness, fearlessness, and psychopathy

Tables

Table 1
Exclusionary Criteria.

1. Current suicidal or homicidal ideation
2. Psychosis
3. Self-reported pregnancy
4. Breathing difficulties or the following respiratory illnesses: asthma, chronic obstructive pulmonary disease, emphysema
5. Current serious medical conditions, including: heart problems, epilepsy, sleep apnea, narcolepsy, or kidney or liver problems.
6. Use of benzodiazepines (e.g., Xanax, Ativan) within the last 8 hours
7. Lifetime diagnosis of panic disorder
8. Previous participation in a CO_2 study
9. Formal training to tolerate elevated levels of CO_2 or bodily arousal
10. Diagnosis of an endocrine disorder
11. Current medications that affect the endocrine system
10. The inability to provide written informed consent

Table 2
Sample Characteristics

	M (SD) or N *(%)*
Age	27.19 (*10.48)*
Gender	
Female	36 (48.6%)
Male	34 (45.9%)
Non-binary	2 (2.7%)
Prefer not to answer	1 (1.4%)
No response	1 (1.4%)
Race[a]	
Native American/Alaskan Native	2 (2.7%)
Black	2 (2.7%)
Asian	8 (10.8%)
Pacific Islander	1 (1.4%)
White	55 (74.3%)
Other	10 (13.5%)
Ethnicity	
Latinx	10 (13.5%)
Non-Latinx	64 (86.5%)
Education	
Freshman	4 (5.4%)
Sophomore	8 (10.8%)
Junior	12 (16.2%)
Senior	14 (18.9%)
Graduate Student	19 (25.7%)
Faculty or Staff	14 (18.9%)
Not affiliated with the University	3 (4.1%)
Employment	
Unemployed	18 (24.3%)
Employed 1-20 hours per week	27 (36.5%)
Employed 20-30 hours per week	7 (9.5%)
Employed full time	22 (29.7%)
Lifetime History of Anxiety Treatment	
Yes	12 (16.2%)
No	62 (83.8%)
Legal Involvement	
Previous arrest	5 (6.8%)
Previous conviction	6 (8.1%)

Note. [a]Frequencies exceeded the total sample because participants could select more than one response.

Table 3
Boldness Inventory Subscales: Internal Consistency Reliabilities and Example Items

Scale	# Items	α	Example Items
Social Assurance	14	.90	I feel pretty confident when meeting new people. It's easy to embarrass me. (-)
Dominance	14	.94	I seek out positions of power. I don't like to take the lead in groups. (-)
Persuasiveness	12	.92	I like the challenge of convincing other people. Negotiating with others is not my strength. (-)
Self-Confidence	01	.92	I've got what it takes to succeed. I don't stack up well against most others. (-)
Optimism	13	.89	I generally feel hopeful about the future. It's always hard for me to see the light at the end of the tunnel. (-)
Resilience	11	.86	I recover from setbacks more quickly than other people. I am readily defeated even by minor problems. (-)
Valor	13	.89	I stay calm, cool, and collected in scary situations. I am very easily frightened. (-)
Intrepidness	17	.92	I would pay to go bungee jumping off of a tall bridge or cliff. I stay away from physical danger as much as I can. (-)
Tolerance for Uncertainty	15	.88	I enjoy doing new things that other people are afraid to do. It bothers me to be in new situations where things are uncertain (-).

Note. (-) indicates reversed-scored items.

Table 4
Challenge manipulation results

	Pre-challenge mean (SD)	Challenge mean (SD)	Paired samples t-test
Fear ratings	1.02 (.13)	3.26 (2.43)	t (55) = -6.96, p <.001
Heart rate	72.53 (10.39)	86.45 (12.77)	t (55) = -9.89, p < .001

Note. Pre- and post-challenge fear ratings and heart rate were averaged over the 120-150s epoch.

Table 5

Correlations, Means, and Standard Deviations of Primary Study Variables Using Analytic Sample (N = 56)

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11	12	Mean (SD)	Observed Range
1. ASI-3	1	-.39**	.38**	.01	.56**	-.001	.43**	.09	-.17	.002	-.07	-.30*	19.33 (14.72)	1-66
2. BI		1	-.66**	.03	-.70**	.04	-.36**	-.29*	-.17	-.21	-.13	.82*	237.51 (47.46)	100-319
3. BIS			1	.23	.71**	.06	.41**	.11	.12	.07	-.02	.12	2.99 (.53)	1.71-4
4. DSQ				1	.16	.11	.10	.14	.39**	.05	.29*	.09	35.75 (17.25)	1-83
5. STAI					1	.06	.63*	.21	.13	-.06	-.05	-.10	41.68 (9.40)	25-63
6. SUDS-A						1	.20	.19	.03	.13	.19	.07	.92 (1.26)	0-5
7. PHQ-9							1	.42*	-.03	.11	.12	.27	4.64 (4.12)	0-17
8. Baseline Fear								1	.19	.10	.13	.09	1.02 (.13)	1-2.01
9. Challenge Fear									1	-.02	.27**	.29*	3.26 (2.43)	1-10.01
10. Baseline HR										1	.60**	.06	72.53 (10.39)	--
11. Challenge HR											1	.16	86.45	--
12. TriPM-Boldness												1	145.83 (15.50)	118-178

Note. ASI-3 = Anxiety Sensitivity Inventory; BI = Boldness Inventory; BIS/BAS = Behavioral Inhibition/Behavioral Activation Scale; DSQ = Diagnostic Sensations Questionnaire; STAI = State-Trait Anxiety Inventory; SUDS-A = Subject Units of Distress – Anticipatory Anxiety; PHQ-9 = Patient Health Questionnaire; TriPM = Triarchic Psychopathy Measure-Boldness.

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

Table 6

Boldness Inventory predicting challenge response.

Predictor	Full Sample (N =56)				Responders (N = 45)			
	t	*β*	SE	*p*	*t*	*β*	SE	*p*
Anticipatory anxiety[a]	-.43	-.05	.004	.67	.38	.06	.004	.71
Mid-challenge fear	-.48	-.07	.007	.64	-.78	-.13	.01	.44
Baseline fear	1.18	.17	2.57	.24	.83	.13	2.59	.41
Challenge heart rate	-.17	-.02	.03	.87	-1.22	-.17	.18	.23
Baseline heart-rate	4.74	.57	.15	< .001	2.83	.40	.18	<.05

[a] n = 74; anticipatory anxiety data were collected prior to drop-out during the air breathing challenge.

Table 7

Correlations, Means, and Standard Deviations of Primary Study Variables among Responders (N = 45)

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11	12	Mean (SD)	Observed Range
1. ASI-3	1	-.39**	.40**	-.007	.48**	.09	.37*	.13	-.12	.20	.17	-.16	17.90 (12.96)	1-55
2. BI		1	-.64**	.07	-.70**	.06	-.39**	-.32	.17	-.27	-.28	.83**	238.52 (48.34)	100-319
3. BIS			1	.19	.72**	.06	.40**	.12	.18	.11	.03	.17	2.98 (.55)	1.71-4
4. DSQ				1	.24	.03	.08	.16	.39**	.03	.24	.002	37.96 (15.01)	12-83
5. STAI					1	.09	.61*	.25	.21	.11	.18	-.04	41.41 (9.41)	25-59
6. SUDS -A						1	.22	.18	-.11	.10	.12	-.04	1.08 (1.34)	0-5
7. PHQ-9							1	.46**	-.09	.24	.19	-.22	4.89 (4.11)	0-17
8. Baseline Fear								1	.18	.11	.13	.08	1.02 (.15)	1-2.01
9. Challenge Fear									1	-.04	.19	.21	3.82 (2.41)	1.17-10
10. Baseline HR										1	.54**	.001	72.63 (9.78)	--
11. Challenge HR											1	.13	88.23 (11.78)	--
12. TriPM-Boldness												1	148.02 (15.15)	119-178

Note. ASI-3 = Anxiety Sensitivity Inventory; BI = Boldness Inventory; BIS/BAS = Behavioral Inhibition/Behavioral Activation Scale; DSQ = Diagnostic Sensations Questionnaire; STAI = State-Trait Anxiety Inventory; SUDS-A = Subject Units of Distress – Anticipatory Anxiety; PHQ-9 = Patient Health Questionnaire; TriPM-Boldness = Triarchic Psychopathy Measure – Boldness.

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

Table 8
Descriptive Statistics for Boldness Inventory Subscales and Total Scores for Sample as Whole and by Sex

	All participants (N = 74)		*Women (N = 40)*		*Men (N = 34)*		*t-test*
Scale	*M (SD)*	Range	*M (SD)*	Range	*M (SD)*	Range	*p*
Social Assurance	21.12 (9.17)	3-40	20.40 (9.99)	5-40	21.97 (8.17)	3-36	.08
Dominance	24.38 (9.46)	0-41	23.98 (9.68)	0-41	24.85 (9.32)	1-40	.86
Persuasiveness	19.01 (7.67)	0-34	18.03 (7.96)	1-34	20.18 (7.25)	0-31	.27
Self-Confidence	44.99 (8.77)	24-60	44.08 (9.17)	25-58	46.06 (8.28)	24-60	.45
Optimism	28.36 (6.70)	5-38	28.23 (6.90)	11-38	28.52 (6.55)	5-38	.21
Resilience	23.16 (5.77)	4-33	22.70 (5.60)	9-31	23.71 (6.00)	4-33	.45
Valor	23.96 (7.52)	6-38	22.15 (7.75)	6-37	26.09 (6.74)	6-38	.33
Intrepidness	28.23 (11.82)	0-50	27.38 (12.74)	0-50	29.35 (8.32)	8-48	.28
Tolerance for Uncertainty	24.80 (8.21)	3-42	23.33 (8.32)	7-38	27.18 (6.82)	9-42	.05*
Total	233.56 (57.28)	116-355	228.88 (53.93)	100-355	245.85(46.11)	116-319	.05*

Table 9
Multiple regression output: Intrepidness, Resilience, Valor, and Tolerance of Uncertainty predicting anticipatory anxiety, mid-challenge fear, and heart rate among challenge responders (N = 45)

	t	*β*	SE	*p*
Intrepidness				
Anticipatory anxiety	-.72	-.11	.03	.47
Mid-challenge fear	-.32	.-.05	.03	.75
Baseline fear	1.14	.18	2.47	.26
Heart rate	-.77	-.11	.18	.45
Baseline heart-rate	3.07	.43	-.18	< .01**
Resilience				
Anticipatory anxiety	.44	.07	.05	.66
Mid-challenge fear	-1.19	-.19	.09	.24
Baseline fear	.82	.13	2.51	.42
Heart rate	-1.98	-.27	.34	.05
Baseline heart-rate	3.13	.42	.17	<.01**
Tolerance for Uncertainty				
Anticipatory anxiety	-.72	-.11	.03	.47
Mid-challenge fear	-.07	-.13	2.50	.41
Baseline fear	-.83	.15	.05	.36
Heart rate	-.62	.-.09	.20	.54
Baseline heart-rate	2.94	.42	.18	< .01*
Valor				
Anticipatory anxiety	.26	-.04	.03	.82

Mid-challenge fear	-.59	-.10	.06	.57
Baseline fear	.86	.14	2.62	.39
Heart rate	-.35	-.05	.23	.73
Baseline heart-rate	3.08	.45	.18	<.01**

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

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Figures

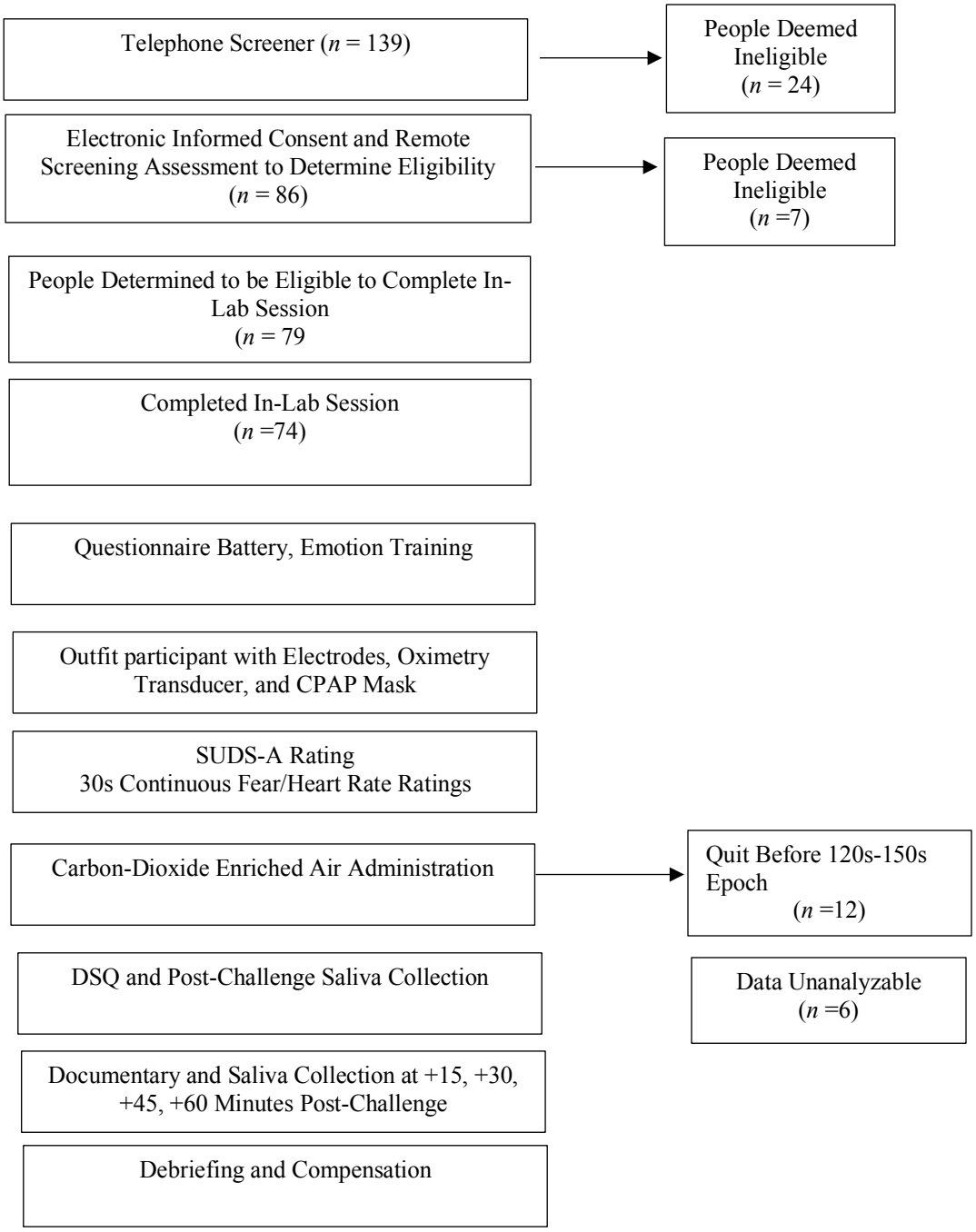

Figure 1.
Diagram of Study Procedures

Note. During virtual screening procedures participants were excluded if they endorsed a current or previous diagnosis of anxiety or panic disorder (n = 1), difficulties with breathing (n = 1), participation in another study involving carbon-dioxide enriched air (n = 3), or current medications affecting the endocrine system (n = 1). Five participants declined to participate despite eligibility.

Appendix A

Emotion Training

Anxiety and fear are common terms used to describe one's emotional state. These terms are often used interchangeably; however, they have specific meanings and outcomes.

Fear is a reaction to a specific, immediate threat and is associated bodily arousal and escape behaviors. For example, a bunny invading a vegetable garden may experience fear when it sees a gardener with a shovel. The bunny will experience a surge of physiological arousal (e.g., increased heart rate and blood flow) and flee the garden hoping to escape the gardener.

Anxiety tends to be future-oriented, diffuse, and general in nature; it reflects anticipation of a *potential* threat and is associated with avoidance behavior. For example, a student may feel anxious about a class where the teacher randomly calls on students and asks difficult questions. When thinking about going to class, the student may feel worried and tense. As a result, the student may avoid going to class.

Stated simply, a key difference between fear and anxiety lies in the nature of the threat as well as the physiological elements and behaviors that accompany the two states. Anxiety is experienced *before* an anticipated event, while fear occurs *in the presence of an immediate threat*."

Fear Instructions

*"You will indicate current levels of **fear** using this dial. If you turn the dial to the left, you can indicate lower levels of current fear, all the way to "1," which represents no fear at all. If you turn the dial to the right, you can indicate higher levels of current fear, all the way to "10," which represents extreme fear. The dial is set at 1 to begin with for everyone. You will keep your hand on the dial throughout the baseline. If you don't feel any fear at all, you wouldn't have to turn the dial. However, if your fear levels change during the baseline, please move the dial accordingly."*