ANACHRONISTIC ADAPTATION: AN EMPIRICAL TEST OF THE RESPONSE-READINESS THEORY

by

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To Heather,
My Dearest Love and Closest Friend

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Common, heritable mental illnesses constitute a considerable challenge for evolutionary models of human behavior. Attention-Deficit/Hyperactivity Disorder (ADHD), a neurodevelopmental disorder characterized by hyperactivity, impulsivity and inattention, is especially difficult to reconcile with evolutionary theory given its high prevalence and association with considerable dysfunction. Response-readiness theory attempts to explain ADHD as an evolutionary mismatch, which occurs when previously adaptive traits are rendered maladaptive by environmental change. Particularly, response-readiness theory frames ADHD as an adaptation to environments that are dangerous, resource scarce, unpredictable, and harsh (i.e., the environmental adversity hypothesis), arguing that inattention facilitated environmental scanning, important in detecting threats in unpredictable environments (i.e., the hypervigilance hypothesis), whereas hyperactivity facilitated investigative exploration, vital in orienting to novel and unfamiliar environments (i.e., the exploratory hyperactivity hypothesis).

Study One tested the environmental adversity hypothesis, indicating that harsh and unpredictable childhood environments were associated with inattention, whereas unpredictability alone was associated with hyperactivity. Study Two tested the hypervigilance hypothesis, conceptualizing hypervigilant threat detection in terms of both

the proficient detection of threats, as well as a more general bias to perceive threats in ambiguous cues. Although the latter conceptualization was supported, the former was not. Study Three tested the exploratory hyperactivity hypothesis, indicating that inattention, not hyperactivity, was indirectly associated with exploratory information seeking in both domain-general and domain-specific contexts, and that these relationships were mediated by individual differences in intolerance of uncertainty.

Although providing only mixed support for response-readiness theory, the results of this project present an opportunity to break new theoretical ground, particularly in the development of the hyperactive facilitation theory. This theory advocates for the contextualization of response-readiness within a larger differential susceptibility framework. Informed by the present results, the proposed theory frames hyperactivity as a mechanism of development plasticity (i.e., the readiness spectrum hypothesis), intolerance of uncertainty as a vital motivator of investigative exploration, orienting ancestral individuals to unfamiliar environments (i.e., the uncertainty reduction hypothesis) and inattention as a cognitive filter, necessary for coping with the informational demands of environmental unpredictability (i.e., the attentional filter hypothesis), The implications of each novel hypothesis are discussed, followed by recommendations in testing them.

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Chapter One: Response-Readiness Theory

Evolutionary psychology attempts to inform understanding of the human mind and behavior through the lens of evolutionary biology. Generally, this entails explaining aspects of human psychology as adaptations, or features that increase an organism's fitness (i.e., relative success in replicating its genes, often through advantages in reproduction, survival, or resource acquisition). Some aspects of human psychology are intuitively adaptive; for example, perspective-taking facilitates accuracy in forecasting the behavior of others (Povinelli & Preuss, 1995) and fear reactions motivate harm avoidance (Ekman, 1992). However, others, such as heritable psychopathology (i.e., mental illnesses), are considerably more difficult to reconcile with evolutionary theory.

Although precise definitions of mental illness have proven contentious, Wakefield's (1992) proposal of "harmful dysfunction" is particularly apt for present purposes given its basis in evolutionary theory. According to Wakefield, psychopathology represents the confluence of biological dysfunction (i.e., failure of a physical or psychological mechanism to perform the function for which it evolved) and socio-culturally defined harm (i.e., context-specific impairment experienced by an individual resulting from their dysfunction). That is, for an aberrant psychological process to be psychopathological, it must impair an individual's capacity to cope with the demands of their present environment. Consequently, psychopathology should entail fitness costs to the afflicted individual. Indeed, multiple forms of psychopathology are associated with decreased reproductive success (e.g., Wilson et al., 2021) such that individuals high in psychopathology should be less successful in replicating their genes, culminating in the

elimination of these traits over evolutionary time (Keller & Miller, 2006). However, Keller and Miller note that many forms of psychopathology display prevalence rates well above what would be predicted for traits with no adaptive value, presenting a serious conundrum for evolutionary psychology.

A central tenet of evolutionary psychology, the specificity principle, states that adaptations are domain-specific solutions to a specific environmental challenge recurrent in a species' history (Tooby & Cosmides, 2015). This means that the utility of an adaptation is dependent on the presence of a relevant environmental challenge. This principle is of special importance because environments are not static, but dynamic. Thus, significant environmental changes may render previously adaptive traits maladaptive, a phenomenon known as an evolutionary mismatch (Robertson & Chalfoun, 2016). One of the best documented cases of an evolutionary mismatch concerns industrial melanism in the peppered moth *(Biston betularia)*. Peppered moths are generally white with a complex pattern of black dots and lines (i.e., the dotted-line variant, hereafter "DL"; Kettlewell, 1958). Because the DL pattern resembles the lichen found in the peppered moth's native forests, it acts as camouflage, making the peppered moth less conspicuous to predators. This advantage in fitness allows DL variants to outperform conspecifics, such as the melanistic variant (i.e., mostly or entirely black). As a result, DL variants are over-represented in most peppered moth populations.

According to the specificity principle, the coloration of the DL variant increases fitness by solving the specific challenge of avoiding predation in lichen-rich forests. Consequently, these fitness enhancing effects should dissipate in environments visually

dissimilar to such forests. This is precisely what Kettlewell (1958) observed in Birmingham, England, the industrialization of which dispersed soot, blackening the cityscape and killing local lichen populations (Bishop et al., 1978). The city became the visual inverse of the peppered moth's native environment, with an abundance of black backgrounds and dearth of white. This shift conferred a substantial fitness advantage to melanistic variants, which could hide easily against the soot-blackened urban environment. Conversely, the inability of DL variants to hide against black backgrounds made them more conspicuous to predators, substantially decreasing their fitness. Thus, as predicted by the specificity principle, substantial environmental changes rendered the previously adaptive DL pattern maladaptive, transforming an adaptation into a fitness-reducing liability.

Similarly, the environments of modern humans vary markedly from those of their ancestors. Perhaps the most dramatic of these differences is the relatively recent adoption of sedentary agriculturalism, encouraging the abandonment of the nomadic hunter-gatherer lifestyle characteristic of 95% of human history (Chaudhary & Swanepoel, 2023). This environmental shift may have provided a potent substrate for the development of an evolutionary mismatch; traits now considered psychopathological may have increased fitness in the environments of ancestral hunter-gatherers. In this vein, multiple arguments have been made regarding the adaptive value of certain psychopathologies, including attention-deficit/hyperactivity disorder (hereafter "ADHD"). ADHD is a heritable neurodevelopmental disorder characterized by inattention, hyperactivity, and impulsivity. The prevalence of ADHD, estimated to be

11% in childhood and 4% in adulthood in the United States, is particularly difficult to reconcile with its associated dysfunction, including increased risk of substance abuse, anti-social behavior, and premature mortality (American Psychiatric Association [APA], 2013; Estévez et al., 2016; Faraone et al., 2005; Fletcher & Wolfe, 2009; National Institute of Mental Health [NIMH], n.d.; Storebø & Simonsen, 2016; Young & Thome, 2011). Indeed, an 18-year longitudinal study by Dalsgaard and colleagues (2015) tracked nearly 2 million participants and found that children, adolescents and adults with ADHD experience increased mortality risk relative to their neurotypical (i.e., "healthy," characterized by undisturbed, typical neurodevelopmental processes; hereafter "NT") peers, above and beyond the effects of anti-social behavior and substance abuse comorbidities. That these differences in mortality risk appear in childhood, prior to reproductive viability, implies that ADHD incurs heavy costs to fitness.

ADHD Dysfunction as an Evolutionary Mismatch

According to evolutionary theory, the traits that persist in a population over time tend to be those that exert more positive than negative effects on overall fitness (but see Buss et al., 1998). Consequently, the continued prevalence of ADHD suggests that the ADHD behavioral phenotype has, over evolutionary time, enhanced fitness substantially enough to make up for the fitness costs associated with premature mortality. Thus, concurrent with Wakefield's (1992) emphasis on context-specific impairment in defining psychopathology, it is possible that ADHD represents yet another case of evolutionary mismatch, having been adaptive in certain ancestral contexts, despite being associated with dysfunction in modern ones. However, the question remains as to how seemingly

maladaptive traits such as inattention, hyperactivity and impulsivity may have increased fitness in ancestral humans.

A review by Thagaard and colleagues (2016) identified four primary theories regarding the potential adaptive value of ADHD. These include the wader theory, the fighter theory, the hunter-farmer theory, and the response-readiness theory. Shelley-Tremblay and Rosen's (1996) wader theory extends the aquatic ape theory of human evolution, which explains key differences between humans and other primates, such as a lack of body hair, as adaptations to coastal environments (e.g., Morgan, 1972). Because primate infants often cling to their mother's hair, the wader theory argues that the loss of body hair would have resulted in decreased maternal care quality, and that the demanding behavioral traits (e.g., externalizing behaviors) of individuals with ADHD may have served to monopolize maternal attention and maximize care quality. Additionally, Shelley-Tremblay and Rosen propose the fighter hypothesis, arguing that the aggressive tendencies associated with ADHD were adaptive in a speculative "genocidal war" between humans and neanderthals *(Homo neanderthalensis)*, contributing to the eventual extinction of the latter.

However, advancements in anthropology raise serious questions about both theories. The wader theory is likely inaccurate because the aquatic ape theory, which it extends, has been rejected as pseudoscience by mainstream anthropology on both theoretical and empirical grounds (e.g., Foley & Lahr, 2014; Langdon, 1997; Rae & Koppe, 2014; Rafferty, 2022). The fighter theory presents similar inconsistencies with modern anthropology; competition with humans, relative to demographic (e.g.,

population size) and environmental (e.g., natural disasters) factors, is thought to have played a minor role in the neanderthal extinction, as indicated by a survey of paleoanthropological experts (Vaesen et al., 2021). Thus, neither the wader theory, nor the fighter theory, appear particularly promising in explaining the evolutionary origins of ADHD.

Hartmann's (1993; 2019) hunter-farmer theory argues that variation in the environments of ancestral humans produced two types of human culture, hunter-gatherers and agriculturalists. Hartmann frames individuals with ADHD as descending from hunter-gatherer cultures, possessing a cognitive specialization for hunting (i.e., inattention represents a tendency to scan the environment for prey-relevant cues, hyperactivity represents tireless pursuit of prey, and impulsivity allows for flexible responses to rapidly changing hunts). Although this theory served as an impetus for the other theories discussed, it is a work of journalism, and its presentation is more akin to editorialization and advocacy than a serious scientific proposition. Further, Jensen and colleagues' (1997) response-readiness theory, to be discussed momentarily, represents a conceptually similar, although much more developed effort. Thus, the hunter-farmer theory is mentioned as a matter of historical interest, rather than a serious consideration.

Similar to the hunter-farmer theory, the response-readiness theory conceptualizes ADHD as a cognitive specialization (Jensen et al., 1997). A key difference between the two lies in the proposed role of the environment in the expression of ADHD; whereas the hunter-farmer theory treats ADHD as a static, innate trait, the response-readiness theory invokes phenotypic plasticity (i.e., when environmental factors influence genetic

expression; West-Eberhard, 2008). That is, Jensen and colleagues argue that individuals genetically predisposed to ADHD will develop the disorder only when exposed to specific environmental factors. The emphasis on phenotypic plasticity is a strength for several reasons, not the least of which is its concurrence with modern psychiatric models, which stress the role of gene-environment interactions in the development of psychopathology (e.g., the diathesis-stress model; Broerman, 2020). More specifically, the response-readiness theory posits that ADHD is a cognitive specialization for environments that are characterized by novelty, resource poverty, unpredictability, danger and temporal urgency (hereafter, the environmental adversity hypothesis). In such environments, the core symptoms of ADHD would be adaptive, with diffuse attentional states facilitating vigilant environmental scanning (hereafter the hypervigilance hypothesis), impulsivity facilitating expedient responses to threats and opportunities, and hyperactivity facilitating exploratory behavior, useful in gathering information about unfamiliar environments (hereafter, the exploratory hyperactivity hypothesis).

A further advantage of the response-readiness theory's emphasis on phenotypic plasticity is that it squares well with life history theory (hereafter "LHT"), a popular framework in evolutionary science that examines adaptations as fitness-maximizing trade-offs (Del Giudice et al., 2015). The central premise of LHT is that, because organisms operate on finite energy budgets, resource allocations that enhance fitness in one domain often entail decreased fitness in another. For example, all else equal, the volume of finite resources (e.g., time, energy, food, etc.) an organism invests in each of its individual offspring is constrained by the number of offspring produced by that

organism. Consequently, greater fecundity generally comes at the cost of poorer parental care quality and vice versa. For a given trade-off to be adaptive, its benefits to overall fitness must outweigh the costs it incurs. LHT further observes that certain clusters of adaptations commonly co-occur (e.g., high fecundity is often accompanied by relatively early onset of sexual maturity). Suites of these co-occurring adaptations are known as life history strategies and vary along the fast-slow continuum, which considers an organism's relative investment in immediate (i.e., "fast" strategies) versus future (i.e., "slow" strategies) reproductive effort. Accordingly, traits characteristic of a fast life history strategy (hereafter, "fast strategy traits") are those that maximize immediate reproductive success (i.e., accelerated onset of sexual maturity at the cost of reduced body mass and longevity), whereas those consistent with a slow life history strategy (hereafter, "slow strategy traits") tend to maximize future reproductive success (i.e., greater body mass and longevity, at the cost of delayed onset of sexual maturity). As with adaptations more generally, whether fast or slow strategy traits are adaptive in a given context relies heavily on the environmental characteristics of that context. For instance, dangerous and unpredictable environments favor fast strategy traits, as traits that prioritize present reproductive efforts tend to mitigate the risk of premature (i.e., pre-reproductive) mortality inherent in such environments.

Life history strategies vary at both inter- and intraspecific levels (Del Giudice et al., 2015). Humans, for instance, are characterized by an especially slow life history strategy relative to other species, as evidenced by their relatively long lifespans, late onset of sexual maturity and high levels of parental investment (Brumbach et al., 2009).

However, as a phenotypically plastic species, humans exhibit a range of life history strategies that represent gene environment interactions, such that an individual's pace of life is sensitive to characteristics of their rearing environment. Indeed, the typical range of human life history strategies presents a spectrum of its own, with some individuals adopting faster or slower strategies relative to their conspecifics. Consequently, where an individual lands on the fast-slow continuum represents an interaction of genotypic individual differences and the reaction norms (i.e., cues indicative of environmental quality) present in their rearing environment (Brumbach et al., 2009; Del Giudice et al., 2015). Thus, humans reared in environments characterized by fast life history reaction norms (i.e., those indicative of environmental harshness and unpredictability, such as pathogen risk or conspecific aggression; hereafter, "fast strategy reaction norms") should express more fast strategy traits than conspecifics reared in more forgiving environments. Notably, many of the characteristics (e.g., resource scarcity, unpredictability, danger) that Jensen and colleagues (1997) ascribe to the response-ready environment of evolutionary adaptedness (EEA) are consistent with environments that favor fast life history strategies. Given these similarities, it may be expected that the ADHD behavioral phenotype is characterized by fast strategy traits.

Beyond the typical interspecific fast strategy traits described above, Del Giudice (2014) reviews a number of fast strategy traits found in humans, including tendencies toward antisocial, sexually promiscuous, and otherwise high-risk behaviors (e.g., Borowsky et al., 2009; Brezina et al., 2009; Chen & Vazsonyl, 2009; Wang et al., 2009), as well as a present-oriented cognitive style that discounts future outcomes (Dunkel &

Decker, 2010; Kruger et al., 2008). Individuals with ADHD appear to display many of these traits, with research indicating associations between ADHD and antisocial tendencies (Fletcher & Wolfe, 2009; Storebø & Simonsen, 2016;), risk-taking, both in sexual contexts and more generally (e.g., Flory et al., 2006; Pollak et al., 2019), and steeper rates of temporal discounting (i.e., decreases in the perceived value of a reward as a function of delayed receipt of that reward; e.g., Barkley et al., 2001) relative to NT peers. Indeed, the fast strategy behavioral profile of individuals with ADHD further underscores parallels between Jensen and colleagues' (1997) EEA and prototypical environments favoring fast life history strategies.

These parallels appear to suggest that ADHD may represent extreme expression of fast strategy traits – a possibility that is not mutually exclusive with response-readiness theory. Indeed, such a possibility is consistent with Del Giudice's (2014) integration of psychopathology into a larger LHT framework, which holds that some forms of psychopathology represent maladaptive levels of otherwise adaptive life history traits. This approach to psychopathology is not entirely unfounded, mirroring sentiments in the clinical literature conceptualizing personality disorders as abnormal levels of otherwise functional personality traits (e.g., Samuel et al., 2013). Further, Del Giudice advocates for taxonomizing psychopathology along the fast-slow continuum, with taxa of fast and slow spectrum disorders representing dysfunctional levels of their namesake traits. Although not explicitly described as such by Del Giudice, the behavioral characteristics of individuals with ADHD appear prototypical of the fast spectrum category. Similarly, despite considerable theoretical overlap, Jensen and colleagues (1997) make no specific

reference to LHT. In light of this conceptual overlap, integration of response-readiness theory within a larger LHT framework may prove informative for both theories.

Empirical Shortcomings of Response-Readiness Theory

Thagaard and colleagues (2016) regard response-readiness theory as the most promising of extant evolutionary accounts of ADHD – with the caveat that direct tests of the theory are vanishingly rare. This relative dearth of direct investigations is further complicated by the state of indirect evidence, some veins of which appear to support Jensen and colleagues' (1997) theory, whereas others appear to refute it. For instance, although the environmental adversity hypothesis is remarkably well-supported by a rich literature identifying numerous aspects of childhood adversity as risk factors for the development of ADHD (e.g., Biederman et al., 1995; 2002), the same can be said for a range of other psychopathologies (e.g., Björkenstam et al., 2016), constituting an apparent violation of the specificity principle. Similarly, research indicating potential insensitivity to social threat cues in individuals with ADHD (e.g., expressions of anger; Pelc et al., 2009) are difficult to reconcile with the hypervigilance hypothesis. However, as will be made clear in later chapters, the shortcomings of response-readiness theory are not so severe as to necessitate abandonment over modification.

Perhaps the most promising of such potential modifications lies in the adoption of an LHT-informed individual differences approach. Indeed, Del Giudice's (2014) conceptualization of some forms of psychopathology as maladaptive levels of otherwise adaptive life history traits presents an especially elegant avenue through which to rehabilitate response-readiness theory. This is because ADHD is remarkably consistent

with Del Giudice's concept of a fast spectrum disorder, suggesting that, despite associations with considerable dysfunction in clinical populations, subclinical levels of ADHD traits may prove adaptive in certain contexts. Indeed, research by Schippers and colleagues (2024) found that subclinical levels of ADHD traits were associated with numerous potential strengths, including sensory sensitivity, task-specific hyperfocus and cognitive flexibility.

Although subsequent chapters will question the validity of response-readiness theory as it applies to clinical populations, it remains possible that the advantages described by Jensen and colleagues (1997) apply to individuals with elevated (i.e., above average) but subclinical levels of ADHD traits. Thus, by treating ADHD traits not as clinical symptomology, but as dimensions of individual difference that vary in the population at large, explicit adoption of an LHT approach to ADHD presents an opportunity to enrich LHT discourse on psychopathology, as well as better integrate response-readiness theory with dominant theories of contemporary evolutionary psychology. What follows is a series of three studies that test the validity of a modified formulation of response-readiness theory, rooted in an LHT approach to individual differences and applied to non-clinical, undergraduate samples.

Chapter Two: The Environmental Adversity Hypothesis

Introduction

The environmental adversity hypothesis represents perhaps the broadest claim made by response-readiness theory, maintaining that expression of the ADHD behavioral phenotype is contingent on exposure to environmental characteristics consistent with Jensen and colleagues' (1997)'s EEA. These characteristics (hereafter, "response-ready reaction norms") include resource scarcity, unpredictability, danger, and temporal urgency. Consequently, the environmental adversity hypothesis predicts greater prevalence of ADHD in modern environments characterized by such response-ready reaction norms.

Resource Scarcity as an Environmental Predictor of ADHD

Resource scarcity represents one response-ready reaction norm proposed by Jensen and colleagues (1997). Indeed, foraging in such environments may have posed a substantial challenge in resource acquisition. Although modern humans have largely abandoned traditional foraging in favor of sedentary agriculture, some must still contend with modern manifestations of such scarcity. Indeed, research by Coleman-Jensen and colleagues (2021) indicates that individuals living below federally-defined poverty thresholds in the United States are at significantly greater risk of food insecurity than those above such thresholds. In light of irs associations with food insecurity, material poverty provides a suitable modern analogue for the resource scarcity with which Jensen and colleagues characterized response-ready environments.

Consequently, the environmental adversity hypothesis predicts that expression of the ADHD behavioral phenotype should be more common among those reared in impoverished environments. In line with this claim, environmental characteristics indicative of poverty (e.g., low socio-economic status, parental neglect, receipt of government financial assistance) represent significant ADHD risk factors (Baran Tatar & Cansiz; Biederman et al., 2002; Björkenstam et al., 2016; but see Kallman et al., 2023). Thus, when operationalized as material poverty, resource scarcity is significantly associated with the development of ADHD, providing support for its role as a response-ready reaction norm.

Unpredictability, Danger, and Temporal Urgency as Environmental Predictors of ADHD

The environmental adversity hypothesis further proposes unpredictability, danger and temporal urgency as response-ready reaction norms (Jensen et al., 1997), thus predicting increased prevalence of ADHD in modern environments with these characteristics. Although humans in most parts of the world no longer face significant predation risk as described by Jensen and colleagues, ADHD is associated with modern manifestations of unpredictability and danger. For instance, ADHD is associated with unpredictability of childhood environments in the form of instability of residence, separation from caregivers, parental psychopathology, domestic conflict, and familial dysfunction (Biederman et al., 1995; 2002; Bjorkenstam et al., 2016; Foley, 2011; Kallman et al., 2023). Further, studies identifying both mental and physical abuse as significant ADHD risk factors are consistent with an association between ADHD and

dangerous childhood environments (Kallman et al., 2023; Tatar & Cansiz, 2019). Finally, insofar as unpredictable and dangerous environments demand rapid responses to changing circumstances, the above findings also support the relationship between temporal urgency and ADHD. Thus, the association between ADHD prevalence and unpredictable, dangerous, and temporally urgent rearing environments fosters further support for the environmental adversity hypothesis.

General Adversity as an Environmental Predictor of ADHD

Although treated separately above, the response-ready reaction norms described by Jensen and colleagues (1997) are often discussed collectively as adverse childhood experiences (hereafter "ACEs"; Biederman et al., 1995; Biederman et al., 2002; Calthorpe et al., 2021; Kallman et al., 2023). Not only are individual ACEs ADHD risk factors, but these effects also appear to be cumulative, with Biederman and colleagues (1995) finding substantial increases in ADHD risk with each additional ACE experienced by an individual. These cumulative effects have been replicated in studies using government data in Sweden and Denmark with samples of over 100,000 and 900,000 respectively (Björkenstam et al., 2016; Østergaard et al., 2016). Although existing evidence supports the environmental adversity hypothesis, it should be noted that the relationship between childhood adversity and psychopathology may not be unique to ADHD. Indeed, childhood adversity is associated with several other forms of psychopathology, including mood, anxiety and psychotic disorders (Björkenstam et al., 2016), which may present a violation of the specificity principle. If the relationship between ADHD and childhood adversity is merely a specific case of the general

relationship between psychopathology and suboptimal rearing environments, it is difficult to frame ADHD as a specific solution to the challenges presented by these factors.

It must also be stressed that the correlational nature of the above research necessarily precludes definitive causal claims. Indeed, although the evidence provided above may reflect environmental influences on the expression of ADHD, they may also reflect environmental qualities evoked by the ADHD behavioral phenotype. Consider the association between childhood abuse and ADHD (e.g., Kallman et al., 2023; Tatar & Cansiz, 2019). Although it is possible that abuse is an environmental determinant of ADHD, it is also possible that the externalizing behaviors common among children with ADHD (e.g., Factor et al., 2016) may evoke abusive responses from caregivers. Given its considerable heritability (e.g., Grimm et al., 2020), it is also possible that the above associations reflect the effects of parental ADHD in shaping the rearing environment of their offspring (i.e., passive genotypic effects; Scarr & McCartney, 1983). For instance, observed associations between poverty and ADHD risk (e.g., Baran Tatar & Cansiz; Biederman et al., 2002; Björkenstam et al., 2016) may reflect that impoverished rearing environments encourage the expression of ADHD, but it is also possible that they reflect a tendency for parents with ADHD to curate rearing environments characterized by poverty. Indeed, research indicating that childhood ADHD is associated with adult economic adversity (e.g., Phelham et al., 2020) lends credence to this interpretation. In short, although there is support for the environmental adversity hypothesis, theory suggests caution in the interpretation of the relationship between ADHD and its environmental predictors.

The Modified Environmental Adversity Hypothesis

The environmental adversity hypothesis argues that ADHD emerges as a phenotypically plastic cognitive specialization for environments characterized by response-ready reaction norms (e.g., resource scarcity, unpredictability, danger, and temporal urgency; Jensen et al., 1997). This emphasis on phenotypically plastic responses to adversity is not only relatively well-supported by research into environmental antecedents of ADHD risk (e.g., Biederman et al., 1995; but see Scarr & McCartney, 1983), but also makes predictions that are remarkably consistent with those already made by LHT regarding exposure to fast-strategy reaction norms (Del Giudice, 2014; Del Giudice et al., 2015). As a consequence of such conceptual overlap, the environmental adversity hypothesis requires only two modifications for integration into an LHT-informed individual differences approach. The first is the explicit adoption of LHT terminology (e.g., re-framing Jensen and colleagues' (1997) environmental contingencies as response-ready reaction norms, as above). The second necessary modification is reconceptualization of ADHD traits as dimensions of individual difference, rather than clinical symptomology, thus generalizing predicted relationships between response-ready reaction norms and ADHD traits to subclinical populations. It follows then that the modified environmental adversity hypothesis predicts that environments characterized by response-ready reaction norms favor the adoption of ADHD traits (i.e., inattention and hyperactivity) in the population at large.

Thus, the expression of ADHD traits (as measured the Adult ADHD Self-Report Scale; Kessler et al., 2005) should be positively associated with rearing environments

characterized by response-ready reaction norms, including harshness (as measured by the Childhood Harshness Scale; Maranges et al., 2022), unpredictability (as measured by the Childhood Unpredictability Scale; Maranges et al., 2022), danger (i.e., physical abuse, as measured by the physical abuse subscale of the shortform Childhood Trauma Questionnaire; Bernstein et al., 2003) and resource scarcity (i.e., physical neglect, as measured by the physical neglect subscale of the shortform Childhood Trauma Questionnaire).

Response-readiness theory, however, predicts a *general* relationship between adverse rearing environments and ADHD traits, without making explicit reference to which specific response-ready reaction norms should predict a given facet of ADHD traits (i.e., inattention and hyperactivity/impulsivity, respectively). Despite this, prior research into dimensions of individual difference predictive of ADHD traits in subclinical populations has found evidence of distinct, facet-specific associations. For instance, trait neuroticism is predictive of hyperactivity, but not of inattention (Mckinney et al., 2012). An implication of such findings is the possibility that response-ready reaction norms exhibit similar, facet-specific associations with ADHD traits. Consequently, analyses will be performed modeling environmental predictors of trait inattention and hyperactivity (as measured by their namesake scales on the Adult ADHD Self-Report Scale; Kessler et al., 2005) separately. Thus, the present study will test the following hypotheses:

H_1: Harshness of childhood environment will be positively associated with trait inattention.

H_2: Unpredictability of childhood environment will be positively associated with trait inattention.

H_3: Childhood physical abuse will be positively associated with trait inattention.

H_4: Childhood physical neglect will be positively associated with trait inattention.

H_5: Harshness of childhood environment will be positively associated with trait hyperactivity.

H_6: Unpredictability of childhood environment will be positively associated with trait hyperactivity.

H_7: Childhood physical abuse will be positively associated with trait hyperactivity.

H_8: Childhood physical neglect will be positively associated with trait hyperactivity.

Method

Participants

Exclusion Criteria. From an initial sample of 609, 153 participants were excluded for the following reasons: 129 participants (21.2% of total sample) for having failed more than three of the six attention check items or otherwise careless or incomplete responding, 12 participants (2% of total sample) were excluded as univariate outliers (i.e., producing values greater than three standard deviations above or below the sample average) and 2 participants (0.3% of total sample) for being of insufficient age (i.e., under

18 years). Finally, because of documented sex differences in ADHD traits (e.g., Li et al., 2019; but see Fedele et al., 2012), sex was to be entered as a dichotomous predictor (1 = male; 0 = female) in study models. Given conceptual differences between gender (i.e., a component of one's social identity; Bem, 1981) and biological sex (i.e., the sex one is assigned at birth), 9 participants (1.5% of total sample) who identified as transgender were treated as the sex they were assigned at birth for analyses, whereas 10 participants (1.6% of total sample) who identified as non-binary or preferred not to indicate gender were excluded from analyses.

Final Sample. The post-exclusion sample consisted of 456 American college students, 18 years or older, enrolled in introductory psychology courses and recruited through Oakland University's SONA recruitment tool. Of this post-exclusion sample, 77.2% of participants (n = 352) were female and 22.8% (n = 104) were male, with an average age of 20.03 years (SD = 2.68). The racial composition of the sample was 74.1% White (n = 338), 9.2% Black (n = 42), 5.9% Asian (n = 27), and 3.7% Hispanic (n = 17), with 5.5% selecting "other" or not indicating their racial identity (n = 25), and 3.2% (n = 21) identifying with more than one racial group or explicitly identifying as bi-racial. 77 participants (16.9% of final sample) indicated prior diagnosis of one or more attention-related neurodevelopmental disorder (i.e., attention-deficit disorder or attention-deficit/hyperactivity disorder).

Measures

Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005). The Adult ADHD Self-Report (ASRS; α =.92) is an 18-item self-report measure of Attention-

Deficit/Hyperactivity Disorder symptomology. This measure contains two subscales measuring inattention (9 items; sample item: “How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?”; α = .87) and hyperactivity/impulsivity (9 items; sample item: “How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?” ; α = .84). Participants responded on a 5-point Likert scale (1 = “Never,”; 5 = “Very often,”) indicating how often each item has described them in the past 6 months. Notably, Kessler and colleagues (2005) indicate that this measure has adequate concurrent validity with the outcomes of blind clinical interviews assessing ADHD symptomology. Although this measure was designed as a clinical screening tool, it will be used to measure individual differences in ADHD traits for the purposes of this study. This measure can be found in Appendix D.

Childhood Harshness Scale (CHS; Maranges et al., 2022). The Childhood Harshness Scale (α = .92) is an 11-item self-report measure of perceived harshness (i.e., resource scarcity) of childhood environment (sample item: “I felt uncomfortable asking my parents for money because money was tight,”). Participants responded on a 7-point Likert scale (1 = “Strongly disagree,”; 7 = “Strongly agree,”) indicating their level of agreement with each item. This measure can be found in Appendix E.

Childhood Unpredictability Scale (CUS; Maranges et al., 2022). The Childhood Unpredictability Scale (α = .93) is a 15-item self-report measure of perceived unpredictability of childhood environment (sample item: “I did not know what to expect from my family when I had friends over,”). Participants responded on a 7-point Likert

scale (1 = “Strongly disagree,”; 7 = “Strongly agree,”) indicating their level of agreement with each item. This measure can be found in Appendix F.

Childhood Trauma Questionnaire - Short Form (CTQ-SF; Bernstein et al., 2003). The Childhood Trauma Questionnaire (α = .93) is a 25-item self-report measure of traumatic childhood experiences. This measure contains five subscales measuring emotional abuse (5 items; sample item: “Called names by family,”; α = .88), physical abuse (5 items; sample item: “Hit hard enough to see the doctor,”; α = .88), sexual abuse (5 items; sample item: “Was touched sexually,”; α = .91), emotional neglect (5 items; sample reverse-scored item: “Felt loved,”; α = .90), and physical neglect (5 items; sample item: “Parents were drunk or high”; α = .73). Participants responded on a 5-point Likert scale (1 = “Never true,” 5 = “Very often true”) indicating how often they experienced each item. Specifically, the physical abuse and physical neglect subscales of the CTQ-SF will be used to operationalize the response-ready reaction norms of danger and resource scarcity, respectively. As indicated by Cruz (2023), prior research has treated outcomes on this measure both qualitatively (i.e., categorical division of samples into discrete categories of abuse and neglect severity) and quantitatively (i.e., allowing abuse and neglect severity to vary continuously within samples). As the hypotheses tested in this study concern the degree to which variation in environmental adversity predicts continuous expression of inattentive and hyperactive traits in the general population, adoption of the latter, continuous approach is appropriate. This measure can be found in Appendix G.

Results

Intercorrelation of Study Variables

See Table 2.1 for descriptive statistics and intercorrelations of study variables.

Predictors of Trait Inattention

Diagnostic tests confirmed that the assumptions of linear regression were met. A Durbin-Watson value of 2.11 and variance inflation factors (VIFs) ranging from 1.01 to 1.80 indicated independence of observations and absence of multicollinearity among predictors. Visual inspection of a scatterplot plotting studentized residuals against unstandardized predicted values indicated that assumptions of linearity and homoscedasticity were met. Finally, visual inspection of a histogram of standardized residuals indicated that the distribution of residuals was approximately normal.

To examine environmental predictors of trait inattention, trait inattention was regressed on participant sex, harshness and unpredictability of childhood environment, as well as childhood physical abuse and physical neglect. In light of aforementioned differences in the presentation of ADHD symptomology, terms probing interactions between participant sex and each of the other predictors were entered at the second step of analyses. Note that all study variables, with the exception of sex, were zero-centered prior to analyses. The model explained approximately 6% of the variance in trait inattention (R^2_{adj} = .06, p < .001). Notably, harshness (β = 0.11, t_{455} = 2.14, p = .03, 95% CI [.01, .22]) and unpredictability (β = 0.15, t_{455}= 2.49, p = .01, 95% CI [.03, .27]) of

Table 2.1

Descriptive Statistics and Intercorrelations of Study Variables

	1	2	3	4	5	6	7
1. Hyperactivity	-						
2. Inattention	.77***	-					
3. Harshness	.17***	.19***	-				
4. Unpredictability	.22***	.21***	.52***	-			
5. Physical Abuse	.08	.02	.30***	.39***	-		
6. Physical Neglect	.16***	.14**	.39***	.58***	.58***	-	
7. Sex	-.07	-.09	.01	-.01	.08	.04	-
M	2.83	2.95	3.30	2.35	1.34	1.60	0.23
SD	0.77	0.76	1.32	1.18	0.65	0.68	0.42

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

Table 2.2

Hierarchical Regression Predicting Trait Inattention

	R^2_{adj}	ΔR^2	B	*SE* B	β	95% CI for B		*p*
						LL	*UL*	
Step 1	.06							< .001
Constant			0.03	0.05		-0.07	0.13	.59
Harshness			0.11*	0.05	0.12	0.01	0.22	.03
Unpredictability			0.15*	0.06	0.15	0.03	0.27	.01
Physical Abuse			-0.11*	0.05	-0.11	-0.21	-0.002	.05
Physical Neglect			0.07	0.06	0.07	-0.05	0.19	.25
Sex			-0.19	0.11	-0.08	-0.40	0.03	.09
Step 2	.06	.01						< .001
Constant			0.03	0.05		-0.07	0.13	.61
Harshness			0.10	0.06	0.10	-0.02	0.22	.09
Unpredictability			0.15*	0.07	0.15	0.02	0.29	.03
Physical Abuse			-0.18**	0.06	-0.18	-0.30	-0.05	.01
Physical Neglect			0.13*	0.07	0.13	0.001	0.26	.05
Sex			-0.19	0.11	-0.08	-0.40	0.02	.08
Sex x Harshness			0.02	0.14	0.01	-0.26	0.29	.91
Sex x Unpredictability			0.04	0.15	0.02	-0.26	0.34	.78
Sex x Physical Abuse			0.26*	0.12	0.15	0.03	0.50	.03
Sex x Physical Neglect			-0.30*	0.15	-0.15	-0.59	-0.01	.04

Note. CI = confidence interval; LL = lower limit; UL = upper limit; *p < .05. **p < .01. ***p <.001.

probing interactions between participant sex and each of the other predictors were entered at the second step of analyses. Note that all study variables, with the exception of sex, were zero-centered prior to analyses. The model explained approximately 5% of the variance in trait hyperactivity ($R^2_{adj} = .05$, $p < .001$). However, unpredictability of childhood environment ($\beta = 0.16$, $t_{455} = 2.63$, $p < .01$, 95% CI [0.04, 0.28]) emerged as the sole significant unique predictor.

Predictors of Trait Hyperactivity

Diagnostic tests confirmed that the assumptions of linear regression were met. A Durbin-Watson value of 1.97 and VIFs ranging from 1.01 to 1.80 indicated independence of observations and absence of multicollinearity among predictors. Visual inspection of a scatterplot plotting studentized residuals against unstandardized predicted values indicated that assumptions of linearity and homoscedasticity were met. Finally, visual inspection of a histogram of standardized residuals indicated that the distribution of residuals was approximately normal.

To examine environmental predictors of trait hyperactivity, trait hyperactivity was regressed on participant sex, harshness and unpredictability of childhood environment, as well as childhood physical abuse and physical neglect. Additionally, in light of aforementioned sex differences in the presentation of ADHD symptomology, terms probing interactions between participant sex and each of the other predictors were entered at the second step of analyses. Note that all study variables, with the exception of sex, were zero-centered prior to analyses. The model explained approximately 5% of the

Table 2.3

Hierarchical Regression Predicting Trait Hyperactivity

	R^2_{adj}	ΔR^2	B	*SE* B	β	95% CI for B		*p*
						LL	*UL*	
Step 1	.05							< .001
Constant			0.03	0.05		-0.07	0.13	.59
Harshness			0.07	0.05	0.07	-0.03	0.18	.17
Unpredictability			0.16	0.06	0.16	0.04	0.28	< .01
Physical Abuse			-0.03	0.05	-0.03	-0.13	0.08	.63
Physical Neglect			0.05	0.06	0.06	-0.06	0.17	.37
Sex			-0.15	0.11	-0.07	-0.37	0.06	.16
Step 2	.05	.00						< .001
Constant			0.03	0.05		-0.08	0.13	.61
Harshness			0.06	0.06	0.07	-0.05	0.18	.28
Unpredictability			0.18	0.07	0.18	0.05	0.31	< .01
Physical Abuse			-0.08	0.06	-0.08	-0.20	0.05	.22
Physical Neglect			0.07	0.07	0.07	-0.06	0.20	.30
Sex			-0.17	0.11	-0.07	-0.38	0.05	.13
Sex x Harshness			0.02	0.14	0.01	-0.25	0.30	.87
Sex x Unpredictability			-0.06	0.16	-0.03	-0.37	0.24	.69
Sex x Physical Abuse			0.18	0.12	0.10	-0.06	0.42	.14
Sex x Physical Neglect			-0.08	0.15	-0.04	-0.37	0.22	.61

Note. CI = confidence interval; LL = lower limit; UL = upper limit; $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

variance in trait hyperactivity (R^2_{adj} = .05, p < .001). Notably, unpredictability of childhood environment (β = 0.20, t_{455} = 2.63, p < .01, 95% CI [.05, 31]) emerged as the sole significant unique predictor.

Discussion

Environmental Predictors of Trait Inattention

Consistent with the modified environmental adversity hypothesis, rearing environments characterized by response-ready reaction norms such as harshness (H_1) and unpredictability (H_2) were associated with trait inattention in a non-clinical sample of undergraduates. However, contrary to the predictions made by the environmental adversity hypothesis, resource scarcity, operationalized as childhood physical neglect (H_3), did not emerge as a significant predictor of trait inattention. Although this may reflect an inaccuracy in predictions generated by the environmental adversity hypothesis, underlining the necessity of further modification, alternative explanations should be considered before categorically dismissing resource scarcity as a potential response-ready reaction norm.

For instance, harshness, as presently operationalized (i.e., the Childhood Harshness Scale; Maranges et al., 2022), is primarily framed in terms of material need, presenting a potential point of considerable conceptual overlap with resource scarcity. Consequently, the Childhood Harshness Scale may have accounted for variance that the present measure of resource scarcity (i.e., the physical neglect subscale of the Childhood Trauma Questionnaire; Bernstein et al., 2003) otherwise would have. Although both measures index aspects of resource scarcity, it should be noted that the Childhood

Harshness Scale describes scarcity in much milder terms (e.g., not being able to afford fashionable, new clothing) than does the Childhood Trauma Questionnaire (e.g., malnutrition and medical neglect). Certainly, the more severe conditions of scarcity described by the Childhood Trauma Questionnaire are likely a more faithful analogue of resource scarcity as experienced by ancestral humans foraging in response-ready environments. However, although socioeconomic status was not measured in the present study, the sample was drawn from a population disproportionately representative of individuals of high, versus low, socioeconomic status (i.e., those enrolled in post-secondary education; Aud et al., 2011). If those of high socioeconomic status were similarly over-represented in the present sample, it may also be that the milder forms of material deprivation described by the Childhood Harshness Questionnaire more effectively capture resource scarcity as it varies amongst such economically privileged individuals.

The negative association between physical abuse and trait inattention, indicating that higher levels of childhood physical abuse were associated with lower levels of inattention, also appears at odds with the environmental adversity hypothesis, which predicted positive associations between environmental danger and inattention (H_4). However, although both predatory ambush and physical abuse by caregivers certainly constitute environmental threats, they differ substantially in predictability. Research by Pollak and colleagues (2009) suggests that children reared in abusive environments develop a perceptual specialization, becoming hypersensitive to social cues indicative of imminent abusive episodes (e.g., anger displays). That the development of

hypersensitivity to such cues appears specific to abused, versus non-abused, children suggests an associatively learned component such that these cues are at least reasonably reliable at predicting aggression. By comparison, a predatory ambush is, by definition, an unpredictable threat. Thus, it should be considered that hypervigilance may be a multi-faceted construct, relying on different mechanisms to respond to predictable versus unpredictable threats. For instance, it is possible that inattention-mediated environmental scanning is an asset in identifying unpredictable threats, but a liability in detecting threats for which cues are readily available. Thus, experience of predictable threats, such as abuse, may not have captured the kind of unpredictable threat that Jensen and colleagues (1997) initially intended. Differentiating between such manifestations of hypervigilance highlights an important area of future response-readiness research.

Notably, adoption of a multifaceted approach to hypervigilance does *not* explain why participant sex appeared to moderate the negative associations between physical abuse and inattention such that this effect emerged in amongst females, but not males. This may reflect sex differences in social cognition, as numerous studies have found that females outperform males on measures of affect recognition (e.g., Wingenbach et al., 2018). That is, relatively attentive females may have detected affective cues indicative of an imminent abusive episodes that their less attentive counterparts failed to, resulting in differential success in avoiding such episodes. Conversely, comparatively modest competencies in affect recognition may have impaired the detection of such cues even in attentive males, precluding any advantage in abuse avoidance relative to their less attentive counterparts. Alternatively, as has been previously observed (e.g., Richmond et

al., 2015), females are overrepresented in undergraduate samples. Indeed, the sample for this study boasted a paltry 104 male participants, relative to 352 female participants. Thus, it is entirely possible that this sample was underpowered to detect the effects of response-ready reaction norms on inattention in males specifically. Given the male-biased diagnosis rates of ADHD (e.g., Li et al., 2019), this may be especially problematic.

Environmental Predictors of Trait Hyperactivity/Impulsivity

Conversely, unpredictability (H_6) of childhood environment significantly predicted trait hyperactivity, whereas harshness (H_5), danger (H_7), and resource scarcity (H_8) did not. On the one hand, this may again reflect poor operationalization of study variables; in this case, unpredictability. Specifically, the Childhood Unpredictability Scale (CUS; Maranges et al., 2022) emphasizes aversive aspects of unpredictability, including uncertainty regarding neighborhood safety, as well as inconsistent parental care. This is potentially problematic as these concerns overlap considerably with those of other reaction norms, namely danger and resource scarcity. Thus, it is possible that the broad subject matter of the CUS captured variance that the present operationalizations of danger and scarcity otherwise may have. Were this the case, however, one may reasonably expect a similar pattern to emerge in the prediction of trait inattention, which was instead predicted not only by unpredictability, but also harshness and danger.

Alternatively, it is possible that the expression of hyperactivity is simply sensitive to a narrower range of environmental qualities than is the expression of inattention. As Jensen and colleagues (1997) make no explicit predictions as to specific associations between environmental contingencies and trait clusters, this is not inherently problematic

for the environmental adversity hypothesis. Indeed, this may reflect an opportunity to refine response-readiness theory, leveraging existing evolutionary psychopathological theory in further delineating the distinct roles of hyperactivity and inattention in the expression of response-readiness. That is, hyperactivity may instead represent what Belsky (1997) describes as a susceptibility factor, which refers to a trait that acts as a mechanism of phenotypic plasticity by amplifying the effects of environmental quality on the differential expression of developmentally-plastic traits.

Challenging the notion of risk factors in traditional models of psychopathology (e.g., diatheses in the diathesis-stress model), Belsky argues that such traits (i.e., susceptibility factors), are actually mechanisms of phenotypic plasticity more generally. Specifically, Belsky's differential susceptibility model concedes that certain traits appear to facilitate dysfunction, particularly in individuals exposed to unfavorable rearing environments, but further argues that the very same traits enable individuals to thrive when exposed to optimal rearing environments. In essence, this model proposes that susceptibility factors act as moderators, amplifying developmentally plastic responses to reaction norms. Statistically, this interaction constitutes a u-shaped function such that susceptible individuals (i.e., those high in a given susceptibility factor) are disproportionately represented at the functional and dysfunctional extremes of a given developmental outcome, whereas non-susceptible individuals exhibit moderate functionality in that outcome.

Belsky and Pluess (2009) substantiate this claim with considerable empirical evidence, including a longitudinal study by van Aken and colleagues (2007), which found

that infant temperament moderated the effects of maternal sensitivity on later externalizing behavior. More specifically, infants with difficult temperament were disproportionately represented amongst not only infants with the greatest increase in externalizing behavior when reared by insensitive mothers, but also amongst those with the most modest increases when reared by sensitive mothers. In other words, difficult temperament acted as a susceptibility factor, amplifying phenotypically plastic manifestations of externalizing behavior in response to both optimal and suboptimal rearing environments.

Most importantly, susceptibility factors are best understood as mechanisms that facilitate plasticity in the expression of other traits, rather than phenotypically plastic traits themselves. Indeed, Belsky and colleagues (2007) stipulate that susceptibility factors are, necessarily, independent of the environmental factors whose effects they moderate. That is, for a trait to moderate the effects of both favorable and unfavorable rearing environments on a given developmental outcome, it must be expressed in both kinds of rearing environment. This relative insensitivity is further reflected in the candidate susceptibility factors proposed by Belsky and Pluess (2009; e.g., temperament, physiological reactivity), many of which are framed as largely innate. Nonetheless, the differential susceptibility model recognizes that expression of even these relatively stable traits is likely dependent to some degree on characteristics of an individual's prenatal and early childhood environments.

Theory points to unpredictability as one such factor. First, although often discussed together, Belsky and colleagues (2012) assert that harshness and

unpredictability are distinct environmental qualities, and should have unique, dissociable effects on developmental plasticity. Additionally, the differential susceptibility model frames phenotypic plasticity as a form of evolutionary bet hedging, guarding against an uncertain future by diversifying the malleability of offspring to potentially fatal rearing decisions, further strengthening the case for unpredictability as a reaction norm for the expression of susceptibility. Thus, conceptualization of trait hyperactivity as a susceptibility factor accounts reasonably well for its selective sensitivity to unpredictability, as opposed to other reaction norms. That Belsky and Pluess (2009) explicitly propose hyperactivity as a susceptibility factor strengthens this case further yet.

In the larger context of response-readiness theory, trait hyperactivity may moderate attentional capacity in response to cues of environmental quality, with response-ready environments favoring the expression trait inattention in susceptible individuals. However, the current findings also suggest substantial positive correlation between trait hyperactivity and inattention. This constitutes a potential conflict with a further stipulation of Belsky and colleagues' (2011), that susceptibility factors are necessarily independent of the outcomes that they moderate. Statistically speaking, if a given susceptibility factor is high in individuals at the functional and dysfunctional extremes of an outcome, these opposing effects should cancel each other out, resulting in the illusion of an overall non-significant association between susceptibility factor and outcome. Thus, one may conclude that the strong positive association between trait hyperactivity and inattention rules out the former as a susceptibility factor in the expression of the latter.

However, the above conclusion rests on the assumption that the study data represents the full range of attentional outcomes. This assumption is questionable given the present operationalization of inattention. Specifically, the ASRS was designed as a clinical screening tool, meaning that the purpose of its inattention subscale is to detect the presence of *clinically significant* deficits in attentional capacity. Thus, an especially low score on this subscale specifically indicates the absence of such deficits, and does not discriminate those with exceptional attentional capacities from those in the typical range. This should effectively bisect the u-shaped function representing the interaction of environmental adversity and hyperactivity in predicting attentional capacity. Conflation of those with exceptional and typical attentional capacities should dilute any association between hyperactivity and exceptional attentional capacity, whereas the association between trait hyperactivity and profound deficits in attentional capacity should remain salient.

It remains possible that hyperactivity and inattention are not significantly associated with one another when the full range of individual differences in attentional capacity are accounted for. This prospect is difficult to reconcile with multiple studies finding positive associations between trait hyperactivity and inattention in the general population (e.g., Aydin et al., 2023; Boot et al., 2017; Li et al., 2019). However, these studies largely rely on clinical screening and diagnostic tools to measure ADHD traits, similarly conflating exceptional and typical attentional capacities. This highlights the need for future research to rely on objective cognitive and behavioral measures of inattention (e.g., digit span and Stroop tasks; see Nasiri et al., 2023), hyperactivity (e.g.,

accelerometers, motion-tracking software; see Wang et al, 2022) and impulsivity (e.g., Go/No-Go and delay discounting tasks; see Reynolds et al., 2006). The advantages of such tasks are numerous, including increased ecological validity and the capacity to measure the full range of ADHD traits across clinical and neurotypical samples, as well as the ability to dissociate hyperactive and impulsive traits, which clinical measures, such as the ASRS, often collapse into a single, unidimensional construct.

Limitations

Sample characteristics presented a substantial limitation of this study. First, females, relative to males, were overrepresented in this sample, meaning that analyses were likely underpowered to detect male-specific effects, especially relevant given documented sex differences in the prevalence of ADHD (e.g., Li et al., 2019). Additionally, the sample was primarily composed of emerging adults, which creates two issues. First, much of ADHD research, and certainly the majority of the research underpinning the theoretical approach underlying this study, utilized child participants. Second, research has suggested that inattention, and ADHD symptomology more generally, may fluctuate predictably across the lifespan. For instance, Semeijn and colleagues (2021) found that inattention is more likely to persist well into adulthood than is hyperactivity. Thus, potentially relevant information on the environmental antecedents of, at the very least, trait hyperactivity may be obfuscated in a sample composed primarily of emerging adults. These concerns limit generalizability, and underline the necessity of community samples, as well as of designs (e.g., longitudinal, cross-sectional, and cross-sequential) that account for developmental effects.

Additionally, it is clear that some variables, as operationalized in this study, may have been poor analogues for the response-ready reaction norms described by Jensen and colleagues (1997). For instance, as discussed above, self-reports of physical abuse may not capture the predatory threats described by Jensen and colleagues because the former is relatively predictable, whereas the latter is inherently unpredictable. Similarly, future research would do well to adopt more objective performance-based cognitive and behavioral measures of inattention, hyperactivity and impulsivity. One option would be to implement more objective measures of study variables, including response-ready reactions such as danger (e.g., government data on neighborhood crime rates) and scarcity (e.g., indicators of socioeconomic status, such as household income), as well as the more objective measures of ADHD traits as discussed above. Indeed, a longitudinal design implementing these measures in a community sample would not only address demographic concerns regarding sex in the present sample, but also provide valuable information on how the expression of response-readiness traits varies across the lifespan.

Conclusions

Although it is important to acknowledge the above limitations, this study begins to address a large gap in the evolutionary psychopathology literature by providing preliminary direct tests of response-readiness theory. Consistent with the modified environmental adversity hypothesis, this study found that several response-ready reaction norms (e.g., harshness and unpredictability) were associated with higher levels of inattention in a subclinical population, whereas others were not (e.g., physical abuse, physical neglect). As discussed above, however, there is reason to believe that the present

operationalizations of these reaction norms may not have adequately captured Jensen and colleagues' (1997) initial conceptualizations. Similarly, the only response-ready reaction norm predictive of hyperactivity was unpredictability. Although this is inconsistent with the initial form of the modified environmental adversity hypothesis, it also positions hyperactivity as an excellent contender for the role of susceptibility factor in the expression of other response-ready traits. Thus, the limits of this study will serve to strengthen future response-readiness research, not only providing valuable information on the appropriate operationalization of response-ready traits and reaction norms, but also on ways in which response-readiness may be integrated into extant frameworks of evolutionary psychology. Such integration not only serves to inform future directions in refining response-readiness theory, but also to broaden current understanding of the evolutionary underpinnings of individual differences in traits traditionally regarded as psychopathological.

Chapter Three: The Hypervigilance Hypothesis

Introduction

The hypervigilance hypothesis proposes that the diffuse attentional states of individuals with ADHD were adaptive in promoting vigilance in the dangerous environments of Jensen and colleagues' (1997) EEA. Individuals who constantly scan their environments should identify threat cues more readily than those whose attention remains fixated on a single stimulus. As such, it should be expected that individuals with ADHD will display heightened sensitivity to threat cues compared to NT peers. Evolutionary psychologists propose that humans evolved a suite of cognitive mechanisms that identify environmental threats known as the self-protection system (e.g., Prokop & Fančovičová, 2013). To ancestral humans, this system would have been vital to the detection and avoidance of threats, both predatory and social (i.e., physical or reputational harm by other humans). Although modern humans generally enjoy a lifestyle absent from the former, the latter remains, with the expression of anger by others serving as a salient cue to social threats (Coutinho et al., 2018). The importance of such social threat cues is underlined by the anger superiority effect, which describes the tendency to detect threat-congruent displays of facial affect (i.e., anger) more quickly than threat-irrelevant displays (e.g., happiness and sorrow; LoBue, 2009). Thus, the hypervigilance hypothesis suggests that individuals with ADHD should experience a more pronounced anger superiority effect than NT peers.

An enhanced anger superiority effect appears at odds with existing research on social cognition in individuals with ADHD, which finds that individuals with ADHD

display deficits in recognition of facial affect compared to NT controls. In fact, it has been argued that the self-protection systems of individuals with ADHD are impaired relative to NT peers (Coutinho et al., 2018). For instance, a study by Bisch and colleagues (2016) found that adults with ADHD were significantly less accurate than NT controls in identifying happy, angry, disgusted and sexually aroused displays, an effect that held across multiple presentation media (i.e., auditory presentation, visual presentation, and combined auditory and visual presentation). Similarly, although Helfer and colleagues (2021) failed to find significant differences in accuracy of affect recognition between adults with ADHD and healthy controls, evidence of social cognitive deficits were found in the slower latency of individuals with ADHD to respond to the stimuli. Indeed, a meta-analytic review by Bora and Pantelis (2016) suggested that individuals with ADHD display moderate social cognitive deficits.

Interestingly, although studies have demonstrated deficits in the recognition of numerous affective states in individuals with ADHD, these deficits may actually be more pronounced for the recognition of anger, with such individuals regularly, although not ubiquitously, displaying deficits in accurate recognition of anger displays (e.g., Ludlow et al., 2014; Pelc et al., 2006; Tehrani-Doost et al., 2017; Williams et al., 2008; but see Boakes et al., 2008). These findings are complicated by research (Deter et al., 2014) that found divergent associations between anger recognition and clusters of ADHD symptomology, with anger recognition being positively associated with inattention, but negatively associated with hyperactivity. Notably, the positive association between anger recognition and inattention is consistent with the hypervigilance hypothesis.

Despite such evidence, an important criticism of the existing ADHD social-cognitive literature is that many studies fail to account for relevant comorbidities, such as conduct disorder, for which affective processing deficits are a core feature (American Psychiatric Association [APA], 2013). Indeed, after controlling for comorbid conduct disorder, Airdrie and colleagues (2018) found that ADHD individuals were no less accurate at facial affect recognition than healthy controls. Similarly, Schwenck and colleagues (2013) failed to find evidence of affect recognition deficits in a sample of ADHD adolescents that excluded those with conduct disorder, suggesting that the social cognitive deficits described may not be associated with ADHD *per se*, but rather with its common comorbidities.

Alternatively, apparent anger recognition deficits associated with ADHD may instead reflect attentional bias toward negatively valenced stimuli. Passarotti and colleagues (2010) compared children with ADHD, children with bipolar disorder (i.e., a mood disorder characterized by depressive and manic episodes; hereafter "BPD"; American Psychiatric Association [APA], 2013) and NT controls on an emotional valence Stroop test. Each trial of this task requires participants to indicate which of two presented colors match that of a target word, the valence of which varies between positive (e.g., "victory"), negative (e.g., "poor") and neutral (e.g., "table"), with valence-specific impairments in accuracy or reaction time (i.e., latency in registering a response) indicating task distraction, and thus attentional bias toward stimuli of similar valence. Although there were no group differences in accuracy, the reaction times of both clinical

groups indicated valence-specific attentional biases, with children in the BPD and ADHD groups exhibiting attentional bias toward positive and negative stimuli respectively.

Concurrent neuroimaging data collected by Passarotti and colleagues (2010) provides evidence that the attentional biases of children with ADHD are accompanied by affect regulation difficulties, with these children exhibiting significantly less activity in structures associated with affect regulation (i.e., the ventrolateral prefrontal cortex; Silvers et al., 2017) relative to children in the BPD and control groups when exposed to negatively valenced stimuli. Further evidence of affective overarousal in individuals with ADHD exposed to negatively valenced stimuli comes from a study by Posner and colleagues (2011), which found that individuals with ADHD, relative to NT controls, displayed greater activity in structures associated with the experience of fear (i.e., the amygdala; Feinstein et al., 2011) in response to subliminally presented threat cues (i.e., fearful faces). Furthermore, the subliminal nature of these stimuli suggests that orientation toward threat-congruent stimuli is automatic and pre-attentive in individuals with ADHD, consistent with hypervigilant environmental monitoring. This presents the possibility that impaired performance on anger recognition tasks may not reflect social cognitive deficits in individuals with ADHD, but rather disruptions of deliberative and threat-irrelevant processes (i.e., explicit labeling of threatening stimuli) resulting from automatic, hypervigilant responses (i.e., heightened arousal and attentional prioritization) to stimuli perceived as threatening.

In other domains of cognition less focused on affective states, the hypervigilance hypothesis could be operationalized as a suite of negative cognitive and perceptual

biases. That is, individuals with ADHD may be more vigilant to threats because of a generally negative worldview, similar to cognitive models of depression, and consistent with the elevated depression risk (e.g., Biederman et al., 1998; Kessler et al., 2006; Tung et al., 2016), and above average endorsement of depressive attitudes (e.g., Knouse et al., 2013; Mitchell et al., 2013) observed in individuals with ADHD. Unfortunately, prior research examining depressive symptomatology in individuals with ADHD has primarily focused on comorbidity, treating depressive symptoms and attitudes as unidimensional constructs. This contrasts with the greater fidelity offered by more nuanced, multidimensional conceptualizations of depression (e.g., Beck, 1979), which differentiate between different domains of negative beliefs, such as those concerning the self, the world, and the future. Such distinctions are important, as response-readiness theory predicts divergent associations between these domains of belief and ADHD symptomology. Certainly, negative beliefs about the world and future are consistent with perceptions of the world as dangerous and threats as imminent eventualities respectively. Conversely, negative beliefs about the self are arguably incompatible with other aspects of response-readiness theory, namely the exploratory hyperactivity hypothesis.

Intuitively, an organism with little confidence in its ability to cope with environmental stressors should be hesitant to explore novel and dangerous environments. This intuition is supported by research on learned helplessness, which occurs when an organism inhibits exploratory behavior in response to persistent, unconditional punishment (Seligman & Maier, 1967; Teodorescu & Erev, 2014). In terms of conscious cognition, this would essentially be an abandonment of agency resulting from negative

beliefs about one's ability to alter one's outcomes in effectively coping with environmental stressors, suggesting that negative beliefs about the self should imply inhibition of, rather than participation in, the exploratory behavior proposed by response-readiness theory. Consequently, response-readiness theory predicts a particular pattern of depressive attitudes such that individuals with ADHD should exhibit negative beliefs about the world and the future, but not the self. Indeed, although individuals with ADHD report increased endorsement of depressive attitudes more generally (e.g., Knouse et al., 2013; Mitchell et al., 2013), they also evidence a positive illusory bias (i.e., unrealistic overestimation of one's own competencies; Prevatt et al., 2012; Volz-Sidiropoulou, 2016). Nonetheless, future research investigating the specific types of depressive attitudes held by ADHD individuals would benefit both the response-readiness and clinical literatures.

A final area of cognitive research that may shed light on the hypervigilance hypothesis examines the hostile attribution bias, or the tendency to perceive others' behavior as motivated by hostile intent (Anshel, 2001). Although such a bias would be congruent with hypervigilance, multiple studies have failed to find evidence of a hostile attribution bias in individuals with ADHD (e.g., Anshel, 2001; King, 2007; Mikami et al., 2008; Sibley et al., 2010; Schneidt et al., 2019). However, hostile intent may be perceived as threatening. If so, it is possible that individuals with ADHD respond to perceived hostile intent in ways that mirror their responses to other threat cues (e.g., Posner et al., 2011) and negatively valenced stimuli more generally (e.g., Passarotti et al., 2010). That is, hypervigilant responses (i.e., heightened arousal and attentional prioritization) to

actions perceived as motivated by hostile intent may disrupt explicit ascriptions of that intent.

Thus, much ambiguity pervades the ADHD social cognition literature; at face value, research appears to suggest that individuals with ADHD are less vigilant to social threats than their NT peers, as evidenced by difficulties recognizing threat-congruent behaviors and displays of affect. However, questions remain as to whether these findings genuinely reflect the social-cognitive profile of individuals with ADHD, or rather attentional prioritization of threat-relevant processes over threat-irrelevant processes, such as explicit labeling of affect and attributions of intent. These ambiguities underline the need for specific research assessing the validity of the hypervigilance hypothesis, as anger recognition deficits contradict the hypothesis, whereas attentional prioritization of threat-congruent stimuli may lend credence to it.

The Modified Hypervigilance Hypothesis

The validity of the hypervigilance hypothesis is difficult to ascertain in light of the contradictory social cognitive evidence; on the one hand, individuals with ADHD appear to exhibit impaired performance on anger recognition tasks (e.g., Pelc et al., 2006), but also exhibit neural activity consistent with hypervigilant attentional orientation toward threat-congruent stimuli on the other (Posner et al., 2011). Indeed, the latter results may indicate that the anger recognition deficits exhibited by individuals with ADHD instead reflect attentional prioritization of threat-congruent stimuli at the cost of threat-irrelevant processes (e.g., explicit labeling of the threat-congruent affective states). Such pronounced overarousal is further consistent with well-documented affect

regulation deficits in individuals with ADHD, the severity which appear to positively covary with ADHD symptom severity (Christiansen et al., 2019; Graziano et al., 2011). The relationship between affective dysregulation and symptom severity may be vital in tailoring the hypervigilance hypothesis to an individual differences approach.

Particularly, if the positive associations between affect dysregulation and ADHD traits generalize to the continuous expression of such traits in subclinical populations, then individuals on the higher end of the subclinical range of ADHD traits should exhibit mild affective dysregulation, intermediate between NT individuals and those with clinically-significant ADHD symptomology. Consequently, such individuals may be expected to experience moderate, rather than excessive, arousal in response to threat-congruent stimuli. Notably, optimal task performance occurs at moderate, versus especially high or low, levels of arousal (Yerkes & Dodson, 1908), indicating that moderate affective dysregulation may actually promote optimal levels arousal, and thus optimal performance in threat detection contexts.

Research by Pollak and colleagues (2009) characterizes chronically abused children as having a perceptual specialization in anger recognition. Thus, the social cognitive profile of such individuals may prove a useful model for conceptualizing hypervigilance, at least as it relates to social threats. This vein of research appears to suggest two primary manifestations of hypervigilant detection of social threat cues. Research by Pollak and Kistler (2002) found that chronically abused children demonstrate a tendency toward false positives in threat detection, often perceiving ambiguous displays of affect as threat-congruent (i.e., angry). Thus, hypervigilant threat

detection by response-ready individuals may manifest as a general tendency to perceive ambiguous cues as threatening. Additionally, Pollak and Sinha (2002) compared chronically maltreated children to age-matched controls on an affect recognition task in which stimuli progressed from completely masked (i.e., completely distorted, so as to obscure any affective display cues) to unmasked (i.e., non-distorted, displaying easily observable affective cues). Interestingly, chronically maltreated children were able to accurately identify anger displays on the basis of less visual information (i.e., at greater levels of distortion) than controls. Thus, the second potential manifestation of hypervigilant threat detection entails accurate identification of threat cues on the basis of less information than is typically required of others.

Building on the models provided above, the modified hypervigilance hypothesis suggests the self-protection systems of individuals high in the subclinical range of ADHD traits may operate similarly, and thus may manifest as either greater proficiency in the detection of threats (i.e., accurate identification of threat cues on the basis of less, versus more, visual information), or as biases in threat detection (i.e., the tendency to perceive ambiguous cues as threatening). Indeed, both possibilities are consistent with hypervigilance as conceptualized by response-readiness theory, which concedes that increased sensitivity to threat cues likely incurs the cost of increased commission of false-positives in the detection of threats (Jensen et al., 1997). Thus, it is predicted that trait inattention (as measured by the Adult ADHD Self-Report Scale; Kessler et al., 2005) will be positively associated with the ability to accurately identify facial displays of anger, versus other affective states, on the basis of less, versus more, visual information

(i.e., greater distortion), which should further incur increased risk of false positives (i.e., a general tendency to ascribe anger, regardless of actual affective state displayed).

Furthermore, based on evidence that individuals with ADHD exhibit pronounced affective arousal in response to threat-congruent (Posner et al., 2011) and otherwise negatively valenced stimuli (i.e., Passarotti et al., 2010), as well as affective regulation deficits more generally (i.e., Graziano et al., 2011), it is predicted that affective dysregulation, as measured by the short-form Difficulties in Emotion Regulation Scale (DERS-SF; Kaufman et al., 2016) will mediate the relationship between inattention and hypervigilance. Similarly, given that ADHD is associated with increased endorsement of depressive attitudes (e.g., Biederman et al., 1993), negative belief states are proposed as additional mediators of associations between inattention and hypervigilance. In light of evidence that individuals with ADHD demonstrate positive self-illusory biases, negative beliefs about the future and world, but not the self, as measured by future and world subscales of the Cognitive Triad Inventory (CTI; Beckham et al., 1986), will be investigated as potential mediators. Thus, the present study will test the following hypotheses:

> H_1: Trait inattention will be associated with proficiency in threat detection, such that inattention will predict accurate recognition threat-congruent affective displays under conditions of visual ambiguity.
>
> H_2: Trait inattention will be associated with biases in threat detection, such that inattention will predict a tendency to perceive stimuli as angry regardless of affective state displayed.

H_3: Affective dysregulation will mediate predicted associations between trait inattention and biases in threat detection

H_4: Negative beliefs about the future will mediate predicted associations between trait inattention and biases in threat detection

H_5: Negative beliefs about the world will mediate predicted associations between trait inattention and biases in threat detection

Method

Participants

Exclusion Criteria. From an initial sample of 846, 186 participants (22% of total sample) were excluded for the following reasons: 145 participants (17.1% of total sample) for having failed more than one of the three attention check items, and otherwise careless or incomplete responding, 5 participants (0.6% of total sample) were excluded as univariate outliers (i.e., values greater than 3 standard deviations above or below the mean for study variables), and 9 participants (1% of total sample) for being of insufficient age (i.e., under 18 years). Finally, because of documented sex differences in ADHD traits (e.g., Fedele et al., 2012), sex was to be entered as a dichotomous predictor (1 = male; 0 = female) in study models. Thus, 27 participants (3.2% of total sample) who did not explicitly identify as cisgender male or cisgender female (i.e., participants who identified as transgender, non-binary, or did not indicate gender identity) were excluded from analyses.

Final Sample. The post-exclusion sample consisted of 660 American college students, 18 years or older, enrolled in introductory psychology courses and recruited through Oakland University's SONA recruitment tool. Of this post-exclusion sample, 518 participants (78.5%) of were female and 142 (21.5%) were male, with an average age of 19.82 years (*SD* = 3.56). The racial composition of the sample was 69.7% White (*n* = 460), 10.6% Black (*n* = 70), 5% Asian (*n* = 33), 3.8% Hispanic (*n* = 25), 0.2% Pacific Islander (n =1), 0.2% indigenous or Native American (n =1), 4.3% selecting "other" or not indicating their racial identity (*n* = 29) and 6.2% (*n* = 41) identifying with more than one racial group or explicitly identifying as biracial. Additionally, 88 participants (13.3% of final sample) indicated prior diagnosis of one or more attention-related neurodevelopmental disorder (i.e., attention-deficit disorder or attention-deficit/hyperactivity disorder).

Measures

Demographic Information. Participants provided information regarding their age, racial and gender identities, and previous history of mental health diagnoses for several common psychopathologies, including attention-deficit disorder and attention-deficit/hyperactivity disorder.

Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005). The Adult ADHD Self-Report (ASRS; α =.91) is an 18-item self-report measure of Attention-Deficit/Hyperactivity Disorder symptomology. This measure contains two subscales measuring inattention (9 items; sample item: "How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?" α = .86) and

hyperactivity/impulsivity (9 items; sample item: “How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?” α = .86). Participants responded on a 5-point Likert scale (1 = “Never,”; 5 = “Very often,”) indicating how often each item has described them in the past 6 months. Notably, Kessler and colleagues (2005) indicate that this measure has adequate concurrent validity with the outcomes of blind clinical interviews assessing ADHD symptomology. Although this measure was designed as a clinical screening tool, it will be used to measure individual differences in ADHD traits for the purposes of this study. This measure can be found in Appendix D.

Cognitive Triad Inventory (Beckham et al., 1986). The Cognitive Triad Inventory (α = .95) is a 36-item self-report measure of Beck’s (1979) Cognitive Triad of depression. This measure has three subscales, representing negative views of the self (10 items; sample item: “I hate myself,”; α = .88), the world (10 items; sample item: “The world is a very hostile place,”; (α = .79) and the future (10 items; sample item: “My future is simply too awful to think about,”; (α = .92). Participants responded to statements on a 7-point Likert scale (1 = “Totally Disagree,”; 7 = “Totally Agree,”) indicating their agreement with each statement. Although this measure was designed for clinical research, it will not be used diagnostically in this study. Rather, it will be a measure of negative domain-specific information processing biases. This measure can be found in Appendix H.

Difficulties in Emotion Regulation Scale-Short Form (DERS-SF; Kaufman et al., 2016). The difficulties in Emotion Regulation Scale – Short Form (α = .91) is an 18-item self-report measure of affective dysregulation. This measure includes six subscales

measuring emotion regulation strategies (3 items; sample item: “When I’m upset, I believe that I will end up feeling very depressed,”; α = .83), non-acceptance (3 items; sample item: “When I’m upset, I become embarrassed for feeling that way,”; α = .84), impulse (3 items; sample item: “When I’m upset, I become out of control,”; α = .88), goals (3 items; sample item: “When I’m upset, I have difficulty with getting work done,”; α = .89), awareness (3 items; reverse scored; sample item: “I pay attention to how I feel,”; α = .79), and clarity (3 items; sample item: “I have no idea how I am feeling,”; α = .83). Participants responded on a 5-point Likert scale (1 = “Almost Never (0-10%)”; 5 = “Almost Always (91-100%)” indicating how often each item describes themselves. It is important to note that higher scores indicate greater dysfunction. Total scores were used in analyses. This measure can be found in Appendix I.

Threat Detection Task. Participants additionally completed a facial affect recognition task using images gathered from the Racially Diverse Affective Expression face stimulus set (RADIATE; Conley et al., 2018). A random number generator was used to select a male model from each of the four racial groups (Asian, Black, Caucasian, and Hispanic) represented in the RADIATE stimulus set. Males are more likely to engage in direct, impulsive, and physical forms of aggression than are females, making male, versus female, expressions of anger a stronger analogue to the types of predatory cues described by Jensen and colleagues (1997; Archer, 2002). Thus, exclusively male models were used in the present study. A base set of 16 images was collected consisting of the anger, disgust, happiness and neutral expressions for each of the four models. For each of these 16 images, four additional variants were made using an online image editor

(https://pixelate.imageonline.co/; Image Online.Co, n.d.), resulting in a total of 80 images. This editor was used to pixelate each base image to various degrees (pixelation values of 15, 30, 45, 60), represented as "block size" with larger block sizes denoting larger pixels, thus greater distortion of the image. See Figure 3.1 for an example of the stimulus set representing the Black model's anger display at various levels of pixelation. Participants ascribed affective states (anger, disgust, happiness or neutral) to each of the 80 images. For this task, threat detection proficiency was operationalized as the accurate identification of anger displays on the basis of less, versus more, visual information, such that accurate identification of anger displays at high levels of visual distortion reflected greater threat detection proficiency. Additionally, biases toward threat perception were operationalized as disproportionate ascription of anger regardless of stimulus qualities (i.e., affective state, distortion level) such that participants' total anger ascriptions across the entire stimulus set indicated a stronger bias. The full set of stimuli used in this task can be found in Appendix J.

Figure 3.1

Demonstration of Pixelation Technique on Black Male Face Representing Anger

Unaltered *15* *30* *45* *60*

Note: The numbers under each face represent the pixel size selected https://pixelate.imageonline.co/ *for each image.*

Results

Intercorrelations of Study Variables

See Table 3.1 for descriptive statistics and intercorrelations of study variables.

Hierarchical Logistic Model Predicting Accurate Identification of Facial Affect

In recognition of the nested nature of the present data (i.e., observations of specific stimuli nested within participants), a series of generalized linear mixed models (GLMMs) were conducted with a binary distribution and logit link function to examine accuracy of affect recognition task (correct, incorrect). Analyses were performed using the mixed model function of IBM SPSS Statistics (Version 31.0; IBM, 2025). Each model included the fixed effects of affective state (coded categorically; anger, disgust, happiness, and neutral), inattention, hyperactivity, and the interactions of inattention and hyperactivity with affective state. Participant identity was included as a random effect. Because we expected ADHD traits to predict accuracy for detecting emotions signaling threat (i.e., anger, disgust), and for these effects to emerge only when the emotions were somewhat obscured, and therefore more challenging to identify, five separate models were run; one for each level of "block size," with successive levels of block size indicating greater pixelation, and thus distortion[1].

[1] Ideally, we would conduct a full model allowing for a three-way interaction between block size, emotion and ADHD traits, but these models required too many resources to run, so I adopted the strategy of examining each model for the pattern predicted by my hypotheses.

Table 3.1

Descriptive Statistics and Intercorrelations of Study 2 Variables

	1	2	3	4	5	6	7
1. Sex	-						
2. Trait Inattention	-.09*	-					
3. Trait Hyperactivity	-.06	.81***	-				
4. Negative Beliefs About the World	-.01	-.30***	-.30***	-			
5. Negative Beliefs About the Future	-.01	-.21***	-.23***	.78***	-		
6. Affective Dysregulation	-.10*	.50***	.50***	-.57***	-.59***	-	
7. Biases in Threat Detection	-.10**	.05	.01	.05	.08*	-.05	-
M	0.23	2.90	2.79	4.98	5.49	2.53	0.18
SD	0.41	0.73	0.72	0.83	1.06	0.71	0.07

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

Block Size: 0 Model. Model fit was indicated by a corrected AIC of 120,069.89. The overall model was significant ($F_{3,\ 10,544} = 597.69$, $p < .001$). A significant fixed effect emerged only for affective state ($F_{3,\ 10,531} = 515.84$, $p < .001$). Pairwise contrasts indicated that accuracy was lower for anger displays than for disgust ($t_{10,544} = -35.67$, $p_{Adj} < .001$, 95% CI [-0.58, -.052]), happiness ($t_{10,544} = -32.38$, $p_{Adj} < .001$, 95% CI [-0.59, -0.53]), or neutral ($t_{10,544} = -42.05$, $p_{Adj} < .001$, 95% CI [-0.62, -0.56]) displays. Additionally, although accuracy was not significantly different between disgust and happiness displays ($t_{10,544} = -0.60$, $p_{Adj} = .55$, 95% CI [-0.04, 0.02]), accuracy was significantly lower for disgust displays than for neutral displays ($t_{10,544} = -3.75$, $p_{Adj} < .001$, 95% CI [-0.06, -0.02]). Finally, accuracy was lower for happiness displays than for neutral displays ($t_{10,544} = -2.24$, $p_{Adj} < .001$, 95% CI [-0.02, -0.003]). There were no main effects of trait inattention or hyperactivity. However, the interaction between hyperactivity and emotion emerged as significant ($F_{3,\ 10,544} = 3.30$, $p = .02$). Follow-up logistic regression analyses examining the effects of hyperactivity, controlling for inattention, for each emotion indicated that hyperactivity was significantly positively associated with accuracy in the recognition of disgust displays ($B = 0.19$, $p = .02$), but not anger ($B = -0.05$, $p = .39$), happiness ($B = 0.04$, $p = .77$) or neutral ($B = -0.12$, $p = .11$) displays.

Block Size: 15. The initial model including affective state, inattention, hyperactivity and the interactions of inattention and hyperactivity with emotion failed to converge. Notably, failure to converge can indicate overparameterization (Bates et al., 2015). Thus, two separate, simpler models were specified, both of which included affective state, a single ADHD trait (i.e., inattention or hyperactivity), and the interaction

between that ADHD trait and affective state. Both of these simpler models additionally failed to converge. A final model with fixed effects of affective state, inattention and hyperactivity with interactions excluded similarly failed to converge.

Block Size: 30. Model fit was indicated by a corrected AIC of 53,525.49. The overall model was significant ($F_{3,\ 10,540}$ = 1,160.43, $p < .001$). Significant fixed effects emerged for affective state only ($F_{3,\ 10,540}$ = 510.60 $p < .001$). Pairwise contrasts indicated that accuracy was lower for anger displays than for disgust ($t_{10,540}$ = -14.23, $p_{Adj} < .001$, 95% CI [-0.22, -0.17]), happiness ($t_{10,540}$ = -51,52, $p_{Adj} < .001$, 95% CI [-0.55,-0.51]), and neutral ($t_{10,540}$ = -31.30, $p_{Adj} < .001$, 95% CI [-.40, -.36]) displays. Similarly, accuracy for disgust displays was lower than for happiness ($t_{10,540}$ = -34.06, $p_{Adj} < .001$, 95% CI [-0.36, -0.32]) and neutral ($t_{10,540}$ = -15.88, $p_{Adj} < .001$, 95% CI [-0.21, -0.17]) displays. Finally, accuracy for happiness displays was higher than for neutral displays ($t_{10,540}$ = 19.28, $p_{Adj} < .001$, 95% CI [0.14, 0.17]). There were no main effects of trait inattention or hyperactivity.

Block Size: 45. Model fit was indicated by a corrected AIC of 50,663.82. The overall model was significant ($F_{3,\ 10,531}$ = 2,226.14, $p < .001$). A significant fixed effect emerged for trait inattention ($F_{1,\ 10,531}$ = 6.61, $p < .001$) indicating that inattention was positively associated with accuracy in affect recognition across emotions at this level of distortion. A significant effect also emerged for affective state ($F_{3,\ 10,531}$ = 867.67, p = .01). Pairwise contrasts indicated that accuracy was lower for anger than for disgust ($t_{10,531}$ = -4.97, $p_{Adj} < .001$, 95% CI [-0.08, -0.03]), happiness ($t_{10,531}$ = -70.19, $p_{Adj} < .001$, 95% CI [-0.71, -0.67]) and neutral ($t_{10,531}$ = -35.54, $p_{Adj} < .001$, 95% CI [-0.46, -0.14])

displays. Additionally, accuracy was lower for disgust than for happiness ($t_{10,531}$ = -61.08, p_{Adj} < .001, 95% CI [-0.65, -0.61]) or neutral ($t_{10,531}$ = -29.87, p_{Adj} < .001, 95% CI [-0.40, -0.35]) displays. Finally, accuracy for happiness displays was higher than for neutral displays ($t_{10,531}$ = 23.42, p_{Adj} < .001, 95% CI [0.23, 0.27]) displays. Neither interaction was significant.

Block Size: 60. Model fit was indicated by a corrected AIC of 49,531.75. The overall model was significant ($F_{3,\ 10,534}$ = 1,405.78, p < .001). Significant fixed effects emerged only for affective state ($F_{3,\ 10,534}$ = 834.86, p < .001). Pairwise contrasts indicated that accuracy was higher for anger displays than for disgust ($t_{10,534}$ = 4.93, p_{Adj} < .001, 95% CI [0.03, 0.07]), although accuracy for anger was lower than for happiness ($t_{10,534}$ = -48.85, p_{Adj} < .001, 95% CI [-0.57, -0.53]) and neutral ($t_{10,534}$ = -33.63, p_{Adj} < .001, 95% CI [-0.43, -0.48]) displays. Additionally, accuracy was lower for disgust displays than for happiness ($t_{10,534}$ = -55.70, p < .001, 95% CI [-0.61, -0.58]) or neutral ($t_{10,534}$ = -39.16, p < .001, 95% CI [-0.48, -0.43]). Finally, accuracy for happiness displays was higher than for neutral displays ($t_{10,534}$ = 11.25, p < .001, 95% CI [0.12, 0.17]). There were no main effects of trait inattention or hyperactivity.

Moderated Mediation Analyses

A series of mediation analyses using Model 4 (i.e., simple mediation) of the PROCESS macro version 4.2 (Hayes, 2018) for SPSS were employed to test whether intolerance of uncertainty mediated predicted associations between ADHD traits and biases in anger recognition. Each of these models were run twice, once with each trait hyperactivity and trait inattention as focal predictor, while controlling for the effects of

the other as a covariate. Follow-up analyses using Model 8 (mediation with moderation on the a_1, a_2, a_3, and c' paths) of the PROCESS macro for SPSS were used, specifying sex as moderator to probe for potential sex differences. See Figure 3.2 for conceptual diagrams of study models.

With the exception of sex, all study variables were zero-centered prior to inclusion in the models. In line with recommendations by Hayes (2018), the seed command was used to ensure consistent sampling between models. Note that the intent of these analyses was not a test of causal inference (the typical use case for mediation analyses; see MacKinnon et al., 2007), but rather examination of direct and indirect associations between study variables to assess the hypothesized relations among variables. It is acknowledged that other possible causal patterns are possible. Thus, it must be stressed that no causal claims are being made, explicit or otherwise.

Trait Hyperactivity as Focal Predictor.

Mediation Analysis. An initial mediation analysis indicated that neither the total (c = -0.09, t_{659} = -1.62, p = .10, 95% CI [-0.21, 0.02]), nor direct (c' = -0.07, t_{659} = -1.26, p = .21, 95% CI [-0.19, 0.04]), effects of trait hyperactivity on biases in threat detection were significant. However, trait inattention was significantly positively associated with biases in threat detection (Cov_y = 0.14, t_{659} = 2.33, p = .02, 95% CI [0.02, 0.26]).

Trait hyperactivity was significantly negatively associated with negative beliefs about the future (a_1 = -0.17, t_{659} = -2.60, p < .01 , 95% CI [-0.29, -0.04]), which, itself, was not significantly associated with biases in threat detection (b_1 = 0.07, t_{659} = 1.21, p =

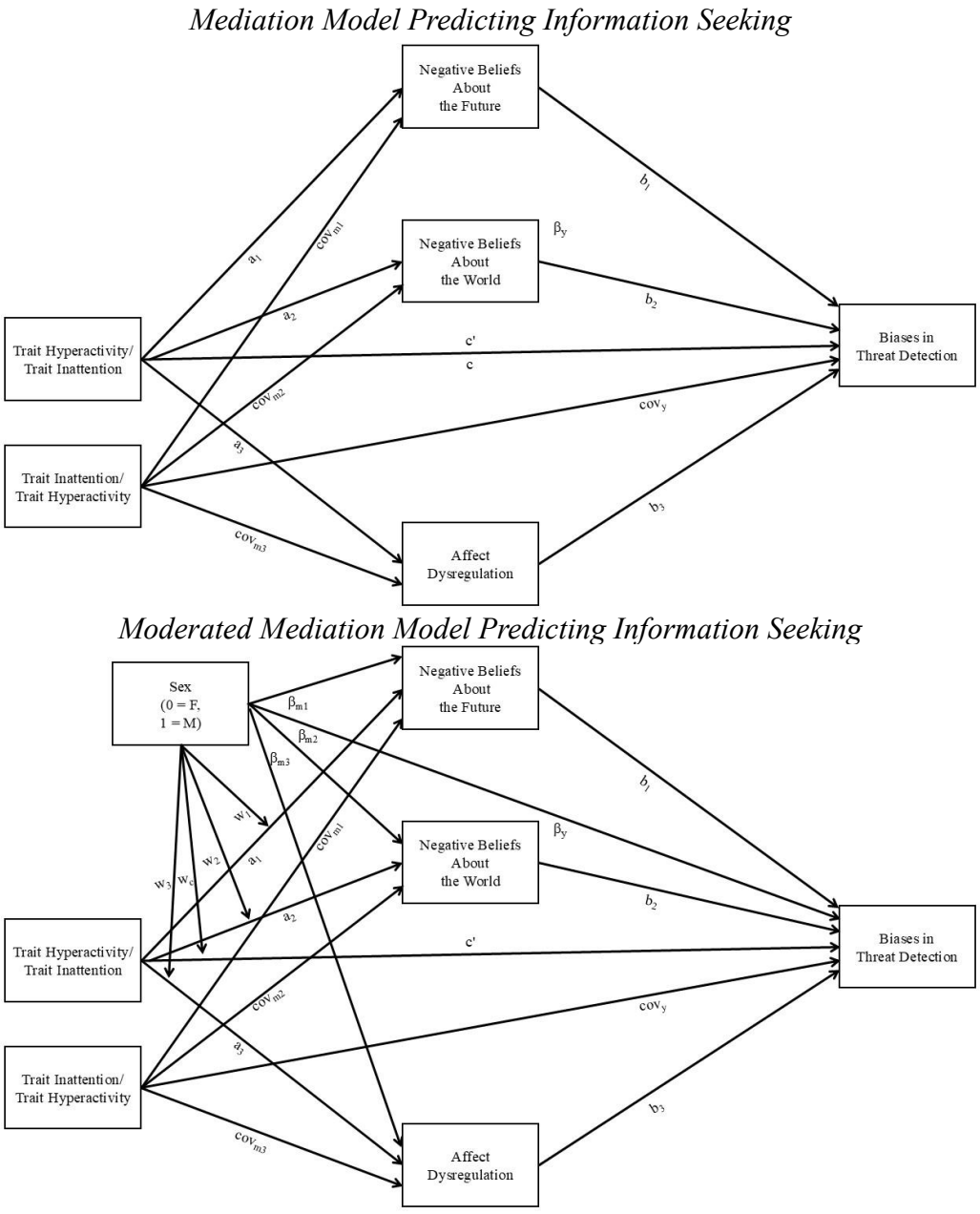
.23, 95% CI [-0.04, 0.18]). Additionally, the indirect effect of trait hyperactivity on biases in anger detection through negative beliefs about the future was not significant (ab_1 = -0.01, 95% CI [-0.04, 0.01]). Trait inattention was not significantly associated with negative beliefs about the future (Cov_{m1} = -.08, t_{659} = -1.23, p = .22, 95% CI [-0.21, 0.05]).

Trait hyperactivity was significantly negatively associated with negative beliefs about the world (a_2 = -0.16, t_{659} = -2.58, p = 01, 95% CI [-0.29, -0.04]), which, itself, was not significantly associated with biases in threat detection (b_2 = -0.01, t_{659} = -0.24, p = .81, 95% CI [-0.12, 0.10]). Additionally, the indirect effect of trait hyperactivity on biases in anger detection through negative beliefs about the world was not significant (ab_2 = .002, 95% CI [-0.02, 0.02]). Trait inattention was significantly negatively associated with negative beliefs about the world (Cov_{m2} = -0.17, t_{659} = -2.70, p < .01, 95% CI [-0.30, -0.05]).Trait hyperactivity was significantly negatively associated with negative beliefs about the world (a_2 = -0.16, t_{659} = -2.58, p = 01, 95% CI [-0.29, -0.04]), which, itself, was not significantly associated with biases in threat detection (b_2 = -0.01, t_{659} = -0.24, p = .81, 95% CI [-0.12, 0.10]). Additionally, the indirect effect of trait hyperactivity on biases in anger detection through negative beliefs about the world was not significant (ab_2 = .002, 95% CI [-0.02, 0.02]). Trait inattention was significantly negatively associated with negative beliefs about the world (Cov_{m2} = -0.17, t_{659} = -2.70, p < .01, 95% CI [-0.30, -0.05]).

Trait hyperactivity was significantly positively associated with affective dysregulation (a_3 = 0.27, t_{659} = 4.56, p < .001, 95% CI [0.16, 0.39]), which, itself, was not

Figure 3.2

Conceptual Diagrams of Study Two Models



Note. Four models were run in two sets of two. Each set included one mediation model predicting biases in anger detection and one moderated mediation model which replicates the prior mediation model with sex as a moderator on the a_1, a_2, a_3, and c' paths. In the first set of two models, inattention served as predictor and hyperactivity as a covariate, whereas the roles of these variables were reversed in the subsequent two models.

significantly associated with biases in threat detection (b_3 = -0.04, t_{659} = -0.87, p = .38, 95% CI [-0.13, 0.05]). Additionally, the indirect effect of trait hyperactivity on biases in anger detection through affective dysregulation was not significant (ab_3 = -.01, 95% CI [-0.04, 0.02]). Trait inattention was significantly positively associated with affective dysregulation (Cov_{m3} = 0.31, t_{659} = 5.09, p < .001, 95% CI [0.19, 0.43]). See Figure 3.3 for a statistical diagram of this model.

Moderated Mediation Analyses. Follow-up moderated mediation analyses indicated that the direct effect of trait hyperactivity on biases in anger detection was not significant (c' = -0.05, t_{659} = -0.74, p = .46, 95% CI [-0.17, 0.08]). Sex was significantly negatively associated with biases in threat detection (β_y = -0.21, t_{659} = -2.66, p < .01, 95% CI [-0.37, -0.06]), indicating that females were more likely than males to perceive displays of facial affect as threatening (i.e., angry). Sex did not significantly moderate the direct effect of trait hyperactivity on biases in threat detection (w_c = -0.09, t_{659} = -1.07, p = .28, 95% CI [-0.25, 0.07]). Trait inattention was significantly positively associated with biases in threat detection (Cov_y = 0.13, t_{659} = 2.16, p = .03, 95% CI [0.01, 0.25]).

Trait hyperactivity was significantly negatively associated with negative beliefs about the future (a_1 = -0.16, t_{659} = -2.37, p = .02, 95% CI [-0.29, -0.03]), which, itself, was not significantly associated with biases in threat detection (b_1 = 0.06, t_{659} = 1.05, p = .29, 95% CI [-0.05, 0.17]). Sex was not significantly associated with negative beliefs about the future (β_1 = -0.07, t_{659} = -0.77, p = .44., 95% CI [-0.24, 0.11]), nor did it significantly moderate the direct effect of trait hyperactivity on negative beliefs about the future (w_1 = -0.02, t_{659} = -0.20, p = .84, 95% CI [-0.20, 0.17]). Additionally, sex did not

moderate the indirect effect of trait hyperactivity on biases in threat detection through negative beliefs about the future (w_{ab1} = -0.001, 95% CI [-0.02, 0.02]). Trait inattention was not significantly associated with negative beliefs about the future (Cov_{m1} = -0.09, t_{659} = -1.29, p = .17, 95% CI [-0.22, 0.04]).

Trait hyperactivity was significantly negatively associated with negative beliefs about the world (a_2 = -0.17, t_{659} = -2.59, p < .01, 95% CI [-0.31, -0.04]), which, itself, was not significantly associated with biases in threat detection (b_2 = -0.02, t_{659} = -0.29, p = .77, 95% CI [-0.12, 0.09]). Sex was not significantly associated with negative beliefs about the world (β_2 = -0.08, t_{659} = -0.86, p = .39, 95% CI [-0.24, 0.10]), nor did it significantly moderate the direct effect of trait hyperactivity on negative beliefs about the world (w_2 = 0.05, t_{659} = 0.53, p = .59, 95% CI [-0.13, 0.23]). Additionally, sex did not moderate the indirect effect of trait hyperactivity on biases in threat detection through negative beliefs about the world (w_{ab2} = -0.001, 95% CI [-0.02, 0.01]). Trait inattention was significantly negatively associated with negative beliefs about the world (Cov_{m2} = -0.18, t_{659} = -2.73, p < .01, 95% CI [-0.30, -0.05]).

Trait hyperactivity was significantly positively associated with affective dysregulation (a_3 = 0.31, t_{659} = 4.85, p < .001, 95% CI [0.18, 0.43]), which, itself, was not significantly associated with biases in threat detection (b_3 = -0.06, t_{659} = -1.21, p = .23, 95% CI [-0.15, 0.03]). Sex was not significantly associated with affective dysregulation (β_3 = -0.15, t_{659} = -1.79, p = .07, 95% CI [-0.31, 0.01]), nor did it significantly moderate the direct effect of trait hyperactivity on affective dysregulation (w_3 = -0.13, t_{659} = -1.49, p = .14, 95% CI [-0.30, 0.04]). Additionally, sex did not moderate the indirect effect of

trait hyperactivity on biases in threat detection through affective dysregulation (w_{ab3} = .01, 95% CI [-0.01, 0.03]). Trait inattention was significantly positively associated with affective dysregulation (Cov_{m3} = 0.30, t_{659} = 4.38, p < .001, 95% CI [0.18, 0.42]). See Figure 3.3 for a statistical diagram of this model.

Trait Inattention as Focal Predictor.

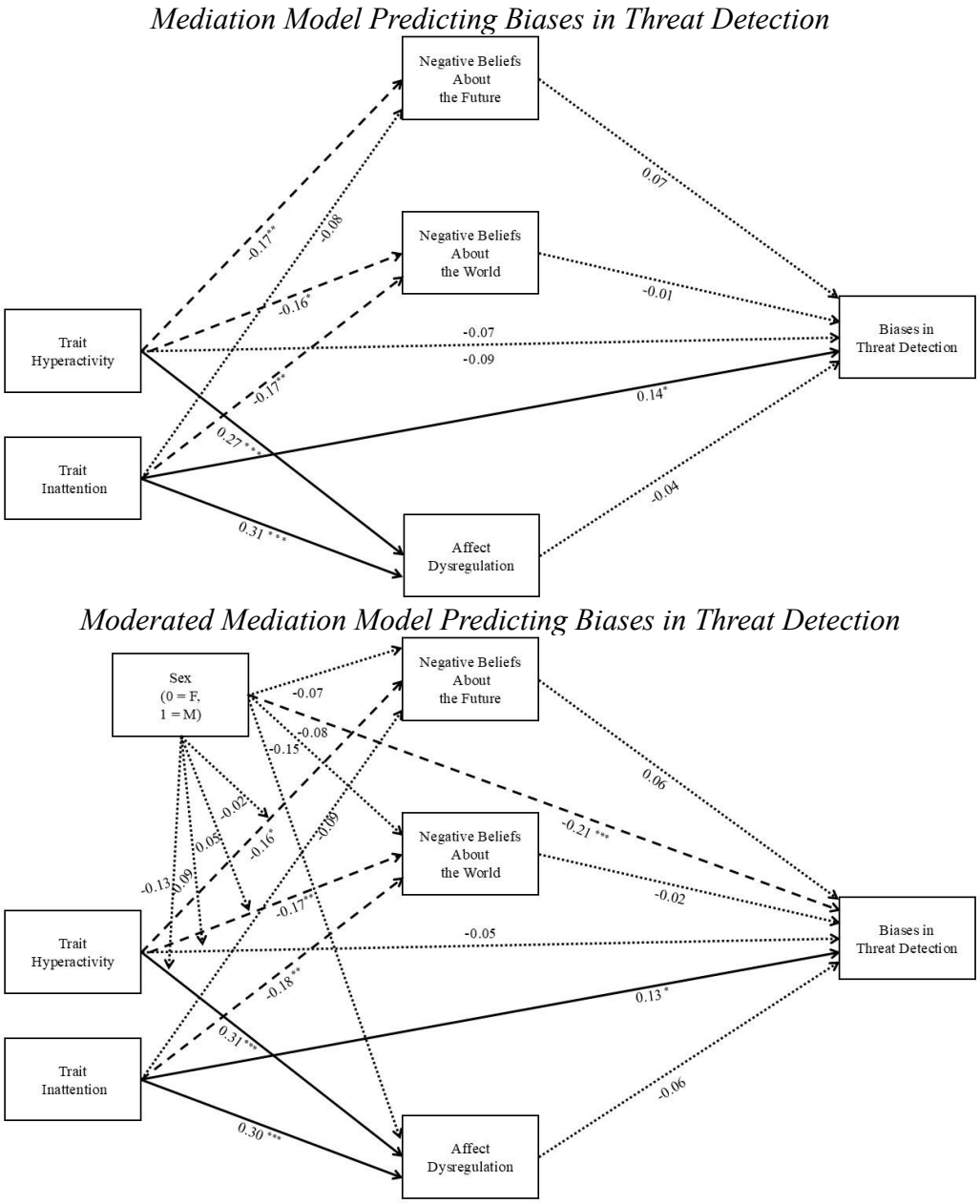
Mediation Analysis. An initial mediation analysis indicated that the total (c = 0.12, t_{659} = 2.12, p = .03, 95% CI [0.01, 0.24]) and direct (c' = 0.14, t_{659} = 2.33, p = .02, 95% CI [0.02, 0.26]) effects of trait inattention on biases in threat detection were significant. Trait hyperactivity was not significantly associated with biases in threat detection (Cov_y = -0.07, t_{659} = -1.26, p = .21, 95% CI [-0.19, 0.04]).

Trait inattention was not significantly associated with negative beliefs about the future (a_1 = -0.08, t_{659} = -1.23, p = .22, 95% CI [-0.21, 0.05]), which, itself, was not significantly associated with associated with biases in threat detection (b_1 = 0.07, t_{659} = 1.21, p = .23, 95% CI [-0.04, 0.18]). Additionally, the indirect effect of trait inattention on biases in anger detection through negative beliefs about the future was not significant (ab_1 = -0.01, 95% CI [-0.02, 0.01]). Trait hyperactivity was significantly negatively associated with negative beliefs about the future ($Covm_1$ = -0.17, t_{659} = -2.60, p < .01, 95% CI [-0.29, -0.04]).

Trait inattention was significantly negatively associated with negative beliefs about the world (a_2 = -0.17, t_{659} = -2.70, p < .01, 95% CI [-0.30, -0.05]), which, itself, was not significantly associated with associated with biases in threat detection (b_2 = -0.01, t_{659}

Figure 3.3

Statistical Models Predicting Biases in Threat Detection with Hyperactivity as Focal Predictor



Note. *p < .05. **p < .01. ***p < .001. Solid lines represent significant positive effects, dashed lines represent significant negative effects, dashed-dotted lines represent significant moderation effects, and dotted lines represent non-significant effects.

= -0.24, p = .81, 95% CI [-0.12, 0.10]). Additionally, the indirect effect of trait inattention on biases in anger detection through negative beliefs about the world was not significant (ab_2 = 0.002, 95% CI [-0.02, 0.02]). Trait hyperactivity was significantly negatively associated with negative beliefs about the world (Cov_{m2} = -0.16, t_{659} = -2.58, p = .01, 95% CI [-0.29, -0.04]).

Trait inattention was significantly positively associated with affective dysregulation (a_3 = 0.31, t_{659} = 5.09, p < .001, 95% CI [0.19, 0.43]), which, itself, was not significantly associated with associated with biases in threat detection (b_3 = -0.04, t_{659} = -0.87, p = .38, 95% CI [-0.13, 0.05]). Additionally, the indirect effect of trait inattention on biases in anger detection through affective dysregulation was not significant (ab_3 = -0.01, 95% CI [-0.05, 0.02]). Trait inattention was significantly positively associated with affective dysregulation (Cov_{m3} = 0.27, t_{659} = 4.56, p < .001, 95% CI [0.16, 0.39]). See Figure 3.4 for a statistical diagram of this model.

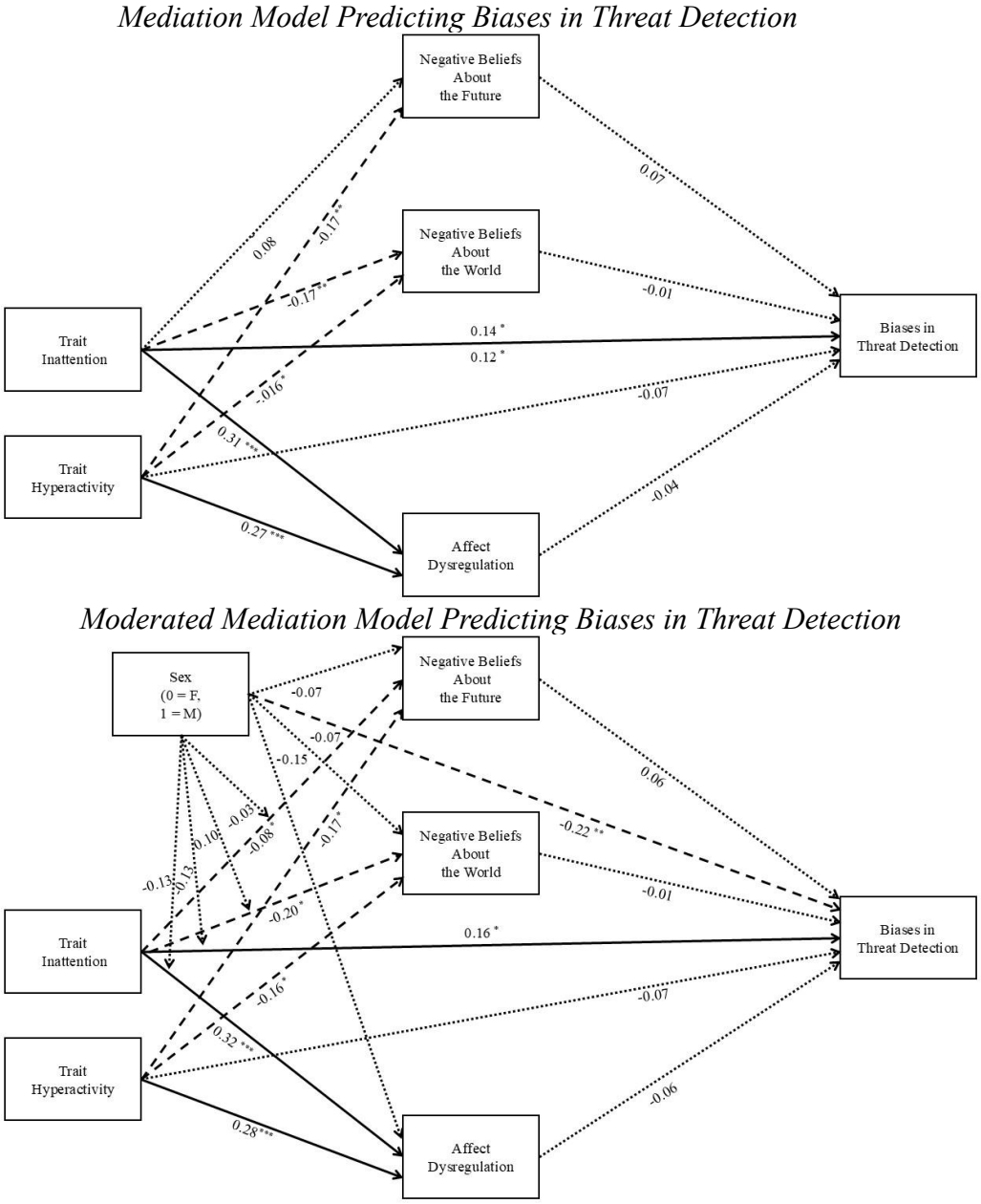
Moderated Mediation Analyses. Follow-up moderated mediation analyses indicated a significant positive direct effect of trait inattention on biases in threat detection (c' = 0.16, t_{659} = 2.53, p = .01, 95% CI [0.04, 0.28]). Sex was negatively associated with biases in threat detection (β_y = -0.22, t_{659} = -2.73, p < .01, 95% CI [-0.37, -0.06]), indicating that females are more likely than males to perceive displays of facial affect as threatening (i.e., angry). Sex did not significantly moderate the direct effect of trait hyperactivity on biases in threat detection (w_c = -0.13, t_{659} = -1.47, p = .14, 95% CI [-0.30, 0.04]). Trait hyperactivity was not significantly associated with biases in threat detection (Cov_y = -0.07, t_{659} = -1.15, p = .25, 95% CI [-0.18, 0.05]).

Trait inattention was significantly negatively associated with negative beliefs about the future (a_1 = -0.08, t_{659} = -1.14, p = .02, 95% CI [-0.21, 0.06]), which, itself, was not significantly associated with biases in threat detection (b_1 = 0.06, t_{659} = 0.99, p = .32, 95% CI [-0.06, 0.17]). Sex was not significantly associated with negative beliefs about the future (β_1 = -0.07, t_{659} = -0.79, p = .43., 95% CI [-0.24, 0.10]), nor did it significantly moderate the direct effect of trait inattention on negative beliefs about the future (w_1 = -0.03, t_{659} = -0.34, p = .73, 95% CI [-0.22, 0.16]). Additionally, sex did not moderate the indirect effect of trait inattention on biases in threat detection through negative beliefs about the future (w_{ab1} = -0.002, 95% CI [-0.03, 0.01]). Trait hyperactivity was significantly negatively associated with negative beliefs about the future (Cov_{m1} = -0.17, t_{659} = -2.57, p = .01, 95% CI [-0.29, -0.04]).

Trait inattention was significantly negatively associated with negative beliefs about the world (a_2 = -0.20, t_{659} = -2.96, p < .01, 95% CI [-0.33, -0.07]), which, itself, was not significantly associated with biases in threat detection (b_2 = -0.01, t_{659} = -0.22, p = .83, 95% CI [-0.12, 0.10]). Sex was not significantly associated with negative beliefs about the world (β_2 = -0.07, t_{659} = -0.79, p = .43, 95% CI [-0.24, 0.10]), nor did it significantly moderate the direct effect of trait inattention on negative beliefs about the world (w_2 = 0.10, t_{659} = 1.08, p = .28, 95% CI [-0.08, 0.29]). Additionally, sex did not moderate the indirect effect of trait inattention on biases in threat detection through negative beliefs about the world (w_{ab2} = -0.001, 95% CI [-0.02, 0.02]). Trait hyperactivity was significantly negatively associated with negative beliefs about the world (Cov_{m2} = -0.16, t_{659} = -2.56, p = .01, 95% CI [-0.29, -0.04]).

Figure 3.4

Statistical Models Predicting Biases in Threat Detection with Inattention as Focal Predictor



Note. *p < .05. **p < .01. ***p < .001. Solid lines represent significant positive effects, dashed lines represent significant negative effects, dashed-dotted lines represent significant moderation effects, and dotted lines represent non-significant effects.

Trait inattention was significantly positively associated with affective dysregulation (a_3 = 0.32, t_{659} = 5.14, p < .001, 95% CI [0.20, 0.45]), which, itself, was not significantly associated with biases in threat detection (b_3 = -0.06, t_{659} = -1.23, p = .22, 95% CI [-0.15, 0.03]). Sex was not significantly associated with affective dysregulation (β_3 = -0.15, t_{659} = -1.80, p = .07, 95% CI [-0.31, 0.01]), nor did it significantly moderate the direct effect of trait inattention on affective dysregulation (w_3 = -0.13, t_{659} = -1.46, p = .14, 95% CI [-0.30, 0.04]). Additionally, sex did not moderate the indirect effect of trait inattention on biases in threat detection through affective dysregulation (w_{ab3} = 0.01, 95% CI [-0.01, 0.03]). Trait hyperactivity was significantly positively associated with affective dysregulation (Cov_{m3} = 0.28, t_{659} = 4.61, p < .001, 95% CI [0.16, 0.39]). See Figure 3.4 for a statistical diagram of this model.

Discussion

In its original formulation, the hypervigilance hypothesis proposed that the diffuse attentional states of ancestral individuals with ADHD subserved hypervigilant scanning, of vital importance for detecting threats in unpredictable environments of Jensen and colleagues' (1997) EEA. This would seem to imply that individuals with ADHD should exhibit an enhanced self-protection system, which refers to a species-typical suite of cognitive mechanisms underlying threat-detection in humans (Coutinho et al., 2018). Furthermore, Coutinho and colleagues (2018) note that facial displays of threat-congruent affect (i.e., anger) serve as especially salient cues of the potential threats posed by conspecifics. Indeed, the importance of such cues is demonstrated in the anger superiority effect, which describes a common attentional bias that favors rapid detection of facial

displays of anger over those of other, non-threat-congruent affective states, such as happiness (Lobue, 2009; Hansen & Hansen, 1988). Thus, the hypervigilance hypothesis seems to predict a more pronounced anger superiority effect in individuals with ADHD relative to NT peers.

Contrary to this prediction, the clinical literature has not only identified that individuals with ADHD often exhibit poorer accuracy (e.g., Bisch et al., 2016) and increased response latency (Helfer et al., 2021) on affect recognition tasks when compared to NT peers, but that these impairments in accuracy are especially pronounced in the recognition of anger relative to other affective states (e.g., Ludlow et al., 2014; Williams et al., 2008). However, research by Passarotti and colleagues (2010) presents an alternative interpretation of the apparent anger recognition deficits of individuals with ADHD. Passarotti and colleagues found that attentional biases toward negatively valenced stimuli observed in individuals with ADHD are accompanied by concurrent hypoarousal in brain structures implicated in affect regulation. Thus, the anger recognition deficits observed in individuals with ADHD may reflect affective over-arousal in response to the negatively valenced nature of anger displays, and threat-congruent stimuli more generally. Indeed, this conclusion is further consistent with research by Posner and colleagues (2011) demonstrating that subliminal presentation of negatively valenced displays of facial affect (i.e., fear) induce elevated activity in fear-implicated structures amongst individuals with ADHD.

Taken together, these results suggest that individuals with ADHD demonstrate evidence of an elevated fear response, accompanied by affective dysregulation, in the

presence of negatively valenced stimuli. Although more consistent with an attentional prioritization of threat-congruent anger displays than with a diminished capacity to recognize them, these patterns of neural activity still present an empirical challenge for the hypervigilance hypothesis. It has long been observed that task performance is enhanced in states of moderate levels of arousal, but suffers in states of hypo- or hyperarousal (Yerkes & Dodson, 1908). Consequently, even if this excessive arousal reflects hypervigilant attentional prioritization of threat cues, it should do so at the cost of efficacy in responding to those cues.

Such an overarousal response is unsurprising given documented affect regulation deficits associated with ADHD (Christiansen et al., 2019), the severity of which positively covaries with ADHD symptom severity (Graziano et al., 2011). If such positive covariance extends continuously to the general population, it stands to reason that individuals high in the subclinical range of response-ready traits may exhibit moderate affective dysregulation and thus, moderate arousal in response to threat cues, consistent with optimal performance in responding to such threats. In recognition of this possibility, the present study tested the modified hypervigilance hypothesis, which proposed that individuals with elevated but subclinical levels of response-ready traits (i.e., inattention and affective dysregulation) may exhibit the hypervigilant threat detection faculties described by response-readiness theory.

Using the social cognitive profile of chronically abused children as a model, response-ready hypervigilance was proposed to manifest in two potential ways, proficiency (H_1) in threat detection (i.e., the ability to recognize threat cues on the basis

of less visual information than would be required by others; Pollak & Sinha, 2002) or biases (H_2) in threat detection (i.e., the tendency to perceive ambiguous cues as threatening; Pollak & Kistler, 2002). Here, to test the former conceptualization of hypervigilance, inattention was examined as a predictor of accuracy on an affect recognition task in which stimuli varied by affective state and level of visual ambiguity (i.e., pixelation). If inattention subserves proficiency in threat detection, individuals high in inattention should outperform their more attentive peers in the recognition of anger at higher, versus lower, levels of visual ambiguity. Statistically speaking, this would constitute a three-way interaction between inattention, affective state and pixelation level in predicting stimulus identification accuracy.

Contrary to this prediction, no such interaction was observed. Indeed, inattention emerged as a significant predictor of accuracy only at one level of visual ambiguity (i.e., at block size 45). Perhaps the most interesting finding of these analyses, however, is that participant accuracy was lowest for stimuli depicting anger displays across almost all levels of visual ambiguity tested. Although this represents an apparent contradiction of the anger superiority effect, these results must be interpreted with caution for two reasons. First, Gong and Smart (2021) observe that the anger superiority effect has traditionally been demonstrated in visual search tasks, in which participants must detect facial stimuli embedded within visual distractors. Conversely, affect categorization tasks, such as was used in present study, are actually more likely to produce a happiness, versus anger, superiority effect (i.e., greater efficiency in the detection of happiness displays, versus those of other affective states; e.g., Becker et al., 2011; Craig et al., 2014).

Secondly, Ceccarini and Caudek (2012) note that studies that have found evidence of an anger superiority effect have generally relied on schematic (i.e., animated or abstract) facial display stimuli. Indeed, Ceccarini and Caudek further found that, when using realistic facial stimuli, observation of an anger superiority effect relied on the use of dynamic, versus static, stimuli. Thus, the static presentation of realistic affective displays, such as in the present study, may not be an appropriate index of such an effect.

Consistent with the alternative conceptualization of hypervigilance in terms of biases toward threat detection, trait inattention was positively associated with overall anger ascription across all stimuli, suggesting that inattention predicted the tendency to ascribe anger to stimuli, regardless of actual stimulus characteristics (i.e., affective state displayed, level of visual ambiguity). More specifically, given the moderate affect regulation deficits expected of individuals in the higher end of the subclinical range of response ready traits, it was predicted that the effects of trait inattention on biases in threat detection would, at least in part, be mediated by affect dysregulation (H_3). Contrary to this prediction, affect dysregulation was positively associated with both inattention and hyperactivity, but not with biases in threat detection as measured by total anger ascriptions across stimuli.

It was also predicted that depressive attitudes, namely negative beliefs about the future (H_4) and the world (H_5), would mediate associations between ADHD traits and biases in threat detection. Contrary to this prediction, depressive attitudes were not associated with biases in threat detection at all. Even more curious are the negative associations between ADHD traits and depressive attitudes, with trait hyperactivity being

negatively associated with negative beliefs about the future and world, and trait inattention being negatively associated with negative beliefs about the world alone. This is surprising given that individuals with ADHD are characterized by elevated depression risk (e.g., Biederman et al., 1998; Kessler et al., 2006; Tung et al., 2016) and greater endorsement of depressive attitudes (Knouse et al., 2013; Mitchell et al., 2013). It may be that ADHD traits constitute a risk for depression only at clinically-significant levels. This possibility finds support from research on the adverse effects of stigmatization on individuals with ADHD. ADHD symptom severity is not only positively associated with perceived stigmatization amongst individuals with ADHD (Musuch et al., 2019), but also higher levels of actual stigmatization in the form of negative appraisals by others (Meza et al., 2019). Notably, Kellsion and colleagues found that perceived stigmatization predicts depression risk among individuals with ADHD. Thus, it may be that the stigmatization associated with clinically significant expression of ADHD traits may better explain the depressive symptoms of such individuals than does an inherent tendency toward a negative worldview.

Limitations

As with Study One, sample characteristics represent a potential limitation of the present study. The sample was over 75% female, which may be problematic in light of male-biased sex differences in the prevalence of ADHD (e.g., Li et al., 2019). Furthermore, the present operationalization of threat detection as a function of anger recognition presents at least two primarily limitations. First, as discussed above, the affect recognition task used in this study bares a number of characteristics (e.g., the static

presentation of realistic facial stimuli; Ceccarini & Caudek, 2012) that are suboptimal in capturing the anger superiority effect. Thus, the present task may not have adequately measured individual differences in social threat detection. Additionally, Posner and colleagues (2011) induced apparent fear reactions in individuals with ADHD using the subliminal presentation of fear displays. Consequently, omission of fear in the present range of emotions presented (i.e., angry, disgusted, happy, and neutral) appears a missed opportunity not only to examine response-ready reactions to a wider breadth of threat cues, but also to better integrate the present study within the existing literature.

It is also possible that an affect recognition task more generally was not the optimal measure of threat detection as conceptualized by Jensen and colleagues (1997). Although certainly relevant in light of the contradictory evidence concerning social cognition in individuals with ADHD, future research may benefit from the adoption of more traditional measures of threat detection, perhaps those that utilize measures of reaction time (e.g., the dot-probe task; e.g., Frewen et al., 2008). Indeed, this approach would both further the present understanding of the threat detection capacities of response-ready individuals, as well as provide a chance to test Jensen and colleagues' (1997) claim that impulsivity subserves expedient reactions to detected threats.

Conclusions

Of the hypotheses generated by response-readiness theory, the hypervigilance hypothesis is perhaps the most difficult to interpret as it pertains to the existing literature. Most notably, much uncertainty pervades current understandings of the social cognitive profile of individuals with ADHD. Whereas some research appears to suggest that

individuals with ADHD are relatively insensitive to the social threat cues demonstrated by their peers (e.g., Pelc et al., 2009), other veins of research appear to indicate that these individuals exhibit a heightened fear response (e.g., Posner et al., 2011) to threat-congruent stimuli, as well as affective dysregulation (Passerotti et al., 2010) in response to negatively-valenced stimuli more generally. Indeed, even if one favors the latter interpretation, it remains to be seen whether such dramatic arousal constitutes an asset or a hindrance in threat detection and response contexts - although the latter appears more likely in light of documented associations between arousal and task performance (Yerkes & Dodson, 1908). Nonetheless, as a novel test of the potential utility of ADHD traits in threat detection contexts, this study represents an important first step in better understanding the evolutionary substrates that selected for such traits. Of most interest to response-readiness theory, the present study provided support for the perhaps counterintuitive claim that inattention may have had adaptive utility in facilitating enhanced threat detection. Future research on the potential utility of often pathologized traits, such as inattention, may prove illuminating to the literature concerning both the evolution of individual differences in such traits, as well as the evolution of individual differences more generally.

Chapter Four: The Exploratory Hyperactivity Hypothesis

Introduction

The exploratory hyperactivity hypothesis maintains that trait hyperactivity subserved exploratory behavior (i.e., behavior that functions to gather information in novel conditions; American Psychological Association, n.d.), arming ancestral individuals with ADHD with knowledge vital in coping with the demands of unfamiliar and unpredictable environments (Jensen et al., 1997). Thus, this hypothesis predicts that individuals with ADHD should display higher levels of exploratory behavior than NT individuals.

Organisms must regularly choose between exploration (i.e., seeking novel opportunities) and exploitation (i.e., utilizing previously identified opportunities; Cohen et al., 2007). Consider foraging; when searching for food, an organism must decide whether to seek new foraging sites of unknown quality, or to exploit familiar sites for which quality is known. The optimal choice between these strategies is heavily dependent on a number of environmental determinants (Kacelnik et al., 1981). For instance, exploratory foraging strategies are particularly adaptive in environments with high levels of competition over common resources, allowing an organism to sample new foraging sites while simultaneously monitoring for territorial incursions by rivals. Conversely, it has been proposed that unpredictable environments should favor exploitation over exploration (e.g., Frankenhuis & Gopnik, 2023). Given that unpredictability has been identified as a characteristic of environments that favor fast strategy traits (e.g., Del Giudice et al., 2015), this presents a possible point of divergence between response-

readiness theory and LHT. Particularly, Frankenhuis and Gopnik (2023) argue that the present-oriented cognitive style associated with fast strategies (i.e., discounting of future consequences) should favor exploitation because the benefits of exploration may not be immediately realized. Indeed, research by Xu and colleagues (2023) found that exploratory preferences were negatively associated with perceived unpredictability of childhood environment. Thus, whereas response-readiness theory predicts preferences for exploration over exploitation in individuals with ADHD, its conceptualization as a fast spectrum disorder appears to predict the opposite. Despite this, a longitudinal study of Chinese adolescents by Shen and colleagues (2024) measured self-reports of stress related to uncertainty in several areas of participants' current lives, as well as exploratory risk-taking behavior and found that, although uncertainty-related stress was negatively associated with immediate exploratory tendencies, it may be associated with greater future preferences for exploratory risk taking. Initially, this presents the possibility that adolescent exposure to unpredictability may predict eventual adult exploratory behavior. Although this may seem to reconcile the divergent predictions of response-readiness theory and LHT, Shen and colleagues recorded data across only a 6-month period, prompting caution in generalizing these effects to longer time scales.

Gliga and colleagues (2018) studied visual foraging behavior in infants and young children at risk for ADHD and autism spectrum disorder (hereafter ASD), a neurodevelopmental disorder characterized by deficits in social cognition, restricted interests and repetitive behaviors (American Psychiatric Association [APA], 2013). Based on prior research indicating associations between ADHD symptomology and trait

novelty-seeking (e.g., Salgado et al., 2008), as well as between ASD and exploitative foraging strategies (e.g., Pellicano et al., 2011), Gliga and colleagues predicted that ADHD and ASD risk would be associated with opposing preferences for exploratory and exploitative foraging strategies respectively. Operationalizing ADHD risk based on prescribed clinical cutoffs on an ADHD screening tool, and ASD risk as prior ASD diagnosis in an older sibling, participants were divided into three groups: children at risk for both ADHD and ASD (hereafter "ASD+"), children at risk for ASD alone (hereafter "ASD-"), and children at risk for neither (hereafter, low risk or "LR"). A visual foraging task, measuring visual exploration of a series of images via eye-tracking software indicated that, although participants in the ASD- groups engaged in significantly less visual exploration than those in the LR group, ASD+ participants did not significantly differ from either other group. That is, the exploratory preferences associated with ADHD risk appear to have attenuated the exploitative tendencies associated with ASD risk in the ASD+ group, producing an intermediate level of exploratory behavior. Associations between ADHD risk and visual exploratory behavior are not only consistent with the increased exploratory behavior predicted by the exploratory hyperactivity hypothesis, but also with the visual scanning behaviors predicted by the hypervigilance hypothesis.

However, exploration versus exploitation is a broad distinction, and exploration itself represents a number of related strategies, which can be novelty-based (i.e., a preference for exploring novel, versus familiar, stimuli and environments), or value-free (i.e., random exploration, without consideration for existing information, novelty, or familiarity; Dubois et al., 2022). Consider an organism foraging for fruit; adoption of a

novelty-based exploratory strategy allows for integration relevant knowledge, sampling novel sites similar to those in which fruit has been previously found, such as those dense with trees. Conversely, adoption of value-free exploration does not consider prior knowledge, possibly resulting in exploration of sites that novelty-based strategies would preclude, such as tree-barren beaches or caves. In this way, novelty-based exploration represents a more strategic exploration heuristic than value-free exploration.

Dubois and colleagues (2022) utilized the "Maggie's Farm task" to examine exploratory strategy preferences in adolescents with and without clinically significant ADHD symptomology. This decision-making task requires participants to forage from a selection of trees, with the goal of maximizing payoff (i.e., cumulative mass of apples collected). Each trial presents an assortment of three trees, varying in yield (operationalized as mean size of apples previously sampled per tree) and amount of available information (operationalized as the number of samples provided per tree). In all, four varieties of trees were present: the standard tree (Standard yield with a single prior sample), certain-standard tree (Standard yield with three prior samples), the low-value tree (Sub-standard yield, with a single prior sample) and the novel tree (Standard yield with no prior sample). With its evident sub-standard yield, selection of the low-value tree represents a failure to integrate existing information in foraging decisions, in line with value-free exploration. Conversely, selection of the novel tree, for which there was no information, represents a preference for novelty-based exploration. Participants completed an ADHD screening tool, and were divided into high and low ADHD trait groups on the basis of prescribed clinical cutoffs. The high ADHD trait group displayed a

significant preference for value-free exploration relative to low ADHD participants. Selection of this less strategic heuristic raises questions regarding whether ADHD exploratory behavior effectively aids in information gathering.

Real-life environments are complex and dynamic, with optimal foraging strategies in such environments varying with environmental change (Cohen et al., 2007). Conversely, hypothetical static environments ensure the indefinite validity of gathered information, resulting in the emergence of an objective, optimal solution. In such environments, the optimal strategy involves early exploration, which then informs later exploitation (Gittins & Jones, 1979). That is, in a static environment, the best strategy utilizes exploration to identify the highest yield site, followed by exploitation of that site. In light of this, Dubois and colleagues (2022) also varied task horizon (i.e., the number of apples participants were allowed to pick per trial), between short-horizon (i.e., participants were allowed to pick one apple) and long-horizon (i.e., participants were allowed to pick six apples). Over short horizons, exploration is not useful, because information gained cannot be applied to later decisions. Thus, over short horizons the optimal choice is to forage from the site with the highest known yield whereas over long horizons, information gained from exploration on the first choice can be used to maximize yield on the remaining five choices.

The high ADHD trait group employed exploration strategies strategically, using them more often in the long-horizon, versus short-horizon, trials. However, subsequent perseveration on this strategy led to poorer long-term performance compared to the low ADHD trait group. That is, although the high ADHD trait group effectively applied

exploratory strategies when these would be optimal (i.e., early in the trial where they could inform future choices), they often failed to shift to exploitation, rendering the information useless. Although the general preference for exploration is consistent with the exploratory hyperactivity hypothesis, the specific preference for value-free random exploration and failure to switch to exploitation when appropriate suggests difficulty integrating existing knowledge into foraging decisions. The failure of individuals with ADHD to meaningfully integrate information gained through exploration casts doubt as to the utility of ADHD exploratory tendencies in foraging contexts, presenting a serious challenge to the exploratory hyperactivity hypothesis.

The exploratory hyperactivity hypothesis further argues that the adaptive value of exploratory behavior lies in gathering information about unfamiliar environments. If hyperactivity subserves information seeking in individuals with ADHD, such individuals should display greater motivation to gather information than their NT peers. An important motivator of informational exploration is intolerance of uncertainty, which refers to cognitive, affective and behavioral responses to, and stemming from discomfort with, uncertainty (Bartoszek et al., 2022; Freeston et al., 1994). Consistent with the exploratory hyperactivity hypothesis, Gramszlo and colleagues (2018) found that individuals with ADHD reported greater intolerance of uncertainty than NT controls. Because the exploratory hyperactivity hypothesis specifies that these information-seeking tendencies were especially important in the exploration of novel environments, performance on information-seeking tasks should improve in the presence of uncertainty.

Research by Lin (2023) calls this assumption into question. Participants with and without ADHD completed a pair of visual search tasks, requiring participants to visually locate a target embedded in a field of competing distractors. In the spatial certainty condition, figures were organized in equidistant, structured rows, whereas in the spatial uncertainty condition, figures were arranged randomly throughout the field. Lin indexed performance using a number of metrics, including Q scores, which considered both accuracy and task completion time. Although the Q scores of individuals with ADHD indicated poorer performance in the spatial certainty condition compared to NT controls, these deficits were substantially more pronounced in the spatial uncertainty condition. Thus, the IU tendencies of individuals with ADHD may actually impair their ability to gather information. These results contradict the claim that hyperactivity served information seeking in novel (i.e., uncertain) environments, challenging the exploratory hyperactivity hypothesis. Further, research has found associations between intolerance of uncertainty and a variety of psychopathologies, including anxiety, ASD, mood disorders, and obsessive-compulsive disorder (Keefer et al., 2024; Mahoney & McEvoy, 2012; Pinciotti et al., 2021). This violation of the specificity principle raises further theoretical concerns regarding the validity of the exploratory hyperactivity hypothesis.

The Modified Exploratory Hyperactivity Hypothesis

The exploratory hyperactivity hypothesis argues the hyperactive traits of ancestral individuals with ADHD motivated investigative exploratory behavior of unfamiliar and unpredictable environments. Thus, it is predicted that modern individuals with ADHD will exhibit greater exploratory information-seeking tendencies than their NT peers. This

claim has received mixed support in light of extant research on the exploratory preferences and behavior of individuals with ADHD. On the one hand, research indicates a general distaste for uncertainty (e.g., Gramszlo et al., 2018) and preferences for exploratory, versus exploitative, foraging strategies (Dubois et al., 2022) amongst those with clinically significant ADHD symptomology. On the other hand, research also indicates that individuals with clinically significant ADHD not only underperform relative to NT peers on measures of visual foraging, but show especially impaired performance under conditions of uncertainty (e.g., Lin et al., 2023). Furthermore, individuals with ADHD often perseverate on exploratory strategies (e.g., Dubois et al., 2022), consequently failing to meaningfully apply the fruits of their exploratory labors to future foraging endeavors.

However, Dubois and colleagues (2022) also report a relationship between ADHD traits and exploratory preferences more generally. Assuming this effect generalizes to subclinical expression of these traits, individuals with elevated (i.e., above average) but subclinical levels of ADHD traits should exhibit exploratory preferences intermediate between non-hyperactive peers and clinically significant counterparts. This prospect becomes more promising still in light of research by Schippers and colleagues (2024) that found elevated levels of ADHD traits were associated with greater cognitive flexibility in the general population. Consequently, individuals with elevated but subclinical levels of ADHD traits should exhibit tempered exploratory preferences, complemented by the cognitive flexibility to pivot toward exploitative strategies when appropriate. As such, the

modified exploratory hyperactivity hypothesis predicts that trait hyperactivity will be associated with exploratory behavior in nonclinical samples.

Thus, it is predicted that ASRS hyperactivity scores will be associated with greater information-seeking tendencies, as measured by the bead task (Phillips & Edwards, 1966), described below. Furthermore, as an important motivator of information seeking, intolerance of uncertainty, as measured by the discomfort with ambiguity subscale of the Multidimensional Attitude Towards Ambiguity Scale (MAAS; Lauriola et al., 2016), is expected to mediate the relationship between hyperactivity and domain general information-seeking tendencies.

However, LHT conceptualizes adaptations as tradeoffs (Del Giudice et al., 2015). Accordingly, as an extension of LHT, modified response-readiness theory predicts divergent associations between hyperactivity and information seeking across different domains of fitness. Jensen and colleagues (1997) maintain that informational exploration was vital in informing ancestral foraging strategies in the EEA. Consequently, hyperactivity should be positively associated with information seeking in the resource acquisition domain, as measured by the financial subscale of the Domain Specific Information Seeking Scale (DSIS; Vonk et al., 2021). As with the domain-general hypothesis above, it is predicted that intolerance of uncertainty, as an important motivator of information-seeking behavior, will mediate the relationship between hyperactivity and information seeking in the resource acquisition domain. Response-readiness theory, as originally formulated, does not explicitly make predictions concerning information-seeking behavior in other fitness domains. However, Del Giudice (2014) describes the

discounting of future consequences and sexual promiscuity as patently fast strategy traits. Thus, in the interest of integrating response-readiness theory within a larger LHT framework, the modified exploratory hyperactivity hypothesis suggests that hyperactivity predicts less diligent information seeking in the domains of health and mating, as measured by the health and mating, dating, and childcare DSIS subscales respectively. Finally, given the proposed negative associations between hyperactivity and information seeking in these domains, intolerance of uncertainty is not predicted to mediate these relationships. Thus, the present study will test the following hypotheses:

H_1: Trait hyperactivity will be positively associated with domain-general information seeking tendencies

H_2: Intolerance of uncertainty will mediate predicted associations between trait hyperactivity and domain-general information seeking tendencies.

H_3: Trait hyperactivity will be positively associated with information-seeking in the LHT-relevant domains of reproduction, resource acquisition, and health.

H_4: Intolerance of uncertainty will mediate predicted associations between trait hyperactivity and information seeking in LHT-relevant domains.

Method

Participants

Exclusion Criteria. From an initial sample of 825, data from 198 participants (24% of total sample) were excluded for the following reasons: 154 (18.7% of total sample) for having failed more than one of the three attention check items and otherwise

careless or incomplete responding, 7 participants (0.8% of total sample) as univariate outliers and 7 participants (0.8% of total sample) for being of insufficient age (i.e., under 18 years). Finally, because of documented sex differences in ADHD traits (e.g., Fedele et al., 2012), sex was entered as a dichotomous predictor (1 = male; 0 = female) in study models. Thus, data from 30 participants (3.6% of the total sample) who did not explicitly identify as cisgender male or cisgender female (i.e., those who identified as transgender, non-binary, or did not indicate gender identity) were excluded from analyses.

Final Sample. The post-exclusion sample consisted of 627 American college students, 18 years or older, enrolled in introductory psychology courses and recruited through Oakland University's SONA recruitment tool. Of this post-exclusion sample, 500 participants (79.7%) were female and 127 (20.3%) were male, with an average age of 19.8 years (*SD* = 3.41). The racial composition of the sample was 69.1% White (*n* = 433), 8.8% Black (*n* = 55), 6.1% Asian (*n* = 38), 5.6% Hispanic (*n* = 35), 0.2% indigenous or Native American *(n* = 1), 5.1% other or not indicated (*n* = 32) and 5.3% (*n* = 33) identifying with more than one racial group. 88 participants (14% of final sample) indicated prior diagnosis of one or more attention-related neurodevelopmental disorder (i.e., attention-deficit disorder or attention-deficit/hyperactivity disorder).

Measures

Demographic Information. Participants provided information regarding their age, racial and gender identities, and previous history of mental health diagnoses for several common psychopathologies, including attention-deficit disorder and attention-deficit/hyperactivity disorder.

Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005). The ASRS (α = .88) is an 18-item self-report measure of Attention-Deficit/Hyperactivity Disorder symptomology. This measure contains two subscales measuring inattention (9 items; sample item: "How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?"; α = .83) and hyperactivity/impulsivity (9 items; sample item: "How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?," α = .80). Participants responded on a 5-point Likert scale (1 = "Never,"; 5 = "Very often,") indicating how often each item has described them in the past 6 months. Notably, Kessler and colleagues (2005) indicate that this measure has adequate concurrent validity with the outcomes of blind clinical interviews assessing ADHD symptomology. Although this measure was designed as a clinical screening tool, it will be used solely to measure individual differences in ADHD traits for the purposes of this study. This measure can be found in Appendix D.

Multidimensional Attitude Towards Ambiguity Scale (MAAS; Lauriola et al., 2016). The MAAS (α = .80) is a 21-item self-report measure of ambiguity tolerance. This measure includes three subscales measuring discomfort with ambiguity (7 items; sample item: "I get pretty anxious when I'm in a social situation involving me which I have little control of," α = .78), moral absolutism (7 items; sample item: "You can classify almost all people as either honest or crooked," α = .82) and need for complexity and novelty (7 items; sample item: "I enjoy tackling problems which are complex enough to be ambiguous," α = .80). Participants responded on a 7-point Likert scale (7 items; 1 = "I strongly disagree;" 5 = "I strongly agree,") indicating their level of agreement with each

item. The discomfort with ambiguity subscale will be used to measure intolerance of uncertainty. This measure can be found in Appendix K.

Domain-Specific Information Seeking Scale (DSISS; Vonk et al., 2021). The DSISS (α = .82) is a 60-item self-report measure of information gathering attitudes. This measure includes five subscales, measuring information gathering in the domains of philosophical beliefs and traditions (12 items, 7 reverse-scored, sample item: "I need to seek real-world evidence to be certain that my religious beliefs are true," sample reverse-scored item: "My religious faith is all I need to confirm that God is real," α = .61), mating, dating and child care (12 items, 5 reverse-scored; Sample item: "If my sexual partner suddenly lost interest in sex, I immediately assume they are seeing someone else," sample reverse-scored item: "I am not interested in seeking other people's instruction on how I should raise my children," α = .53), relationships with friends, family and strangers (12 items, 5 reverse-scored, Sample item: "If my best friend told me that an acquaintance of mine was a liar, I would investigate the claim on my own," sample reverse-scored item: "If I'm told by a good friend not to befriend someone because others don't like that person, I immediately take their advice," α = .48), finance and business (12 items, 6 reverse-scored; sample item: "I seek other financial opportunities, even if my current enterprise is successful," sample reverse-scored item: "If I read an article on the internet foreshadowing a serious drop in value for stock shares that I currently own, I would sell my shares right away," α = .36) and health and exercise (12 items, 5 reverse-scored, sample item: "If my doctor recommends a prescription, I would research more about the drug from other sources before taking it," sample reverse-

scored item: “I do not see my doctor for my annual physical if I feel healthy,” α = .53). Participants responded on a 5-point Likert scale (1 = “Highly disagree;” 5 = “Highly agree”) indicating their level of agreement with each item.). This measure can be found in Appendix L.

Central to Life History Theory is the idea that organisms must balance investment in present versus future reproduction, resulting in individual behavioral differences related to domains that serve later reproductive effort (Del Giudice et al., 2015). This also includes domains that indirectly serve later reproductive effort, such as resource acquisition and somatic maintenance. In light of these less direct investments in reproductive success, this study will use the DSIS to measure not only information seeking in domains directly related to reproductive effort (i.e., the mating, dating and childcare subscale), but also those less directly related to reproductive effort, concerning issues such as somatic maintenance (i.e., the health subscale) and resource acquisition (i.e., the financial subscale). Because each of these subscales individually demonstrated unacceptably low reliability in this sample (i.e., α < .70; Tavakol & Dennick, 2011), a composite subscale (α = .73) measuring information seeking across all three domains was compiled, with higher scores reflecting greater tendencies to gather information before making decisions related to reproduction, health and resource acquisition. The utility of seeking information largely lies in its application to solve later problems. Consequently, this future-oriented approach to decision-making is consistent with prioritization of future, over present, reproductive effort, and thus adoption of a slow life history strategy. This construct will hereafter be referred to as slow strategy information seeking.

Bead Task. The bead task refers to a behavioral measure of decision making under uncertainty, developed by Phillips and Edwards (1966). Participants are informed of two jars of beads: Jar A (75% black beads, 25% white beads) and Jar B (25% black beads, 75% white beads). Participants are then presented with beads incrementally; for each bead presented, the participant has the opportunity to register a guess as to which jar is being pulled from or to ask for more information. Thus, the number of times a participant asks for more information (i.e., asks to see more beads) before selecting response a or b is indicative of their tendency to gather information, with those responding with relatively little information being low in information-seeking tendencies, and those responding after more information being high on information-seeking tendencies.

This task was adapted for online use via a multiple-choice question format. For each trial, participants were shown the sequence of previously pulled beads, consisting of 60 beads (45 black, 15 white) and randomized using an online list randomizer (Randomizer.org/lists/). Participants were then presented with a question asking which jar the beads were pulled from. Participants then responded by selecting one of three possible responses: a) "Jar A (75% Black, 25% White)," "Jar B (25% Black, 75% White)," or "I would like more information (Show another bead)"). If the participant selected a jar, the task ended. If a participant requested more information, the next trial was presented, up until the 60th trial, where the participant was then forced to choose a jar. Trial order was constant across participants such that the stimulus presented for a given trial was identical for every participant who reached that trial. See Figure 4.1 for an

Figure 4.1

Example Item from the Bead Task – 7th and 8th trials

example of the task format. The full set of stimuli used in this task can be found in Appendix M

The total number of requests a participant made for more beads is indicative of a general tendency to seek out information before making a decision. Whether a participant chose to request an additional bead before registering a guess as to jar from which the beads were being pulled was used to index domain-general information-seeking tendencies and was coded dichotomously (1 = made at least one request for information before guessing, characterizing 289 participants, 42.9% of the final sample; 0 = guessed without asking for additional information, characterizing 358 participants, 57.1% of the final sample).

Results

Intercorrelation of Study Variables

See Table 4.1 for descriptive statistics and zero order correlations of study variables.

Moderated Mediation Analyses

A series of mediation analyses using Model 4 (i.e., simple mediation) of the PROCESS macro version 4.2 (Hayes, 2018) for SPSS were employed to test whether intolerance of uncertainty mediated predicted associations between ADHD traits and slow-strategy information-seeking, as well as domain-general information seeking. Each of these models were run twice, once with each trait hyperactivity and trait inattention as focal predictor, while controlling for the effects of the other as a covariate. Follow-up

Table 4.1

Descriptive Statistics and Zero Order Correlations for Study Variables

	1	2	3	4	5	6
1. Sex (M = 1, F = 0)	-					
2. Trait Hyperactivity	-.05	-				
3. Trait Inattention	-.02	.67***	-			
4. Intolerance of Uncertainty	-.14***	.28***	.34***	-		
5. Domain-General Information Seeking	.06	.04	.10*	.21***	-	
6. Slow Strategy Information Seeking	-.02	.05	.06	.36***	.22***	-
M	0.20	2.91	3.02	4.59	0.43	3.34
SD	0.40	0.69	0.67	0.96	0.50	0.30

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

analyses using Model 8 (mediation with moderation on the *a* and *c'* paths) of the PROCESS macro for SPSS were used, specifying sex as moderator to probe for potential sex differences. See Figure 4.2 for conceptual diagrams of study models.

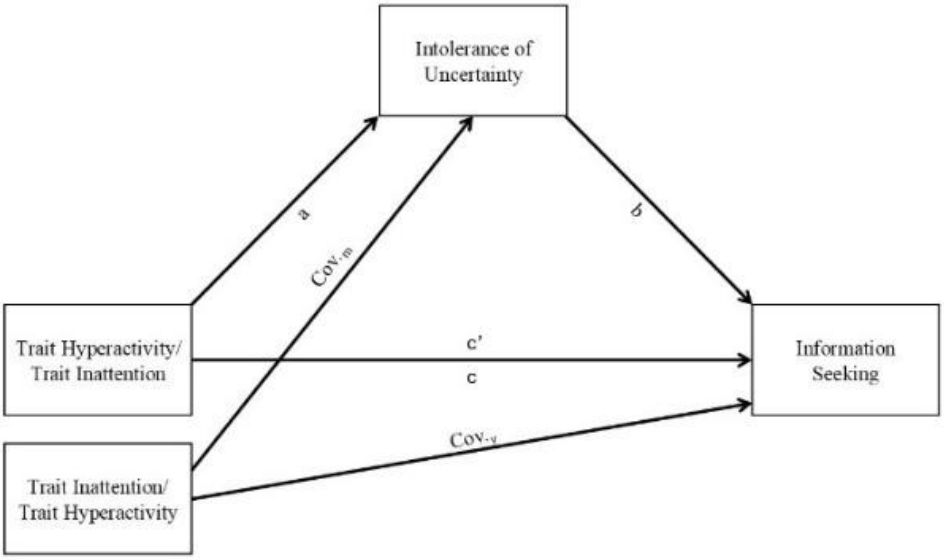
With the exception of sex, all study variables were zero-centered prior to inclusion in the models. In line with recommendations by Hayes (2018), the seed command was used to ensure consistent sampling between models. Note that the intent of these analyses was not a test of causal inference (the typical use case for mediation analyses; see MacKinnon et al., 2007), but rather examination of direct and indirect associations between study variables to assess the hypothesized relations among variables. It is acknowledged that other possible causal patterns are possible. Thus, it must be stressed that no causal claims are being made, explicit or otherwise.

Predictors of Domain-General Information Seeking, Diagnostic tests confirmed that most of the assumptions of linear regression were met. A Durbin-Watson value of 2.04 and variance inflation factors ranging from 1.02 to 1.89 indicated independence of observations and absence of multicollinearity among predictors. Visual inspection of a scatterplot plotting studentized residuals against unstandardized predicted values indicated that assumptions of linearity and homoscedasticity were met. However, visual inspection of a histogram of standardized residuals indicated a bimodal distribution. Notably, linear regression analyses are reasonably robust to violations of normality assumptions (Ernst & Albers, 2017). Thus, analyses proceeded with the untransformed data.

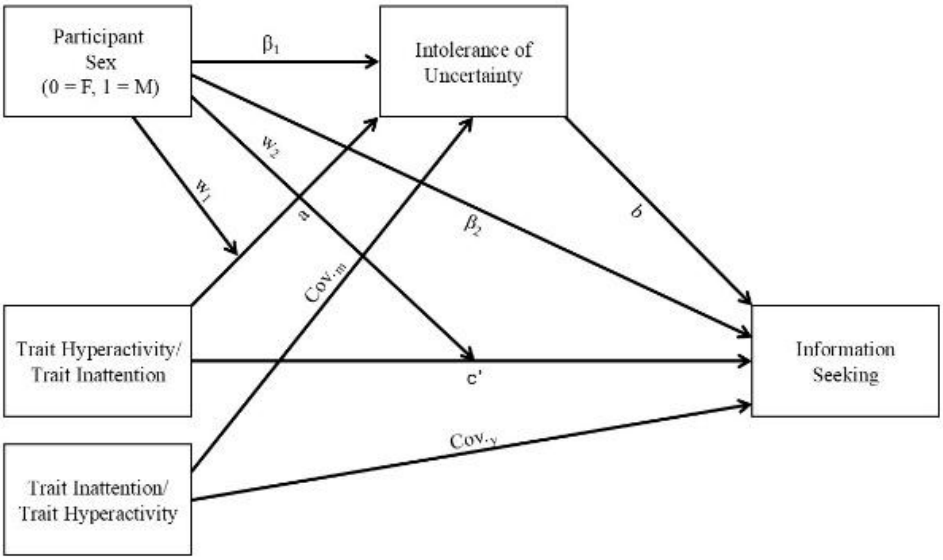
Figure 4.2

Conceptual Diagrams of Study 3 Models

Mediation Model Predicting Information Seeking



Moderated Mediation Model Predicting Information Seeking



Note. Eight models were run in two sets of 4. Each set included two mediation models predicting slow strategy information seeking and domain-general information seeking respectively, and two moderated mediation models which replicated the initial two models while including sex as a moderator on the *a*, *c'* and *ab* paths. In the first set of four models, hyperactivity served as predictor and inattention as a covariate, whereas the roles of these variables were reversed in the subsequent four models.

Trait Hyperactivity as Focal Predictor. Mediation analysis indicated that trait hyperactivity was not significantly associated with intolerance of uncertainty $a = 0.09$, $t_{626} = 1.87$, $p = .06$, 95% CI [-0.005, 0.19]), although intolerance of uncertainty was significantly positively associated with domain-general information seeking ($b = 0.43$, $t_{626} = 4.60$, p < .001, 95% CI [0.25, 0.62]). However, the direct ($c' = -0.15$, $z_{626} = -1.28$, $p = .20$, 95% CI [-0.37, 0.08]) effect of trait hyperactivity on domain-general information seeking was not significant, nor was the indirect effect of trait hyperactivity on domain-general information seeking through intolerance of uncertainty ($ab = 0.04$, 95%CI [-0.01, 0.08]). Trait inattention was significantly positively associated with intolerance of uncertainty ($Cov_m = 0.28$, $z_{626} = 5.61$, $p < .001$, 95% CI [0.18, 0.38]), but not domain-general information seeking ($Cov_y = 0.17$, $z_{626} = 1.44$, $p = .15$, 95% CI [-0.01, 0.10]).

A follow-up moderated mediation analysis indicated that trait hyperactivity was not significantly associated with intolerance of uncertainty ($a = 0.09$, $t_{626} = 1.70$, $p = .09$, 95% CI [-0.01, 0.19]), although intolerance of uncertainty was significantly positively associated with domain-general information seeking ($b = 0.46$, $t_{626} = 4.87$, $p < .001$, 95% CI [0.28, 0.65]). The direct effect of trait hyperactivity on domain-general information seeking was not significant ($c' = -0.18$, $z_{626} = -1.50$, $p = .13$, 95% CI [-0.42, 0.06]). Trait inattention was significantly positively associated with intolerance of uncertainty ($Cov_m = 0.29$, $z_{626} = 5.74$, $p < .001$, 95% CI [0.19, 0.38]) but not domain-general information seeking ($Cov_y = 0.15$, $z_{626} = 1.31$, $p = .19$, 95% CI [-0.08, 0.38]).

Sex was negatively associated with intolerance of uncertainty, ($\beta_1 = -0.31$, $t_{626} = -3.45$, $p < .001$, 95% CI [-0.49, -0.13]) indicating that females exhibited greater

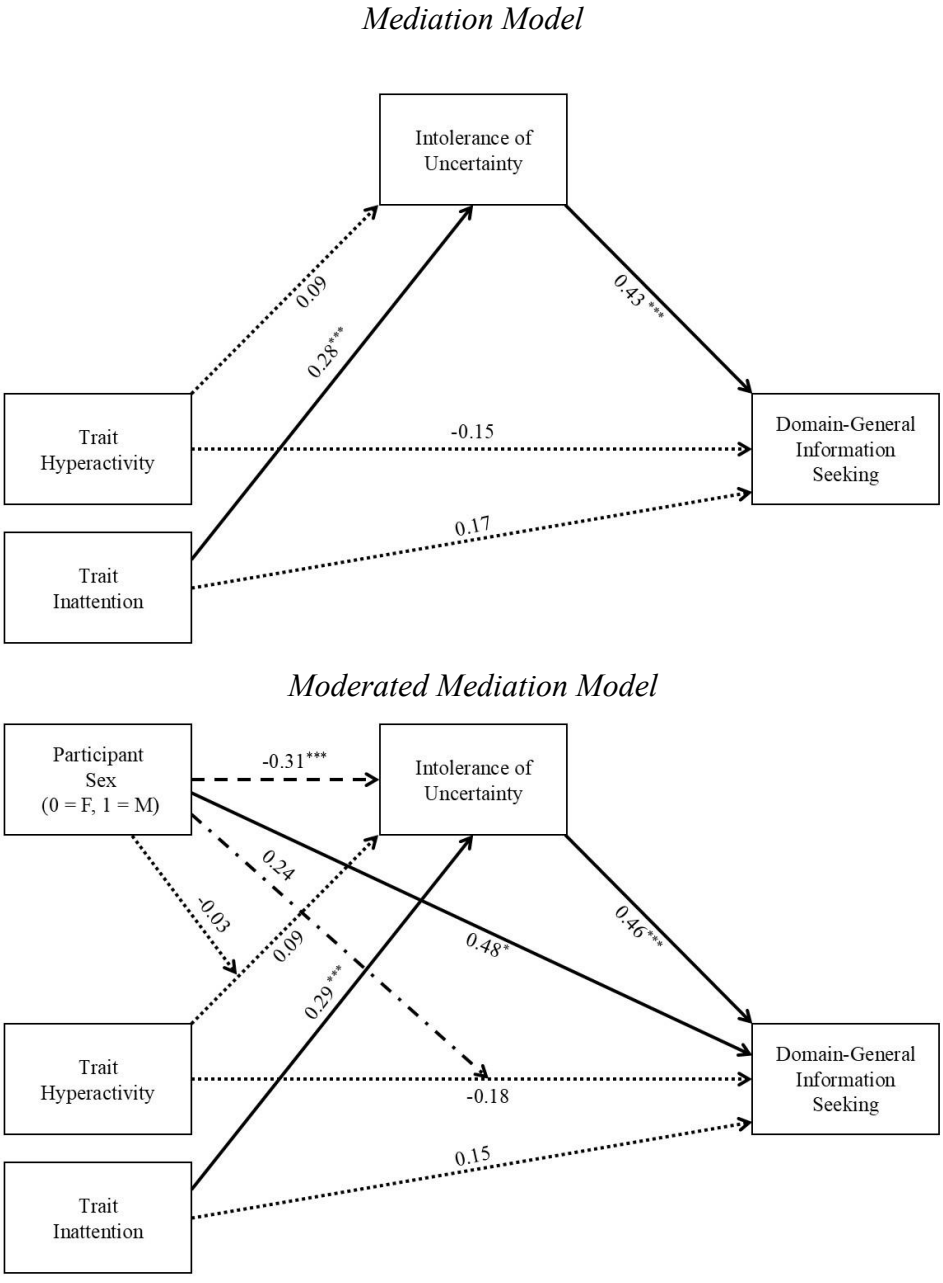
intolerance of uncertainty than did males. Further, sex was significantly positively associated with domain-general information seeking ($\beta_2 = 0.48$, $z_{626} = 2.27$, $p = .02$, 95% CI [0.07, 0.89]), indicating that males exhibited greater domain-general information-seeking tendencies than did females. Sex did not moderate the direct effects of trait hyperactivity on intolerance of uncertainty ($w_1 = -0.03$, $t_{626} = -0.29$, $p = .77$, 95% CI [-0.21, 0.16]), nor on domain-general information seeking ($w_2 = 0.24$, $z_{626} = 1.09$, $p = .28$, 95% CI [-0.19, 0.67]). In addition, sex did not moderate indirect effects of trait hyperactivity on slow strategy information seeking through intolerance of uncertainty ($w_{ab} = -0.01$, 95% CI [-0.10, 0.07]). See Figure 4.3 for statistical diagrams of these models.

Trait Inattention as Focal Predictor. An initial mediation analysis indicated that trait inattention was significantly associated with intolerance of uncertainty ($a = 0.28$, $t_{626} = 5.61$, $p < .001$, 95% CI [0.18, 0.38]). The direct ($c' = 0.17$, $z_{626} = 1.44$, $p = .15$, 95% CI [-0.06, 0.40]) effect of trait inattention on domain-general information seeking was not significant, although the indirect effect of trait inattention on domain-general information seeking through intolerance of uncertainty was significant ($ab = 0.12$, 95%CI [0.06, 0.20]). Trait hyperactivity was not significantly associated ($Cov_m = 0.09$, $t_{626} = 1.87$, $p = .06$, 95% CI [-0.01, 0.19]) with intolerance of uncertainty, nor with domain-general information seeking ($Cov_y = -0.15$, $z_{626} = -1.28$, $p = .20$, 95% CI [-0.37, 0.08]).

A follow-up moderated mediation analysis indicated that trait inattention was significantly associated with intolerance of uncertainty ($a = 0.26$, $t_{626} = 4.85$, $p < .001$, 95% CI [0.15, 0.36]), which itself was significantly positively associated with domain-

Figure 4.3

Statistical Models Predicting Domain-General Information Seeking with Hyperactivity as Focal Predictor



Note. *p < .05. **p < .01. ***p < .001. Solid lines represent significant positive effects, dashed lines represent significant negative effects, dashed-dotted lines represent significant moderation effects, and dotted lines represent non-significant effects.

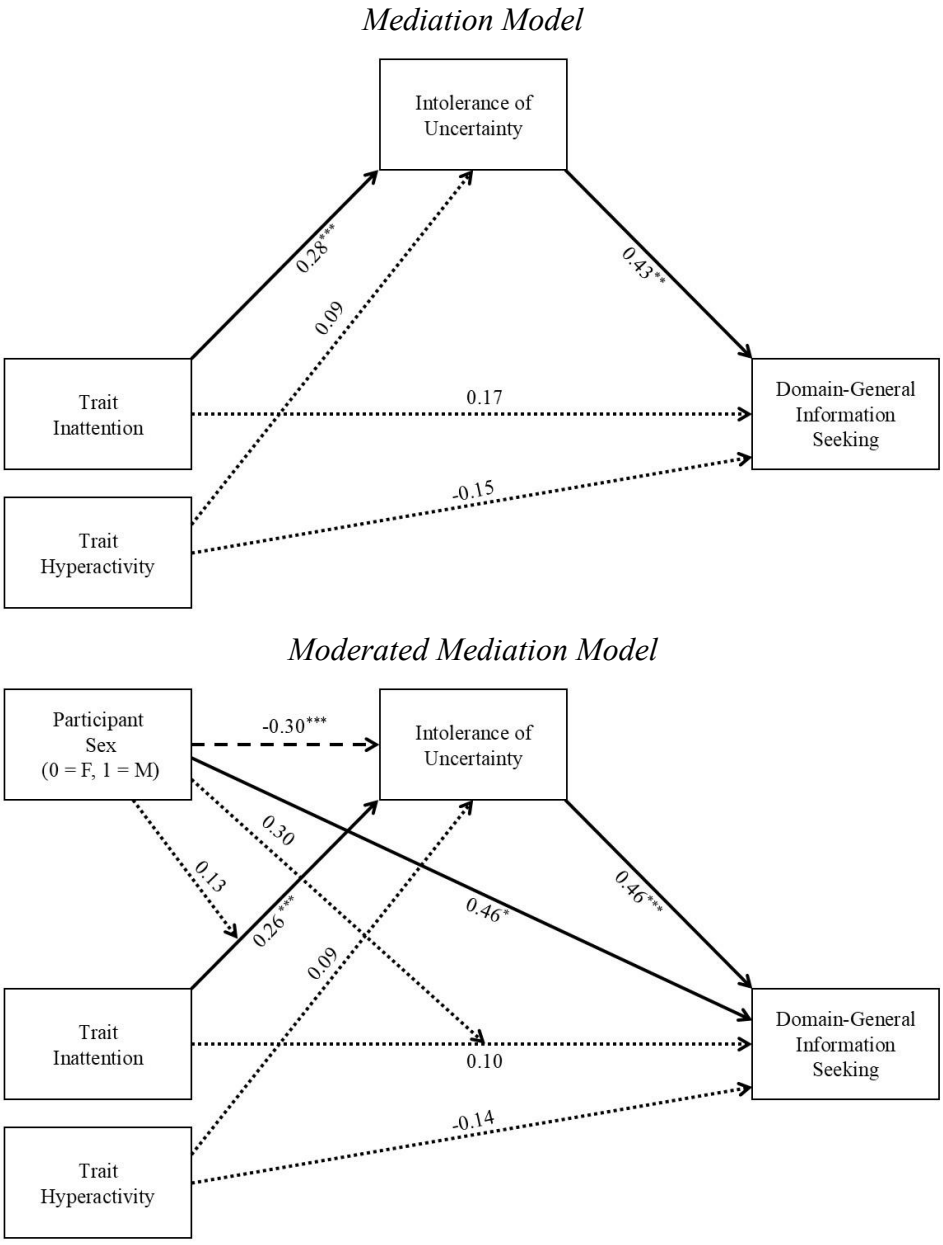
general information seeking ($b = 0.46$, $t_{626} = 4.78$, $p < .001$, 95% CI [0.27, 0.64]). The direct effect of trait inattention on domain-general information seeking was not significant ($c' = 0.10$, $z_{626} = 0.79$, $p = .43$, 95% CI [-0.14, 0.34]). Trait hyperactivity was not significantly with intolerance of uncertainty ($Cov_m = 0.09$, $t_{626} = 1.76$, $p = .08$, 95% CI [-0.01, 0.18]), nor with domain-general information seeking ($Cov_y = -0.14$, $z_{626} = -1.19$, $p = .24$, 95% CI [-0.36, 0.09]).

Sex was significantly negatively associated with intolerance of uncertainty ($\beta_1 = -0.30$, $t_{626} = -3.38$, $p < .001$, 95% CI [-0.48, -0.13]), as well as positively associated with domain-general information seeking ($\beta_2 = 0.46$, $z_{626} = 2.20$, $p = .03$, 95% CI [0.05, 0.87]), indicating that males exhibited greater domain-general information-seeking tendencies than did females. Sex did not moderate the direct effects of trait inattention on intolerance of uncertainty ($w_1 = 0.13$, $t_{626} = 1.45$, $p = .15$, 95% CI [-0.05, 0.31]), nor on domain general information seeking ($w_2 = 0.30$, $z_{626} = 1.34$, $p = .18$, 95% CI [-0.14, 0.72]). In addition, sex did not moderate indirect effects of trait inattention on slow strategy information seeking through intolerance of uncertainty ($w_{ab} = 0.06$, 95% CI [-0.02, 0.15]). See Figure 4.4 for statistical diagrams of these models.

Predictors of Slow Strategy Information Seeking. Diagnostic tests confirmed that the assumptions of linear regression were met. A Durbin-Watson value of 1.82 and variance inflation factors ranging from 1.02 to 1.89 indicated independence of observations and absence of multicollinearity among predictors. Visual inspection of a scatterplot plotting studentized residuals against unstandardized predicted values indicated that assumptions of linearity and homoscedasticity were met. Finally, visual

Figure 4.4

Statistical Models Predicting Domain-General Information Seeking with Inattention as Focal Predictor



Note. *p < .05. **p < .01. ***p < .001. Solid lines represent significant positive effects, dashed lines represent significant negative effects, dashed-dotted lines represent significant moderation effects, and dotted lines represent non-significant effects.

inspection of a histogram of standardized residuals indicated that the distribution of residuals was approximately normal.

Trait Hyperactivity as Focal Predictor. Intolerance of uncertainty was significantly positively associated with slow strategy information seeking (b = 0.40, t_{626} = 9.88, p < .001, 95% CI [0.32, 0.48]). Neither the total (c = 0.02, t_{626} = 0.38, p =.70, 95% CI [-0.09, 0.13]), nor direct (c' = -0.02, t_{626} = -0.33, p = .74, 95% CI [-0.12, 0.08]) effects of trait hyperactivity on slow strategy information seeking were significant, nor was the indirect effect of trait hyperactivity on slow strategy information seeking through intolerance of uncertainty (ab = 0.04, 95% CI [-0.01, 0.09]). Trait inattention was not significantly associated with slow strategy information seeking (Cov_y = -0.07, t_{626} = -1.34, p = .18, 95% CI [-0.17, 0.03]).

A follow-up moderated mediation analysis indicated that intolerance of uncertainty was significantly positively associated with slow strategy information seeking (b = 0.41, t_{626} = 9.89, p < .001, 95% CI [0.33, 0.49]). The direct effect of trait hyperactivity on slow strategy information seeking was not significant (c' = -0.01, t_{626} = -0.25, p = .80, 95% CI [-0.12, 0.09]). Trait inattention was not significantly associated with slow strategy information seeking (Cov_y = -0.07, t_{626} = -1.34, p = .18, 95% CI [-0.17, 0.03]).

Sex was not significantly associated with slow strategy information seeking (β_2 = 0.07, t_{626} = 0.78, p = .43, 95% CI [-0.11, 0.26]). Sex did not moderate the direct effects of trait hyperactivity on slow strategy information seeking (w_2 = -0.01, t_{626} = -0.07, p = .95, 95% CI [-0.20, 0.18]). In addition, sex did not moderate indirect effects of trait

hyperactivity on slow strategy information seeking through intolerance of uncertainty (w_{ab} = -0.01, 95% CI [-0.08, 0.06]). See Figure 4.5 for statistical diagrams of these models.

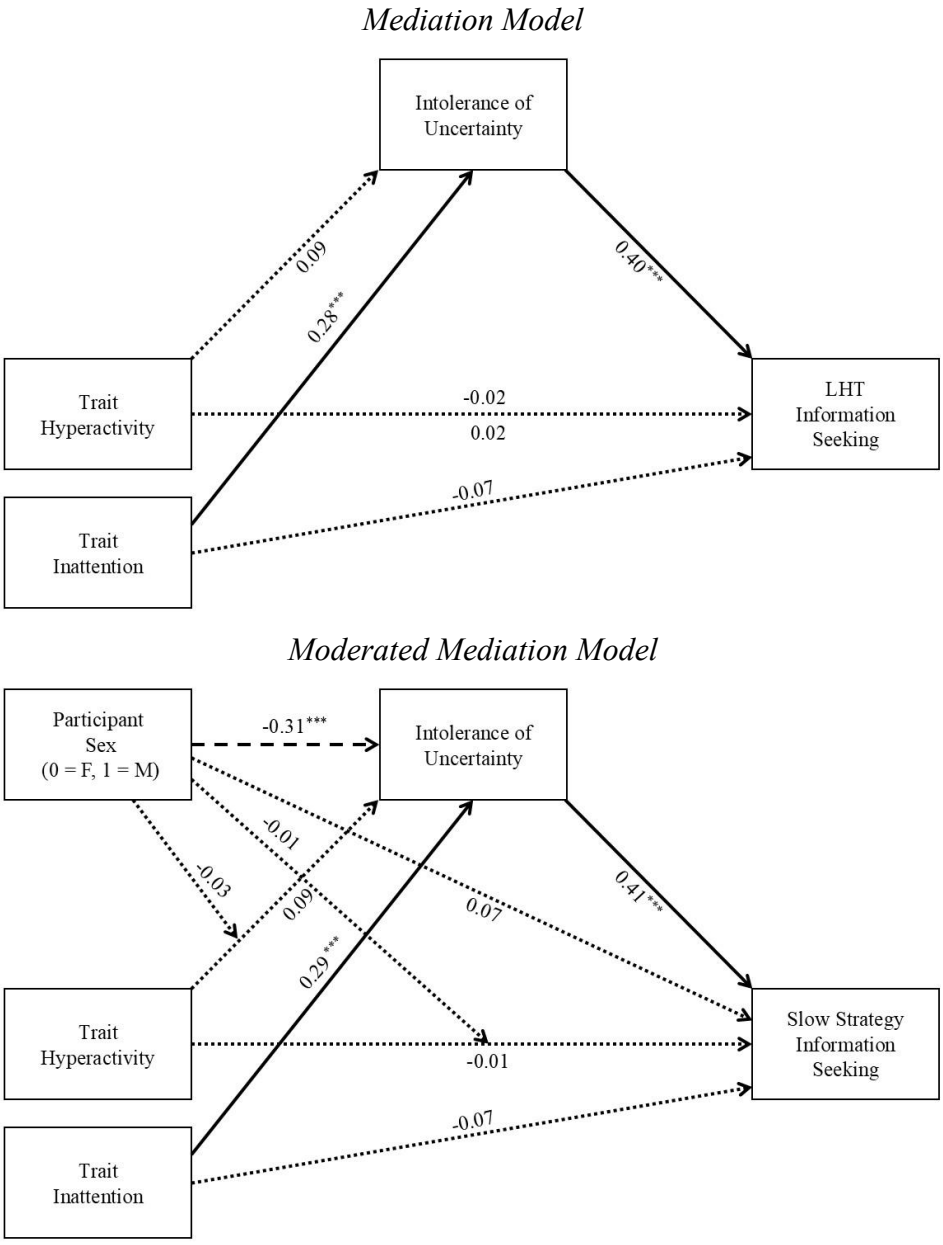
Trait Inattention as Focal Predictor. Neither the total (c = 0.04, t_{626} = 0.79, p =.43, 95% CI [-0.06, 0.15]), nor direct (c' = -0.07, t_{626} = -1.34, p = .18, 95% CI [-0.17, 0.03]) effects of trait inattention on slow strategy information seeking were significant, although an indirect effect of trait inattention on slow strategy information seeking through intolerance of uncertainty emerged as statistically significant (ab = 0.11, 95% CI [0.07, 0.17]).

A follow-up moderated mediation analysis indicated that intolerance of uncertainty was positively associated with slow strategy information seeking (b = 0.41, t_{626} = 9.93, p < .001, 95% CI [0.33, 0.49]). The direct effect of trait inattention on slow strategy information seeking was not significant (c' = -0.06, t_{626} = -0.97, p = .33, 95% CI [-0.16, 0.06]). Trait hyperactivity was not significantly associated with slow strategy information seeking (Cov_y = -0.02, t_{626} = -0.30, p = .76, 95% CI [-0.12, 0.08]).

Sex was not significantly associated with slow strategy information seeking (β_2 = 0.07, t_{626} = 0.76, p = .45, 95% CI [-0.11, 0.25]). Sex did not moderate the direct effect of trait inattention on slow strategy information seeking (w_2 = -.09, t_{626} = -0.97, p = .33, 95% CI [-0.28, 0.09]). In addition, sex did not moderate indirect effects of trait inattention on slow strategy information seeking through intolerance of uncertainty (w_{ab} = 0.05, 95% CI [-0.02, 0.13]). See Figure 4.6 for statistical diagrams of these models.

Figure 4.5

Statistical Models Predicting Slow Strategy Information Seeking with Hyperactivity as Focal Predictor



Note. *p < .05. **p < .01. ***p < .001. Solid lines represent significant positive effects, dashed lines represent significant negative effects, dashed-dotted lines represent significant moderation effects, and dotted lines represent non-significant effects.

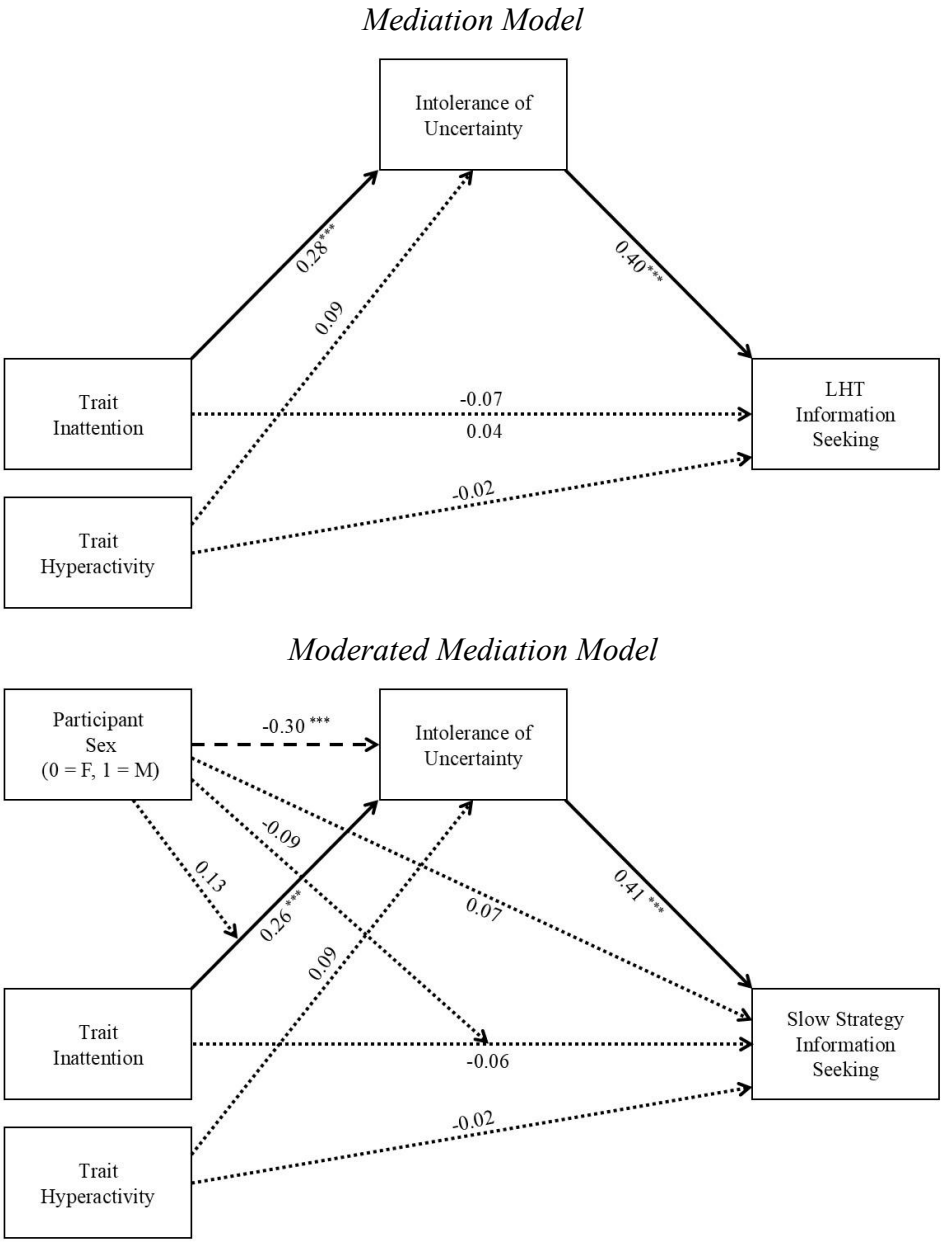
Discussion

In its original formulation, the exploratory hyperactivity hypothesis proposed that hyperactive traits were adaptive in ancestral individuals with ADHD by promoting exploratory behavior, facilitating the gathering of information vital to survival in the unpredictable and unfamiliar environment of Jensen and colleagues' (1997) EEA. This claim has received mixed support from the extant clinical literature on ADHD. For instance, Dubois and colleagues (2022) found that although individuals with clinically significant ADHD symptomology exhibited a preference for exploratory, versus exploitative, foraging strategies, perseveration on such strategies appeared to preclude adoption of exploitative strategies when adaptive (i.e., strategic exploitation of resource-dense sites, informed by prior exploratory behavior). Thus, although individuals with ADHD demonstrated the informational exploration tendencies predicted by the exploratory hyperactivity hypothesis, the utility of these tendencies is questionable.

Notably, Dubois and colleagues (2022) also found evidence of a continuous association between exploratory tendencies and ADHD traits more generally, such that this association may generalize to individuals with elevated but subclinical expression of ADHD traits. Furthermore, Schippers and colleagues (2024) found evidence of associations between subclinical expression of ADHD traits and greater cognitive flexibility in the general population. Taken together, these studies suggest that individuals with elevated levels of ADHD traits in the subclinical range should not only exhibit moderate exploratory tendencies, but also the cognitive flexibility to effectively leverage gathered information by switching from exploration to exploitation when it is

Figure 4.6

Statistical Models Predicting Slow Strategy Information Seeking with Inattention as Focal predictor



Note. *p < .05. **p < .01. ***p < .001. Solid lines represent significant positive effects, dashed lines represent significant negative effects, dashed-dotted lines represent significant moderation effects, and dotted lines represent non-significant effects.

strategically advantageous to do so. Thus, the modified exploratory hyperactivity hypothesis predicted positive associations between trait hyperactivity and information seeking in the general population. Additionally, in light of documented associations between ADHD and intolerance of uncertainty (e.g., Gramszlo et al., 2018), it was proposed that intolerance of uncertainty would, at least in part, mediate predicted associations between trait hyperactivity and information-seeking tendencies.

Contrary to these predictions, trait hyperactivity was neither associated with intolerance of uncertainty, nor with domain-general information seeking, as measured by the bead task (Phillips & Edwards, 1966). Although this appears to refute the exploratory hyperactivity hypothesis, these findings may instead reflect task demands specific to the present implementation of this task. Jacoby and colleagues (2014) presented participants with several iterations of the bead task, each of which varied in uncertainty, including: low uncertainty (85% red, 15% blue), intermediate uncertainty (60% red, 40% blue) and high uncertainty (44% orange, 28% yellow, 28% pink) adaptations. It was found that the high uncertainty task elicited more information requests than did the intermediate task, which generated more requests than the easy task. This implies that bead task difficulty varies as a function of how closely a chosen distribution of beads approximates a ratio of 1:1, with more evenly distributed ratios (e.g., 60% red, 40% blue; distribution ratio of 1.5:1) eliciting more uncertainty - and thus, information requests - than less even distributions (e.g., 85% red, 15% blue; distribution ratio of 5.7:1).

The distribution utilized in the present study (i.e., 75% black, 25% white; distribution ratio of 3:1) may not have been particularly challenging, presenting difficulty

levels between Jacoby and colleagues' (2014) low and intermediate uncertainty tasks. Such an unequal distribution may have made the proportion of black to white beads particularly salient. Indeed, given the relatively low number of requests for further information, the variability of this measure was decreased to a dichotomous outcome. Consequently, the present implementation may not have sufficiently captured intra-individual variation in information seeking, thus failing to capture associations between trait hyperactivity and such tendencies. However, significant effects of both sex and intolerance of uncertainty emerged, suggesting that variability in task performance was sufficient to capture at least some aspects of individual differences in information-seeking behavior.

Indeed, a positive indirect effect of trait inattention on domain-general information seeking emerged as significant. Thus, an alternative interpretation is that, although modified response-readiness theory was broadly correct in predicting associations between subclinical ADHD traits and exploratory tendencies, it was more specifically incorrect in proposing hyperactivity as the mechanism underlying such tendencies. In fact, more recent theoretical work in the field of economics gives reason to believe that inattention may have been the more appropriate candidate all along – especially in the unpredictable environments of Jensen and colleagues' (1997) EEA.

A core principle of behavioral economics is that of bounded rationality (e.g., Simon, 1957), which holds that the capacity of an agent to rationally produce an optimal solution to a given problem is necessarily constrained by practical limitations, including the availability and accuracy of relevant information, the cognitive capacity of the agent

to solve the problem, and the time constraints imposed by the problem. Consider a man attending an auction, (hereafter "Luther"). Deduction of an optimal bid for a given item requires that Luther not only has access to accurate information concerning its value, but also that Luther has the cognitive capacity, as well as sufficient time, to integrate that information and produce an optimal bid. For instance, a lack of knowledge about the value of an especially rare item may prevent Luther from rationally producing a well-informed bid on that item.

Most relevant to present purposes, an excessive volume of available information may present another constraint on rational decision making, especially in unpredictable environments. Working from an LHT framework, Ellis and colleagues (2009) define unpredictability as the degree of spatial-temporal variability within a given environment. Thus, unpredictability presents organisms not only with the adaptive problem of rapid variation in environmental demands, but also similar variation in the information available to meet those demands. Indeed, the ample evidence that environmental complexity selects for the maintenance of costly information processing traits, such as larger relative brain size (e.g., Lefebvre & Sol, 2008), speaks to the substantial cognitive demands of processing information under conditions of unpredictability.

Consequently, mechanisms that can reduce these cognitive demands should be especially adaptive in mercurial environments. Inattention may serve just such a purpose. Introduced by economist Christopher Sims (2003), rational inattention holds that human cognitive resources are finite, and that rational agency necessitates the capacity to discriminate between relevant and extraneous information, attending to the former and

ignoring the latter. Translated into response-readiness theory, this would frame inattention as an informational filter, tuned specifically to extract survival-relevant information (i.e., cues indicative of threat) from a torrent of extraneous environmental data. Indeed, this conceptualization of inattention would be consistent with studies indicating impaired performance on anger recognition tasks among individuals with ADHD (e.g., Ludlow et al., 2014). As discussed in the last chapter, when exposed to negatively valenced stimuli, individuals with ADHD exhibit hyperreactivity of neural structures involved in the experience of fear (e.g., Posner et al., 2011), and hyporeactivity of structures implicated in affect regulation (e.g., Passsarotti et al., 2010). This pattern of activity is consistent with enhanced arousal, suggesting that these performance impairments do not reflect a lack of competence in anger recognition, but rather pre-attentive prioritization of goal-relevant information (i.e., threat cues) over goal-irrelevant information (i.e., explicit labels the detected threat). Indeed, the inattention-mediated hypervigilant environmental scanning proposed by response-readiness theory very much resembles a special case of rational inattention.

Thus, as in the prior two studies, inattention again evidences greater utility than hyperactivity in addressing the immediate demands of response-ready environments. This underlines yet another important modification to response-readiness theory, namely the substitution of inattention for hyperactivity as a vital mechanism for information gathering in response-ready contexts. Furthermore, given that it fully mediated associations between inattention and both measures of information seeking, intolerance of uncertainty seems an appropriate direct replacement for hyperactivity as primary

motivator of response-ready investigative exploration. Consistent with these modifications, trait inattention was indirectly positively associated with slow-strategy information seeking, whereas hyperactivity was not. Notably, this complicates conceptualizations of ADHD as a fast-spectrum disorder. That is, fast strategy traits are those that prioritize immediate, versus future, reproductive effort (Del Giudice et al., 2015). This is understood to translate to more general tendencies to discount future consequences, not only in domains directly related to reproductive effort, but also those that secure the pursuit of future reproduction (i.e., resource acquisition and somatic maintenance). Thus, the tendency to seek information before making decisions in any of these domains, as measured by the slow strategy composite subscale of the DSIS (Vonk et al., 2020), indicates a future-oriented, and thus patently slow-strategy, cognitive style.

That trait inattention was associated with slow-strategy information seeking appears inconsistent with the proposed classification of ADHD as a fast-spectrum disorder. It may be argued that this seemingly contradictory finding reflects the likely tempered response-readiness of an undergraduate, versus clinical, sample. However, the central thrust of Del Giudice's (2014) LHT-informed approach to psychopathology is that psychopathological traits are not qualitatively distinct from, but reflect the extreme expression of, the traits that otherwise characterize typical human behavior. Consequently, conceptualization of ADHD as a fast-spectrum disorder essentially frames it as the extreme expression of otherwise adaptive fast-strategy traits. If so, even subclinical expression of response-ready traits should be associated with adoption of fast-strategy traits more generally. Although Del Giudice never explicitly labels ADHD as a

fast strategy disorder, its resemblance to the behavioral characteristics ascribed to such disorders is undeniable (e.g., risk-taking and impulsivity; American Psychiatric Association [APA], 2013). Thus, the positive indirect association between inattention and slow-strategy information seeking may appear inconsistent with conceptualizations of response-ready traits as indicative of a fast strategy.

However, it is important to remember that, relative to other species, human beings are characterized by considerable longevity, late onset of sexual maturity, and high levels of parental investment – all of which indicate a remarkably slow strategy by interspecific standards (Brumbach et al., 2009). Consequently, although individuals high in ADHD traits may have adopted a fast strategy by intraspecific standards, they are still characterized by a slow strategy in the larger biological context. That is, human traits labeled as fast strategy are better understood as occurring at the upper (i.e., relatively fast) limits of an otherwise slow strategy spectrum. That human behavior more generally skews toward the slow end of the wider pace of life spectrum may explain the apparent contradiction in the co-occurrence of traits considered fast strategy by human standards (i.e., ADHD or response-ready traits) alongside those considered slow strategy by larger, interspecific LHT standards (i.e., information seeking). Nonetheless, this apparent contradiction highlights the necessity of further modification and refinement of response-readiness theory, as well as LHT-informed approaches to psychopathology more generally.

Limitations

Although convenient, the use of undergraduate samples may considerably limit generalizability of these results. Particularly, females were disproportionately represented in this study, which may be particularly problematic in light of documented male-biased sex differences in the diagnosis of ADHD. Young adults were similarly over-represented in this sample as well, which may be problematic in that clinical literature that informed the design in this study primarily focused on juveniles, as well as in consideration of documented developmental trends in the expression of ADHD traits. That is, trait inattention appears more stable, and more likely to persist into adulthood, than hyperactivity (Semejin et al., 2021). Furthermore, future implementations of the bead task should utilize more challenging distributions to further elucidate the role, or lack thereof, of hyperactivity in the expression of response-ready exploratory behavior. Additionally, as they were working for course credit, respondents in the present study may not have been sufficiently incentivized, and thus motivated, to achieve high levels of accuracy on the information-seeking task. This represents a stark contrast to the survival-relevant nature of information seeking in response-ready environments (Jensen et al., 1997). Future studies might improve motivation to respond accurately by implementing performance-contingent bonus incentives, thus increasing the ecological validity of measures of motivated information seeking.

As previously discussed, clinical screening tools, such as the ASRS (Kessler et al., 2005), are designed to detect the presence or absence of clinically-significant ADHD symptomology, and thus likely have limited utility in measuring the variation of such

traits in the population more generally. Thus, it is recommended that future response-readiness research adopts more objective, performance-based measures, capable of measuring the full range of individual differences in the expression of ADHD traits (e.g., measurement of hyperactivity via an accelerometer; see Wang et al., 2022). Indeed, it may be especially informative to complement these objective measures with more naturalistic measures of information seeking, which better approximate foraging under the conditions of unpredictability and scarcity as described by Jensen and colleagues (1997). Research by Arildskov and colleagues (2021) compared performance of children with ADHD, versus NT controls, on a behavioral foraging task in which participants were required to find coins hidden in an unfamiliar room, representing one of the few direct tests of response-readiness theory, as well as a step in the right direction toward more naturalistic foraging tasks. Although this task is arguably more faithful than the bead task in approximating the foraging demands imposed by response-ready environments, further naturalism could be achieved by requiring participants to forage for objects in environment that more closely resemble those of Jensen and colleagues' (1997) EEA. Indeed, adoption of approach alongside implementation of performance-contingent bonus incentives appears particularly appealing from a naturalistic standpoint. Virtual reality simulations present a particularly attractive avenue to this approach, given the danger inherent in response-ready environments.

Conclusion

Contrary to the exploratory hyperactivity hypothesis, inattention, but not hyperactivity, was indirectly associated with information seeking in both domain-general,

as well as domain-specific, contexts. This suggests the need for further refinement of response-readiness theory. For one, future research should more closely examine the possibility that trait inattention functions as an information filter that reduces complexity in the computationally-demanding task of problem solving under conditions of uncertainty. Additionally, this study once again reaffirms the need to critically re-evaluate the role of trait hyperactivity in the expression of response-ready traits. Given the possibility that trait inattention appears to address numerous challenges related to environmental unpredictability (e.g., threat detection, data reduction), the prospect that trait hyperactivity serves as a susceptibility factor in the expression of response-ready traits, rather than a response-ready adaptation itself, appears an increasingly elegant solution.

Chapter Five: General Discussion

Attention-deficit/hyperactivity disorder represents a common form of heritable psychopathology, with estimated prevalence rates as high as 11% in childhood and 4% in adulthood (National Institute of Mental Health [NIMH], n.d.). This disorder is associated with considerable dysfunction, representing a significant risk factor for numerous undesirable outcomes including substance use disorders and anti-social behavior (Estévez et al., 2016; Fletcher & Wolfe, 2009; Storebø & Simonsen, 2016; Young & Thome, 2011). Perhaps the most striking aspect of such dysfunction is the increased risk of premature mortality (Dalsagaard et al., 2015) – a risk that begins in childhood. That this risk emerges prior to the onset of sexual maturity appears to indicate that ADHD incurs relatively heavy reproductive fitness costs. In light of such steep costs, the prevalence of ADHD presents a considerable challenge to evolutionary models of human behavior. A common approach to such challenges is to appeal to mismatch theory, which describes how once adaptive traits may be rendered maladaptive by substantial environmental change (Roberston & Chalfou, 2016). Jensen and colleagues' (1997) response-readiness theory represents one such effort in attempting to reconcile the prevalence of ADHD with evolutionary theory.

In its initial formulation, this theory claims that the behavioral characteristics of ADHD, often pathologized in modern contexts, would have been adaptive in coping with the especially demanding environments of ancestral humans, namely those characterized by response-ready reaction norms such as novelty, resource scarcity, unpredictability, danger and temporal urgency (Jensen et al., 1997). Response-readiness theory contends

that, in such environments, diffuse attentional states would have facilitated vigilant environmental monitoring, aiding rapid detection of environmental threats, whereas impulsivity would have facilitated rapid responses should such threats emerge. Finally, hyperactivity was proposed to have motivated investigative exploration, vital in orienting the response-ready individual to the novel and unpredictable environments for which they are adapted. Building on this work, the present project extracted three testable hypotheses from response-readiness theory.

First, if ADHD represents a phenotypically plastic response to adverse rearing environments (i.e., those characterized by response-ready reaction norms), modern rearing environments with similar characteristics should represent a substantial risk factor for the development of ADHD. Second, if inattention was adaptive in conferring enhanced vigilance upon ancestral individuals with ADHD, the threat detection systems of modern individuals with ADHD should exhibit similar sensitivity. Finally, if hyperactivity was adaptive in motivating investigative exploration of ancestral environments, modern individuals with ADHD should show similar preferences for exploratory information seeking.

Although rarely tested directly (see Thagaard et al., 2016), each of these hypotheses, as initially formulated, have received mixed indirect support. The confused state of this indirect evidence is perhaps best exemplified by research into the social cognitive profile of individuals with ADHD. Facial displays of affect, especially those of anger, serve as a salient universal cue of intended harm by conspecifics, the importance of which is demonstrated by the anger superiority effect (i.e., the tendency to recognize

facial displays of anger more rapidly than those of other affective states; Coutinho et al., 2018; Hansen & Hansen, 1988). Thus, research indicating that individuals with ADHD exhibit impaired performance on anger recognition tasks relative to NT peers represents an apparent contradiction of the hypervigilance hypothesis. Conversely, there is reason to believe that this impairment stems not from social cognitive deficiencies, but rather a state of excessive affective arousal that prioritizes threat-relevant processes (i.e., attentive focus on threat-congruent stimuli) to the detriment of threat-irrelevant processes (i.e., explicitly labeling those stimuli). Evidence of such hyperarousal amongst individuals with ADHD has been demonstrated at the neural level, with exposure to negatively valenced stimuli inducing hyperactivity of structures implicated in the fear response (e.g., Posner et al., 2011), as well hypoactivity of structures implicated in affect regulation (e.g., Pssarotti et al., 2010). Indeed, these discrepant findings are but one case of such evidentiary whiplash among many in the current literature as it relates to the validity of response-readiness theory.

This project represents not only a relatively novel attempt to sidestep such inconsistencies by addressing the validity of response-readiness theory more directly, but also by addressing its theoretical shortcomings, especially as they apply to individuals characterized by clinically significant levels of ADHD traits. This latter goal is achieved by adoption of an LHT-informed individual differences approach to ADHD traits, abandoning traditional clinical dichotomies in recognition that the line between personality and pathology is largely a quantitative, rather than qualitative, distinction. Indeed, this approach mirrors work in evolutionary psychology literature which frames

psychopathology as the extreme expression of otherwise adaptive traits (e.g., Del Giudice, 2014). Examining the full spectrum of ADHD traits as they occur in the population at large may very well be the key to understanding their adaptive value, and thus reconciling them with evolutionary theory. What follows is a review of this project's empirical findings, and subsequent synthesis of these findings in recognition of a clear path forward for response-readiness research, particularly in the context of dominant models of evolutionary psychology and psychopathology.

The Modified Environmental Adversity Hypothesis

The modified environmental adversity hypothesis predicted that rearing environments characterized by response-ready reaction norms would be positively associated with the expression of ADHD traits within the general population. Specifically, it was predicted that factors indicative of danger (i.e., childhood physical abuse) and resource scarcity (i.e., childhood physical neglect), as well as perceived harshness and unpredictability of childhood environments would be positively associated with ADHD traits. The present findings provide mixed support for the environmental adversity hypothesis. Although resource scarcity, as well as perceived unpredictability of childhood environment were both positively associated with the expression of inattentive traits, danger and perceived harshness of childhood environment were not. Indeed, danger (i.e., childhood physical abuse) was, in fact, negatively associated with inattentive traits. These somewhat contradictory findings may, in part, reflect poor operationalization of study variables. Most notably, there is reason to believe the present operationalization of danger (i.e., childhood physical abuse) is not an ideal analog for the kinds of danger

inherent in Jensen and colleagues' (1997) EEA. Evidence suggests that victims of chronic childhood physical abuse develop a perceptual specialization in the recognition of cues predictive of an abusive episode (i.e., anger displays; Pollak et al., 2009). That this specialization is largely unique to victims of childhood abuse implicates associative learning in its development. Thus, the relatively predictable dangers of abusive environments is not entirely congruent with the unpredictable dangers inherent in Jensen and colleagues' (1997) EEA.

Such concerns of operationalization do not go nearly so far in explaining the environmental characteristics, or lack thereof, predictive of trait hyperactivity, Particularly, environmental unpredictability was the sole response-ready reaction norm associated with the expression of trait hyperactivity. Although inconsistent with the predictions generated by the environmental adversity hypothesis, these findings present an interesting opportunity to integrate response-readiness theory within an established model of evolutionary and developmental psychopathology, namely Belsky's (1997) differential susceptibility model. Particularly, the relative environmental insensitivity of hyperactivity is consistent with Belsky and Pluess' (2009) characterization of susceptibility factors as independent of the environmental contingencies whose effects they moderate. Indeed, Belsky and colleagues (2007) go so far as to propose hyperactivity as a susceptibility factor, although not in the context of response-readiness theory. Thus, it appears plausible that trait hyperactivity is not, itself, a response-ready trait, but rather a susceptibility factor that moderates developmental plasticity in the expression of such traits (hereafter, the readiness spectrum hypothesis). This possibility

not only merits further consideration, but will serve as an organizing principle underlying a novel evolutionary account of response-readiness, the hyperactive facilitation theory, to be discussed at length below.

The Modified Hypervigilance Hypothesis

The modified hypervigilance hypothesis predicted that trait inattention would be associated with greater vigilance to environmental threats. Such a cognitive specialization in hypervigilance should be noted as distinct from the way in which Pollak and colleagues (2009) conceptualized hypervigilant threat detection in their research on victims of chronic childhood abuse. As previously discussed, there are theoretically important distinctions to be made between the predictable dangers of abusive environments versus the unpredictable dangers of Jensen and colleagues' (1997) EEA. Thus, it must be stressed that, although the perceptual specializations described by Pollak were used to model how hypervigilance may operate in practice, the unpredictable nature of danger in the EEA implicates a different, non-associatively learned, and perhaps innate, process in the etiology of response-ready hypervigilance.

Nonetheless, the hypervigilance displayed by victims of chronic child abuse appears to manifest primarily in two ways. The first is a bias toward threat detection (i.e., tendencies to perceive ambiguous cues as threat-congruent; Pollak & Kistler, 2002), whereas the second is greater competency in the rapid detection of threats (i.e., accurate identification of threat-congruent stimuli on the basis of less, versus more, visual information; Pollak & Sinha, 2002). Consequently, both operationalizations were used in testing the hypervigilance hypothesis in Study 2. Here, trait inattention was positively

associated with overall anger ascriptions across a racially diverse set of facial affect display stimuli that varied in emotion (i.e., anger, disgust, happiness, and neutral) as well as ambiguity (i.e., level of pixelation and thus, distortion), consistent with the former conceptualization of hypervigilance as a bias toward threat detection.

Relying on accuracy data from the above task, the latter conceptualization of hypervigilance entailed proficiency in the accurate identification of threat-congruent stimuli. Thus, the modified hypervigilance hypothesis predicted that trait inattention would interact with stimulus qualities of affective state and visual ambiguity such that inattention would predict anger-specific advantages in accuracy at higher, versus lower, levels of pixelation. Contrary to this prediction, no significant interaction emerged involving trait inattention. Indeed, trait inattention emerged as a significant predictor of accuracy only for a single level of visual ambiguity more generally (i.e., at block size 45). Thus, the present results suggest that inattention may underlie hypervigilant biases in perception, but not necessarily proficiency in accurate threat detection, demonstrating the tendency toward false positives that Jensen and colleagues (1997) acknowledge as a potential consequence of hypervigilance. Nonetheless, although the present test of hypervigilance is apt in its attempts to address the ambiguities concerning the social cognitive profiles consistent with ADHD (i.e., response-ready) traits, future research may benefit from more traditional threat detection tasks. Indeed, those that utilize measures of reaction time (e.g., the dot-probe task; Frewen et al., 2008) may be useful in testing not only the hypervigilance hypothesis, but also Jensen and colleagues' (1997) proposal that impulsivity facilitates expedient responses in coping with threat cues.

The Modified Exploratory Hyperactivity Hypothesis

The modified exploratory hyperactivity hypothesis predicted that trait hyperactivity would be associated with exploratory information-seeking tendencies in the general population, and that this association would be mediated by intolerance of uncertainty. This hypothesis was tested in Study Three, in which participants completed a domain-general information-seeking task (i.e., the bead task; Phillips & Edwards, 1966). On the first trial of this task, two jars were described to participants, each of which contained a different distribution of colored beads (i.e., Jar A (75% Black, 25% White); Jar B (25% Black, 75% White)). Participants were then presented a single bead and prompted to either identify which jar the bead had been pulled from or request more information in the form of an additional bead. This choice was repeated for each additional trial, and trials ended when participants chose a jar, with a forced choice on the 60^{th} trial. The decision to ask for more information on the first trial, coded dichotomously (1 = requested more information, 0 = answered on the first trial), was used to indicate domain-general information seeking. In addition, participants completed a self-report measure indicating intolerance of uncertainty, as well as information-seeking tendencies across the LHT-relevant domains of reproduction, resource acquisition and health, with higher total scores indicating greater information-seeking tendencies in these domains. Contrary to these predictions, intolerance of uncertainty mediated the indirect effect of trait inattention, not hyperactivity, on both measures of information seeking. These results further underline the need to critically re-evaluate the respective roles that trait inattention

and trait hyperacuity may play in coping with the demands of response-ready environments.

Although it may be tempting to simply substitute inattention for hyperactivity as a motivating factor underlying informational exploration, theory points to a different role of inattention in coping with the informational demands of response-ready environments. The concept of rational inattention (Sims, 2003) proposes that inattention serves as a cognitive filter, facilitating efficient information processing by isolating goal-relevant, and discarding goal-irrelevant, information. It may be that inattentive traits evolved amongst response-ready individuals as just such a filter, extracting survival-relevant information (i.e., cues indicative of threats or resources) embedded in environmental noise. Such a mechanism would be especially adaptive in the mercurial unpredictability of Jensen and colleagues' (1997) EEA. That is, if unpredictability is understood as the degree of spatial-temporal variability in a given environment (e.g., Ellis et al., 2009), unpredictable environments necessarily require organisms to cope with variability in the challenges placed by such environment, as well as similar variability in the information available to address those challenges. Consequently, under conditions of unpredictability, the utility of mechanisms that extract useful data from extraneous environmental information cannot be understated.

As the present results appear to contradict the exploratory hyperactivity hypothesis, two novel alternative hypotheses are proposed below. First, the concept of rational inattention (Sims, 2003) raises the possibility that response-ready inattentive traits acted as a cognitive filter, extracting goal-relevant data and discarding extraneous

information in information-dense, unpredictable response-ready environments (hereafter, the informational filter hypothesis). Second, because it fully mediated the effects of trait inattention on information-seeking tendencies, intolerance of uncertainty seems an apt alternative to hyperactivity in motivating investigative exploration in response-ready environments (hereafter, the uncertainty reduction hypothesis).

Differential Susceptibility to Response-Readiness

Across three studies, trait inattention has demonstrated not only greater sensitivity to response-ready reaction norms than trait hyperactivity, but also greater utility in coping with the demands imposed by such environmental characteristics. Consistent with the inattention-mediated biases in threat detection predicted by the modified hypervigilance hypothesis, Study Two found that inattention was significantly associated with overall ascriptions of anger across a racially diverse set of facial affect stimuli that varied by affective content (i.e., anger, disgust, happiness, neutral) and visual ambiguity (i.e., level of pixelation). Indeed, the superior utility of inattention, relative to hyperactivity, in response-ready contexts was further underlined in Study Three, which found, contrary to predictions generated by the exploratory hyperactivity hypothesis, that inattention, not hyperactivity, was indirectly associated with information seeking in both domain-general and domain-specific contexts.

Although the present results are consistent with inattention as adaptive in response-ready environments, the same cannot be said for hyperactivity. It is possible, however, that hyperactivity plays a less direct, albeit fundamentally indispensable role in the facilitation of response-readiness. As mentioned previously, unpredictability of

rearing environment was the sole response-ready reaction norm associated with the expression of hyperactivity and, indeed, represents the sole accurate prediction made about hyperactivity across all three studies. This solitary association may be the key to understanding what role, if any, hyperactivity plays in the expression of response-ready traits. Specifically, it raises the possibility that hyperactivity is an adaptation not to response-ready environments specifically, but to environmental unpredictability more generally.

The need to cope with uncertainty represents a common adaptive problem that relates not only to all three hypotheses tested in this project, but to response-readiness theory more generally. Whether it concerns the environmental unpredictability proposed to favor the expression of response-ready traits (i.e., the environmental adversity hypothesis), the tendency to perceive visually ambiguous cues as threatening (i.e., the hypervigilance hypothesis), or the apparent necessity of investigative exploration in orienting to unfamiliar and unpredictable environments (i.e., the exploratory hyperactivity hypothesis), response-readiness is perhaps best understood as adaptation that promotes fitness in coping with the challenges posed by environmental unpredictability and uncertainty. Notably, Belsky and Pluess's (2009) account of the differential susceptibility model not only frames developmental plasticity as an adaptive solution to environmental unpredictability, but also proposes hyperactivity as a mechanism of such plasticity. Thus, adoption of a differential susceptibility framework may serve to elucidate the heretofore unclear relationship between hyperactivity and response-readiness.

The Hyperactive Facilitation Theory

Belsky's (1997) proposal of differential susceptibility reconceptualizes the risk factors described in traditional models of psychopathology as more general mechanisms of phenotypic plasticity. These traits, known as susceptibility factors, are proposed to moderate the impact of cues indicative of environmental quality (i.e., reaction norms) on the expression of developmentally plastic behavioral adaptations. However, this sensitivity is not universally adaptive in modern human contexts. Indeed, Belsky describes the behavioral effects of susceptibility as occurring "for better and for worse." That is, the exceptional plasticity afforded by susceptibility is a double-edged sword; susceptible individuals derive not only the greatest benefit when reared in optimal conditions, but also suffer the greatest detriment when subjected to adverse rearing conditions. In this way, susceptibility factors can be understood to amplify the effects of reaction norms on phenotypically plastic behavior.

As a demonstration of differential susceptibility principles, Belsky and Pluess (2009) cite longitudinal research by van Acken and colleagues (2007), which found that infant temperament moderated the effects of maternal sensitivity on the later expression of externalizing behaviors. That is, infants characterized by difficult temperament not only demonstrated the greatest increases in externalizing behavior when reared by insensitive mothers, but also the least severe increases when reared under conditions of maternal sensitivity. Thus, a susceptibility factor (i.e., difficult temperament) amplified the effects of rearing environment (i.e., maternal sensitivity) producing differential results

in the expression of a developmentally plastic outcome (i.e., individual differences in externalizing behavior).

Most relevant to present purposes, Belsky and Pluess (2009) nominate hyperactivity as just such a susceptibility factor. In concurrence with this proposal, what follows is a novel synthesis of response-readiness theory (Jensen et al., 1997), contextualized within a larger differential susceptibility framework (Belsky, 1997). This theory, the hyperactive facilitation theory, frames hyperactivity as a susceptibility factor that increases environmental sensitivity in susceptible individuals (i.e., those high in hyperactivity; hereafter, hyperactive individuals), thus amplifying the effects of response-ready reaction norms on the developmentally plastic expression of trait inattention and intolerance of uncertainty, as well as other potential response-ready traits. However, it is important to remember that differential susceptibility entails that susceptible individuals are disproportionately represented at *both* extremes of a given developmental outcome. Thus, the hyperactive facilitation theory predicts not only that hyperactive individuals will express exceptionally high levels of response-ready traits when reared in environments characterized by response-ready reaction norms (i.e., danger, resource scarcity, harshness and unpredictability), but also exceptionally low levels of these traits when reared in the absence of such environmental contingencies (hereafter, the readiness spectrum hypothesis). As will be discussed below, the hyperactive facilitation theory further proposes that intolerance of uncertainty (i.e., cognitive, affective, and behavioral responses resulting from discomfort under conditions of uncertainty; Bartoszek et al., 2022; Freeston et al., 1994) played a vital role in motivating investigative exploration

among ancestral response-ready individuals (hereafter, the uncertainty reduction hypothesis), and that inattention acted as an informational filter, allowing such individuals to efficiently cope with the informational demands inherent in unpredictable, response-ready environments (hereafter, the attentional filter hypothesis).

The Readiness Spectrum Hypothesis. A central concept of the differential susceptibility model is that susceptible individuals are necessarily disproportionally represented at both extremes of a given developmentally plastic outcome. Thus, the hyperactive facilitation theory predicts that hyperactive individuals will be disproportionately represented amongst those both extremely high, as well as extremely low, in the expression of response-ready traits. More specifically, the readiness spectrum hypothesis predicts individual differences in response-ready traits amongst hyperactive individuals will depend on degree of exposure to response-ready reaction norms (i.e., environmental cues indicative danger, resource scarcity, harshness and unpredictability), such that hyperactive individuals reared in environments characterized by these norms will express exceptionally high levels of response-ready traits (e.g., inattention, intolerance of uncertainty), whereas hyperactive individuals reared in less hostile environments, absent of such reaction norms, should express especially low levels of response-ready traits.

Prior research has indicated significant associations between rearing in adverse environments and both of the presently proposed response-ready traits (i.e., inattention and intolerance of uncertainty). For instance, resource scarcity, operationalized as both maternal malnourishment and low familial socioeconomic status, have been recognized

as risk factors for adolescent attentional deficits (Forns et al., 2012). Furthermore, adverse childhood experiences more generally are significant predictors of subsequent intolerance of uncertainty in adolescence (Jones et al., 2024). Although such results are consistent with a relationship between adverse rearing environments and the later expression of response-ready traits, they are insufficient to demonstrate differential susceptibility. For one, Forns and colleagues (2012) measured inattention using a clinical screening tool. As previously discussed, such tools likely fail to capture subclinical variation in attentional capacity, and thus speak very little to associations between environmental adversity and variation in attentional capacities in the typical to exceptional range.

Failure to capture the entire range of an outcome can lead to misleading and illusory statistical relationships, thus precluding demonstration of differential susceptibility. This is because differential susceptibility necessitates statistical independence between a given susceptibility factor and its associated developmentally plastic behavioral outcome. Using inattention as an example, the readiness spectrum hypothesis proposes that hyperactive individuals should be disproportionately represented at both extremes of the range of individual differences in attentional capacity. Consequently, associations between hyperactivity and either attentional extreme cancel each other out, resulting in a net non-association between hyperactivity and attentional capacity. Thus, measurement of the lower end of the spectrum while failing to measure its higher end may create the illusion of a significant association between hyperactivity and

attentional deficits - an association that may dissipate when accounting for the full range of attentional variability in the population.

Beyond independence between susceptibility factor and developmental outcome, Belsky and Pluess (2009) further require that the susceptibility factors are also independent of the environmental influences that they moderate. That is, for trait hyperactivity to moderate developmentally plastic behavioral responses to optimal and adverse environments alike, it must necessarily occur in both kinds of environments. For instance, were hyperactivity positively associated with environmental adversity, its expression would be unlikely to occur in optimal rearing environments. Notably, although research has demonstrated associations between adverse childhood experiences and trait hyperactivity (e.g., Brown et al., 2017), such studies often frame hyperactivity in clinical terms, and thus, may fail to capture more functional aspects of hyperactive expression. For instance, several studies (e.g., Barriga et al., 2002; Pingault et al., 2011) have indicated that academic achievement impairments are associated with inattentive, rather than hyperactive, dimensions of ADHD symptomology. If the specificity of inattention as a predictor of poor achievement generalizes to other domains, it is possible that individuals who express hyperactivity in the absence of inattention are better able to productively direct their hyperactive tendencies toward goal-relevant tasks than their less attentive counterparts. Finally, Belsky and Pluess (2009) indicate the need to demonstrate specificity of the differential susceptibility relationship, such that the moderation effect does not occur interchangeably with other susceptibility factors and outcomes. In the context of the readiness spectrum hypothesis, this means that hyperactivity should be the

only susceptibility factor that moderates associations between exposure to response-ready reaction norms, or lack thereof, and expression of response-ready traits.

Thus, an adequate test of the readiness spectrum hypothesis requires a specialized methodological approach that addresses inadequacies of the present studies, as well as of those discussed above (e.g., Brown et al., 2017; Forns et al., 2012; Jones et al., 2024), in failing to capture sufficient variability in the response-ready traits, as well as the predictors of those traits. First, the sample utilized in a prospective study of the readiness spectrum hypothesis must represent diversity in quality of rearing environment, so as to demonstrate that hyperactivity is expressed in both optimal and adverse rearing conditions, thus indicating that hyperactivity is independent of environment quality. Furthermore, such a study requires measurement of the full range of variation in hyperactivity and inattention, which would entail not only abandoning operationalization of these traits in terms of their clinically-significant extremes (i.e., the ASRS, as used in this study; Kessler et al., 2005), but more preferably, adoption of objective performance-based cognitive and behavioral measures of these traits, The advantages of adopting such an approach are two-fold. First, such measurements should better capture subclinical variation in ADHD traits, and should be better able to discriminate between the typical and exceptional range of their expression in ways that ADHD screening tools cannot. A second advantage of this approach is that clinical measures of ADHD symptomology (e.g., the ASRS; Kessler et al., 2005) tend to conflate hyperactivity and impulsivity as a single factor, precluding separate examination of these traits. This may prove important to

future research, impulsivity represents a further potential response-ready trait, as originally conceptualized by Jensen and colleagues (1997).

Thus, an adequate test of the readiness spectrum hypothesis would require that a diverse sample of the general population, representative of those reared in both adverse and optimal environments, complete objective measures of susceptibility in the form of hyperactivity (e.g., accelerometer, motion-tracking software; see Wang et al., 2022) as well as response-ready traits such as inattention (e.g., digit span, Stroop tasks; see Nasiri et al., 2023), intolerance of uncertainty (e.g., physiological indicators of distress under conditions of uncertainty; Morriss et al., 2022) and potentially impulsivity (e.g., Go/No-Go, delay discounting tasks; see Reynolds et al., 2006) as well as any other prospective response-ready traits that emerge in subsequent empirical and theoretical development of the hyperactive facilitation theory. Confirmatory evidence of the readiness spectrum hypothesis would entail that trait hyperactivity moderates the effects of environmental quality such that hyperactive individuals demonstrate especially high levels of response-ready traits when reared in environments characterized by response-ready reaction norms, and remarkably low levels of these traits when reared in environments absent of such reaction norms.

The Uncertainty Reduction Hypothesis. Study Two of the present project served as a test of the modified exploratory hyperactivity hypothesis, which proposed that hyperactivity motivated exploratory information seeking in ancestral response-ready individuals. Specifically, it was predicted that trait hyperactivity would be positively associated with information-seeking behavior, and that intolerance of uncertainty would

fully mediate this association. Contrary to these predictions, hyperactivity was not associated, directly or otherwise, with any measure of information seeking in the present study. However, intolerance of uncertainty was positively associated with information seeking in both domain-general (i.e., the tendency to request information in the bead task) and domain-specific (i.e., self-report of slow-strategy information seeking) contexts. Thus, the uncertainty reduction hypothesis proposes that intolerance of uncertainty, rather than hyperactivity, served as the motivational construct underlying exploratory environmental investigation in ancestral response-ready individuals.

Aside from the previously discussed benefits of objective measures of response-ready traits (i.e., physiological measures of intolerance of uncertainty; Morris et al., 2022), future hyperactive facilitation research may benefit from more objective and naturalistic measures of the challenges inherent to response-ready environments. As it pertains to the uncertainty reduction hypothesis, behavioral foraging tasks in three-dimensional space may be especially appropriate in operationalizing investigative exploratory tendencies. Indeed, the sole prior direct test of response-readiness theory (i.e., Arildskov et al., 2021) used such an approach, requiring children with ADHD and NT controls to forage for hidden coins in an unfamiliar classroom setting. Similarly, although not a test of response-readiness theory, research by Maya and colleagues (2019) represents an even closer approximation, investigating the use of previously communicated, as well as personally-obtained, information in a task that required participants to search for objects in an outdoor arena. Additionally, foraging tasks that utilize virtual reality technology (e.g., Simonelli et al., 2024) may present a practical

approach to more faithfully replicate the harsh environmental characteristics of Jensen and colleagues' (1997) EEA without compromising participant safety.

A prospective study could test the uncertainty reduction hypothesis by examining associations between response-ready traits (e.g., physiological indicators of intolerance of uncertainty) and foraging behavior in novel environments. In such a task, exploratory behavior could be operationalized as total area covered while foraging, whereas proficiency in foraging could be indexed by total quantity of resources gathered. This task could provide support for the uncertainty reduction hypothesis in demonstrating positive associations between intolerance of uncertainty and overall exploratory behavior. Indeed, one could even investigate the practical utility of such exploratory tendencies by examining whether exploratory behavior mediates potential associations between response-ready traits and foraging proficiency. Furthermore, examination of whether these associations vary between hyperactive and non-hyperactive individuals may serve as a test of the specificity of such associations. Non-exclusivity of these associations to hyperactive individuals may be indicative of a more general relationship between intolerance of uncertainty and exploratory behavior in the population at large, thus constituting a violation of the specificity principle (i.e., Tooby & Cosmides, 2015), and questioning the validity of the uncertainty reduction hypothesis. Although admittedly provisional in nature, the above considerations may serve as a useful template for future research on the Hyperactive Facilitation theory.

The Attentional Filter Hypothesis. A central tenet of behavioral economics is bounded rationality (Simon, 1957), which argues that the capacity of a rational agent to

solve a given problem is necessarily constrained by practical limitations, including not only the availability of relevant information, but also the cognitive capacity to manipulate that information in producing an optimal solution. Indeed, such sentiments concerning the limitations of human information processing are mirrored in traditional models of selective attention (e.g., Broadbent, 1958), which conceptualize the construct as an informational filter. More specifically, the central thrust of so-called filter theories of selective attention is that individuals must regularly contend with more information than can be concurrently processed in a given moment. Indeed, Bater and Jordan (2020) affirm that the capacity to selectively regulate attentional processes toward goal-relevant information is considered central to efficient information processing, and basic functioning more generally.

Response-ready environments are, by definition, unpredictable (i.e., characterized by high temporal and spatial variability in environmental harshness; Ellis et al., 2009). Given their dynamic nature, such environments pose not only the challenge of coping with rapidly changing environmental demands, but doing so in the context of a torrential stream of incoming extraneous informational "noise." As previously noted, the informational demands inherent in complex environments are evident in research suggesting that such environments select for the maintenance of costly information-processing adaptations (i.e., relative brain size; Lefebvre & Sol, 2008; Sayol et al., 2018). Thus, insofar as unpredictability presents a source of environmental complexity, the unpredictable nature of response-ready environments should exert relatively strong selective pressures in shaping the evolution of mechanisms that act as informational

filters. Consequently, response-ready individuals may be expected to have evolved a keen capacity for strategic allocation of attentional resources in informationally demanding environments.

However, the suggestion that response-ready individuals exhibit such proficiencies runs counter to existing evidence. Indeed, this claim appears particularly indefensible in light of research indicating that ADHD is associated with deficits in selective attention in both children (e.g., Broduer & Pond, 2001) and adults (e.g., Park & Lee, 2021). Thus, insofar as ADHD is understood as the extreme expression of response-ready traits that otherwise vary in the population at large, these results appear to imply that individuals high in subclinical expression of response-ready traits should exhibit similar, albeit attenuated, difficulties in the strategic allocation of attentional resources. Indeed, individuals with difficulty directing attention more generally (i.e., those characterized by trait inattention) should intuitively exhibit such deficits. However, Sim's (2003) proposal of rational inattention offers an alternative interpretation. Rational inattention represents an extension of bounded rationality, and frames strategic use of inattention (i.e., inattentional ignorance of goal-irrelevant information) as an information filtering mechanism. Indeed, considered from this perspective, the difference between selective attention and rational inattention appears largely a matter of semantics, with both concepts arguably representing two sides of the same information-filtering coin.

Although appealing in reconciling seemingly maladaptive aspects of response-readiness with evolutionary theory, the conclusion that response-ready inattentive traits represent a unique information-filtering mechanism must still contend with the available

data. Namely, this conceptualization fails to explain why individuals especially high in response-ready traits (i.e., those with ADHD) exhibit deficient performance on measures of selective attention, as discussed above. However, the specificity principle, a central tenet of evolutionary psychology, argues that behavioral adaptations should be understood as *specific solutions* to *specific environmental challenges* (Tooby & Cosmides, 2015). Thus, the attentional filter hypothesis proposes that the inattentive traits of response-ready individuals represent a special case of rational inattention, shaped by natural selection to solve the specific problem of extracting useful information embedded within informationally dense response-ready environments.

Being shaped by evolution in response-ready environments, the attentional filter of response-ready individuals may be specifically tuned to the types of cues most pertinent in such environments. Thus, the demands placed by traditional tests of selective attention may not provide faithful analogs to the types of challenges that attentional filter evolved to address. Indeed, laboratory tests of selective attention often use neutral focal stimuli (e.g., characters of the Latin alphabet; Park & Lee, 2021) that are unlikely to approximate the survival-relevant cues that the attentional filter evolved to detect. As has already been noted, individuals especially high in response-ready traits (i.e., those with ADHD) have been demonstrated to specifically exhibit attentional biases toward threat-congruent stimuli (e.g., Posner et al., 2011), as well as negatively-valenced stimuli more generally (Passarotti et al., 2010). Such attentional biases suggest that the attentional filter may even be selectively sensitive to threat-congruent cues. Thus, the use of stimuli

of neutral valence more generally may be problematic in attempts to evoke activity in this information-filtering mechanism.

Although some laboratory measures of selective attention do employ aversive cues, these cues generally serve as distractors rather than focal cues. For instance, the emotional valence Stroop task (e.g., Passarotti et al., 2010) requires participants to identify the colors of both positively and negatively valenced words. Thus, this task measures selective attention as a function of the capacity to extract non-valenced, task-relevant information (i.e., the color of the word) while disregarding the task-irrelevant distractors (i.e., the emotional valence of the word). In this way, these tasks represent the inverse of the adaptive problems for which the attentional filter is proposed to have evolved, namely the extraction of negatively valenced (i.e., threat relevant) cues from affectively neutral informational environmental noise. Thus, an ideal test of the informational filter hypothesis would instead require the capacity to track threat-congruent information embedded in task-irrelevant environmental noise. Combination of this task with the above virtual reality foraging task may be particularly informative in elucidating the kinds of information to which this proposed filter is most sensitive, by examining the relative salience of resource-relevant, versus threat-relevant, cues. The development of such tasks is an important consideration in future research on the hyperactive facilitation theory.

General Limitations and Conclusion

General Limitations

As has been discussed previously in all three studies, sample characteristics present a potential limitation to the present research. Most notably, the female-biased samples used by each study may be problematic in light of the male-biased diagnostic rates of ADHD. Similarly, suboptimal operationalization of study variables represented a consistent limitation across all three studies of this project. Most notably, the use of the Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005) may not have been appropriate for capturing individual differences in subclinical expression of ADHD (i.e., response-ready) traits. As this tool was designed to detect the presence or absence of clinically-significant levels of hyperactivity and inattention, it was likely unable to detect subclinical variation in these traits. Thus, future research concerning subclinical expression of ADHD traits should use more objective, cognitive and behavioral measures, such as the use of an accelerometer to measure individual differences in hyperactivity (e.g., Wang et al., 2022), or the use of a delay discounting task to index individual differences in impulsivity (e.g., Reynolds et al., 2006). Indeed, hindsight makes clear that several of the study-specific variables may have been better operationalized as well. For instance, Study One operationalized dangerous rearing environment in terms of childhood physical abuse, as measured by the Childhood Trauma Questionnaire (CTQ; Bernstein et al., 2003). Although physical abuse by a caregiver is undeniably a manifestation of danger, research by Pollak and Kistler (2002) suggests that chronically abused children develop perceptual sensitivity to cues indicative of imminent

abuse, suggesting that childhood physical abuse may not have captured the kinds of unpredictable danger that characterized Jensen and colleagues' (1997) EEA.

On the note of the relative reliability of threat-congruent affect as a predictor of conspecific threats, the present approach of measuring threat detection as a function of anger recognition may have failed to adequately replicate the unpredictable nature of threats in response-ready environments (Jensen et al., 1997). Similarly, that threat detection proficiency was measured as a function of visual ambiguity, rather than reaction time, may have allowed participants greater scrutiny in the identification of threat-congruent stimuli than would have been afforded to ancestral humans in response-ready environments. Indeed, it is difficult to imagine that the predators lurking in response-ready environments would have demonstrated exemplary conscientiousness and consideration in allowing ancestral humans such a luxury. Nonetheless, the use of more traditional reaction time-based threat detection tasks, such as the dot-probe task (e.g., Frewen et al., 2008) would not only address all of the above concerns, but also facilitate tests of Jensen and colleagues' claim that impulsivity was adaptive in furnishing rapid responses to perceived threat cues.

Finally, the present implementation of the bead task (i.e., 75% black, 25% white; distribution ratio of 3:1) was likely not sufficiently challenging to detect individual differences in information seeking, necessitating that future implementations of the bead task in hyperactive facilitation theory research utilize more difficult distributions, namely those that more closely approximate a distribution ratio of 1:1 (e.g., 60% black, 30% white, distribution ration of 1.5:1; see Jacoby et al., 2014). However, the utilization of

three-dimensional search tasks (e.g., Arildskov et al., 2012; Maya et al., 2019) would be of greater utility in approximating the foraging challenges inherent in response-ready environments, and thus should be considered in future hyperactive facilitation theory research.

Conclusion

Despite its limitations, this project not only fills a notable gap in the evolutionary psychopathology literature by contributing some of the first direct empirical tests of response-readiness theory, but also outlines potentially fruitful theoretical and empirical directions in the future study of response-readiness. Across three studies, mixed support was found for the modified response-readiness theory. Study One found that at least two response-ready reaction norms, resource scarcity and environmental unpredictability, were significantly positively associated with the expression of trait inattention, and highlighted potential issues in the measurement of others (e.g., potential meaningful differences between dangers of predictable and unpredictable threats). Similarly, Study Two found that, consistent with the Hypervigilance Hypothesis, trait inattention was positively associated with biases in threat detection. Finally, Study Three found evidence that trait inattention, not hyperactivity, was associated with information-seeking tendencies, prompting reconsideration of not only the role of hyperactivity as a motivator of response-ready information-seeking tendencies, but of the role of hyperactivity in the expression of response-readiness more generally.

However, across all three studies, predictions made by response-readiness theory concerning hyperactivity were almost ubiquitously falsified. Indeed, whereas the non-

significant associations between hyperactivity and information seeking in Study Three raised questions as to its role in response-ready exploratory behavior, its relative insensitivity to response-ready reaction norms, as demonstrated in Study One, called into question its status as a response-ready trait more generally. Nonetheless, these results have illuminated a different potential role for hyperactivity in the expression of response-readiness, namely as a susceptibility factor that moderates the effects of response-ready environmental characteristics on the developmentally plastic expression of response-ready traits

This possibility lies at the heart of the hyperactive facilitation theory, which not only proposes that response-readiness constitutes a special case of differential susceptibility, but also leverages the present results in modifying the hypotheses in inherits from its theoretical predecessor (i.e., response-readiness theory). One such modification involves reconceptualizing hyperactivity not as a phenotypically plastic response to adverse rearing environments (i.e., the environmental adversity hypothesis), but as a susceptibility factor which amplifies the effects of response-ready reaction norms, or lack thereof, on individual differences in the developmentally plastic expression of response-ready traits (i.e., the readiness spectrum hypothesis). Similarly, although inattention is still argued to play a pertinent role in threat detection, it does so not through the facilitation of environmental scanning (i.e., the hypervigilance hypothesis), but by acting as a cognitive filter that sifts through environmental noise to isolate threat-congruent information (i.e., the attentional filter hypothesis). Finally, this novel theory proposes that the exploratory tendencies of response-ready individuals are

motivated not by hyperactivity (i.e., the exploratory hyperactivity hypothesis), but by intolerance of uncertainty (i.e., the uncertainty reduction hypothesis). Thus, although the present study disconfirms aspects of the modified response-readiness theory, it simultaneously presents clear future directions for its predecessor (i.e., the hyperactive facilitation theory). Indeed, further direction can be found in the thankfully rich differential susceptibility literature, not only in better designing empirical tests of the hyperactive facilitation theory, but in informing its further theoretical development.

APPENDIX A

IRB APPROVAL FOR STUDY ONE

OAKLAND UNIVERSITY

Institutional Review Board

Date: October 9, 2023

Study #: IRB-FY2024-61

Study Tile: ADHD Environment Study (AES23)

Submission Type: Initial

IRB Decision: Exempt

Research Team:
Jacob Pappas
Jennifer Vonk

Based on applicable federal regulations, the above referenced study has been determined to be Exempt, with the following categories:
Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:
Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or

Letter and Consent Document:
This letter along with the IRB approved (date-stamped) consent document can be found in Cayuse in the Submission Details page under Letters and Attachments, respectively. Please make sure to use the most recent IRB approved version of the consent form in consenting participants.

Permission from Research Sites:
Please note the following:

- This IRB exemption determination letter means that this research has met one or more of the federal criteria for exemption per 45 CFR 46.104- Exempt Research.
- Before the research is initiated, permission to conduct research at a given site must be obtained from all research locations listed in the IRB submission. You must keep copies of all such permission letters for your files.
- It is the responsibility of each researcher to follow all applicable policies and procedures of any outside institution where the research will be conducted.

Modifications:
Any changes to this exempt project must be reviewed by the IRB prior to initiation by submitting a MODIFICATION request. Do not collect data while the changes are being reviewed. Data collected during this time cannot be used in research.

Record Retention:
Exempt projects will be retained by the IRB office for three years after the last action on the project.

You are approved to start the research. Please retain a copy of this notification for your records.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

APPENDIX B

IRB APPROVAL FOR STUDY TWO

OAKLAND UNIVERSITY

Institutional Review Board

Date: January 24, 2024

Study #: IRB-FY2024-214

Study Tile: ADHD Vigilance and Cognitive Bias Study (AVCB24)

Submission Type: Initial

IRB Decision: Exempt

Research Team:
Jacob Pappas
Jennifer Vonk

Based on applicable federal regulations, the above referenced study has been determined to be Exempt, with the following categories:
Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:
Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or

Letter and Consent Document:
This letter along with the IRB approved (date-stamped) consent document can be found in Cayuse in the Submission Details page under Letters and Attachments, respectively. Please make sure to use the most recent IRB approved version of the consent form in consenting participants.

Permission from Research Sites:
Please note the following:

- This IRB exemption determination letter means that this research has met one or more of the federal criteria for exemption per 45 CFR 46.104- Exempt Research.
- Before the research is initiated, permission to conduct research at a given site must be obtained from all research locations listed in the IRB submission. You must keep copies of all such permission letters for your files.
- It is the responsibility of each researcher to follow all applicable policies and procedures of any outside institution where the research will be conducted.

Modifications:
Any changes to this exempt project must be reviewed by the IRB prior to initiation by submitting a MODIFICATION request. Do not collect data while the changes are being reviewed. Data collected during this time cannot be used in research.

Record Retention:
Exempt projects will be retained by the IRB office for three years after the last action on the project.

You are approved to start the research. Please retain a copy of this notification for your records.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

OAKLAND UNIVERSITY

Institutional Review Board

Date: February 19, 2025

Study #: IRB-FY2024-214

Study Tile: ADHD Vigilance and Cognitive Bias Study (AVCB24)

Submission Type: Modification

IRB Decision: Approved

Research Team:
Jacob Pappas
Jennifer Vonk

The IRB has reviewed the Modification submission related to the above referenced study and determined that the changes listed below do not affect the exemption status of the study. The Modification submission is Approved and the study remains Approved per federal regulations.

The approved modifications are the following:

- Addition of an additional 500 participants

You are approved to implement the aforementioned modifications. Please retain a copy of this notification for your records.

This letter can also be found in Cayuse under the Letters tab in the Submission Details page.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

APPENDIX C

IRB APPROVAL FOR STUDY THREE

OAKLAND UNIVERSITY

Institutional Review Board

Date: February 19, 2024

Study #: IRB-FY2024-247

Study Tile: ADHD Exploratory Behaviors Study (AEBS)

Submission Type: Initial

IRB Decision: Exempt

Research Team:
Jacob Pappas
Jennifer Vonk

Based on applicable federal regulations, the above referenced study has been determined to be Exempt, with the following categories:
Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:
Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or

Notes for Researcher(s):
This submission includes the following approved documents:

- SONA Recruitment
- Information Sheet V 2/19/24
- Survey Questionnaire

Letter and Consent Document:
This letter along with the IRB approved (date-stamped) consent document can be found in Cayuse in the Submission Details page under Letters and Attachments, respectively. Please make sure to use the most recent IRB approved version of the consent form in consenting participants.

Permission from Research Site(s):
Please note the following:

- This IRB exemption determination letter means that this research has met one or more of the federal criteria for exemption per 45 CFR 46.104- Exempt Research.
- Before the research is initiated, permission to conduct research at a given site must be obtained from all research locations listed in the IRB submission. You must keep copies of all such permission letters for your files.
- It is the responsibility of each researcher to follow all applicable policies and procedures of any outside institution where the research will be conducted.

Modifications:
Any changes to this exempt project must be reviewed by the IRB prior to initiation by submitting a MODIFICATION request. Do not collect data while the changes are being reviewed. Data collected during this time cannot be used in research.

Record Retention:
Exempt projects will be retained by the IRB office for three years after the last action on the project.

You are approved to start the research. Please retain a copy of this notification for your records.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

OAKLAND UNIVERSITY

Institutional Review Board

Date: February 19, 2025

Study #: IRB-FY2024-247

Study Tile: ADHD Exploratory Behaviors Study (AEBS)

Submission Type: Modification

IRB Decision: Approved

Research Team:
Jacob Pappas
Jennifer Vonk

The IRB has reviewed the Modification submission related to the above referenced study and determined that the changes listed below do not affect the exemption status of the study. The Modification submission is Approved and the study remains Approved per federal regulations.

The approved modifications are the following:

- Addition of an additional 500 participants

You are approved to implement the aforementioned modifications. Please retain a copy of this notification for your records.

This letter can also be found in Cayuse under the Letters tab in the Submission Details page.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

OAKLAND UNIVERSITY

Institutional Review Board

Date: February 20, 2024

Study #: IRB-FY2024-247

Study Tile: ADHD Exploratory Behaviors Study (AEBS)

Submission Type: Modification

IRB Decision: Exempt

Research Team:
Jacob Pappas
Jennifer Vonk

The IRB has reviewed the Modification submission related to the above referenced study and determined that the changes listed below do not affect the exemption status of the study. The Modification submission is Approved and the study remains Exempt per federal regulations.

The approved modifications are the following:

- Revise the survey by adding demographic questions.

This submission includes the following approved document:

- Revised survey

You are approved to implement the aforementioned modifications. Please retain a copy of this notification for your records.

This letter can also be found in Cayuse under the Letters tab in the Submission Details page.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB

APPENDIX D

ADULT ADHD SELF-REPORT SCALE

Adult ADHD Self-Report Scale (ASRS)

Please answer each question below, rating yourself on each of the criteria shown. As you answer each question, select the box that best describes how you have felt and conducted yourself over that past 6 months.

Never	Rarely	Sometimes	Often	Very Often

1. How often do you have trouble wrapping up the final details of a project, once the challenging points have been done?
2. How often do you have difficulty getting things in order when you have to do a task that requires organisation?
3. How often do you have problems remembering appointments or obligations?
4. When you have a task that requires a lot of thought, how often do you avoid or delay getting started?
5. How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?
6. How often do you feel overly active and compelled to do things, like you were driven by a motor?
7. How often do you make careless mistakes when you have to work on a boring or difficult project?
8. How often do you have difficulty keeping your attention when you are doing boring or repetitive work?
9. How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?
10. How often do you misplace or have difficulty finding things at home or at work?
11. How often are you distracted by activity or noise around you?
12. How often do you leave your seat in meetings or other situations in which you are expected to remain seated?
13. How often do you feel restless or fidgety?
14. How often do you have difficulty unwinding and relaxing when you have time to yourself?
15. How often do you find yourself talking too much when you are in social situations?
16. When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves?

17. How often do you have difficulty waiting your turn in situations when turn taking is required?
18. How often do you interrupt others when they are busy?

Scoring Criteria:

Inattentiveness Subscale: 1, 2, 3, 4, 7, 8, 9, 10, 11

Hyperactivity/Impulsivity Subscale: 5, 6, 12, 13, 14, 15, 16, 17, 18

Reference:

Kessler, R. C., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E. V. A., ... & Walters, E. E. (2005). The World Health Organization Adult ADHD Self-Report Scale (ASRS): a short screening scale for use in the general population. *Psychological medicine*, *35*(2), 245-256.

APPENDIX E

CHILDHOOD HARSHNESS SCALE

Childhood Harshness Scale (CHS)

Instructions: Think back to your life when you were younger than 10. This time includes preschool, kindergarten, and the first few years of elementary school. Rate the extent to which you agree with each of the following statements.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

1. Despite how much my parents worked, my family rarely had enough money for luxury items.
2. I felt uncomfortable asking my parents for money because money was tight.
3. We had to try to save money when shopping for anything.
4. Growing up, I rarely got spoiled because money was so tight.
5. My family was strained financially.
6. I never had the newest style of shoes or clothes.
7. My family rarely had enough money to go out for a nice dinner.
8. My family and I were usually able to purchase expensive presents for holidays, birthdays, etc.
9. My family usually had enough money for things when I was growing up.
10. I grew up in a relatively wealthy neighborhood.
11. I felt relatively wealthy compared with other kids in my school.

Scoring Criteria:

Childhood Harshness: 1, 2, 3, 4, 5, 6, 7, 8, 9*, 10*, 11**

*Note: * indicates reverse scored item(s).*

Reference:

Maranges, H. M., Hasty, C. R., Martinez, J. L., & Maner, J. K. (2022). Adaptive calibration in early development: Brief measures of perceived childhood harshness and unpredictability. *Adaptive human behavior and physiology*, *8*(3), 313-343.

APPENDIX F

CHILDHOOD UNPREDICTABILITY SCALE

Childhood Unpredictability Scale (CUS)

Instructions: Think back to your life when you were younger than 10. This time includes preschool, kindergarten, and the first few years of elementary school. Rate the extent to which you agree with each of the following statements.

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

1. I could not predict which of many caretakers (e.g., babysitters, nannies, neighbors, family) would be watching me.
2. I did not know what to expect from my family when I had friends over.
3. I did not know when I would see my parent(s).
4. I had a hard time knowing what my parent(s) or other people in my house were going to say.
5. I never knew whether my parents would be there to pick me up from school.
6. I often did not know what to expect from other students at school.
7. I was never certain where it was safe to play.
8. My family environment was often tense and on edge.
9. My family life was generally inconsistent and unpredictable from day-to-day.
10. People often moved in and out of my house fairly frequently.
11. The traffic around the house(s) I lived was unpredictable and chaotic.
12. Things were often chaotic in my house.
13. When I left my house I was never quite certain what would happen in my neighborhood.
14. When I woke up, I often didn't know what could happen in my house that day.
15. My family had a consistent schedule, so I know what to expect each day.

Scoring Criteria:

*Childhood Unpredictability: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11. 12, 13, 14, 15**

*Note: * indicates reverse scored item(s).*

Reference:

Maranges, H. M., Hasty, C. R., Martinez, J. L., & Maner, J. K. (2022). Adaptive calibration in early development: Brief measures of perceived childhood harshness and unpredictability. *Adaptive human behavior and physiology*, *8*(3), 313-343.

APPENDIX G

CHILDHOOD TRAUMA QUESTIONNAIRE

Childhood Trauma Questionnaire – Short Form (CTQ-SF)

Please indicate how often the following occurrences were true of your childhood or adolescent experience.

1	2	3	4	5
Never true	Rarely true	Sometimes true	Often true	Very often true

1. Called names by family
2. Parents wished was never born
3. Felt hated by family
4. Family said hurtful things
5. Was emotionally abused
6. Hit hard enough to see doctor
7. Hit hard enough to leave bruises
8. Punished with hard objects
9. Was physically abused
10. Hit badly enough to be noticed
11. Was touched sexually
12. Hurt if didn't do something sexual
13. Made to do sexual things
14. Was molested
15. Was sexually abused
16. Felt loved
17. Made to feel important
18. Was looked out for
19. Family felt close
20. Family was source of strength
21. Not enough to eat
22. Got taken care of
23. Parents were drunk or high
24. Wore dirty clothes
25. Got taken to doctor

Scoring Criteria:

Emotional Abuse: 1, 2, 3, 4, 5

Physical Abuse: 6, 7, 8, 9, 10

Sexual Abuse: 11, 12, 13, 14, 15

Emotional Neglect: 16, 17*, 18*, 19*, 20**

Physical Neglect: 21, 22, 23, 24, 25**

*Note: * indicates reverse scored item(s).*

Reference:

Bernstein, D. P., Stein, J. A., Newcomb, M. D., Walker, E., Pogge, D., Ahluvalia, T., Stokes, J., Handelsman, L., Medrano, M., Desmond, D., & Zule, W. (2003). *Childhood Trauma Questionnaire--Short Form (CTQ-SF)* [Database record]. APA PsycTests.

https://doi.org/10.1037/t09716-000

APPENDIX H

COGNITIVE TRIAD INVENTORY

Cognitive Triad Inventory

This inventory lists different ideas that people sometimes have. For each of these ideas, show how much you agree with it by selecting the answer that best describes your opinion. Answer the items for what you are thinking right now.

TOTALLY DISAGREE	MOSTLY DISAGREE	SLIGHTLY DISAGREE	NEUTRAL	SLIGHTLY AGREE	MOSTLY AGREE	TOTALLY AGREE

1. I have many talents and skills.
2. My job (housework, schoolwork, daily duties) is unpleasant.
3. Most people are friendly and helpful.
4. Nothing is likely to work out for me.
5. I am a failure.
6. I like to think about the good things that lie ahead for me.
7. I do my work (job, schoolwork, housework) adequately.
8. The people I know help me when I need it.
9. I expect things will be going very well for me a few years from now.
10. I have messed up almost all the important relationships I ever had.
11. The future holds a lot of excitement for me.
12. My daily activities are fun and rewarding.
13. I can’t do anything right.
14. People like me.
15. There is nothing left in my life to look forward to.
16. My current problems or concerns will always be there in one way or another.
17. I am as adequate as other people I know.
18. The world is a very hostile place.
19. There is no reason for me to be hopeful about my future.
20. The important people in my life are helpful and supportive.
21. I hate myself.
22. I will overcome my problems.
23. Bad things happen to me a lot.
24. I have a spouse or friend who is warm and supportive.
25. I can do a lot of things well.
26. My future is simply too awful to think about.
27. My family doesn’t care what happens to me.

28. Things will work out well for me in the future.
29. I am guilty of a great many things.
30. No matter what I do, others make it difficult for me to get what I need.
31. I am a worthwhile human being.
32. There is nothing to look forward to in the years ahead.
33. I like myself.
34. I am faced with many difficulties.
35. I have serious flaws in my character.
36. I expect to be content and satisfied as the years go by.

Scoring Criteria:

Negative Beliefs About Self Subscale: 5, 10, 13, 17, 21, 25*, 29, 31*, 33*, 35*

Negative Beliefs About Future Subscale: 6, 9*, 11*, 15, 16, 19, 26, 28*, 32, 36**

Negative Beliefs About World Subscale: 3, 8*, 12*, 18, 20*, 23, 24*, 27, 30, 34*

*Note: * indicates a reverse-scored item*

Reference:

Beckham, E. E., Leber, W. R., Watkins, J. T., Boyer, J. L., & Cook, J. B. (1986). Development of an instrument to measure Beck's cognitive triad: the Cognitive Triad Inventory. *Journal of consulting and clinical psychology*, *54*(4), 566–567. https://doi.org/10.1037//0022-006x.54.4.566

APPENDIX I

DIFFICULTIES IN EMOTION REGULATION – SHORT FORM

Difficulties in Emotion Regulation – Short Form (DERS-SF)

Please indicate how often the following apply to you.

Almost Never (0-10%)	Sometimes (11-35%)	About Half of the Time (36-65%)	Most of the Time (66-90%)	Almost Always (91-100%)

1. I pay attention to how I feel
2. I have no idea how I am feeling
3. I have difficulty making sense out of my feelings
4. I care about what I am feeling
5. I am confused about how I feel
6. When I am upset, I acknowledge my emotions
7. When I am upset, I become embarrassed for feeling that way
8. When I am upset, I have difficulty getting work done
9. When I am upset, I become out of control
10. When I am upset, I believe that I will end up feeling very depressed
11. When I am upset, I have difficulty focusing on other things
12. When I am upset, I feel guilty for feeling that way
13. When I am upset, I have difficulty concentrating
14. When I am upset, I have difficulty controlling my behaviors
15. When I am upset, I believe there is nothing I can do to make myself feel better
16. When I am upset, I become irritated with myself for feeling that way
17. When I am upset, I lose control over my behavior
18. When I am upset, it takes me a long time to feel better

Scoring Criteria:

Strategies: 10, 15, 18

Non-Acceptance: 7, 12, 16

Impulse: 9, 14, 17

Goals: 8, 11, 13

Awareness: 1, 4*, 6**

Clarity: 2, 3 5

*Note: * indicates item is reverse scored*

Reference:

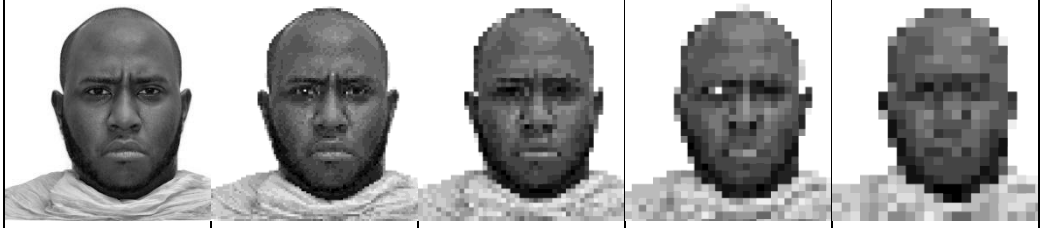
Kaufman, E. A., Xia, M., Fosco, G., Yaptangco, M., Skidmore, C. R., & Crowell, S. E. (2015). The difficulties in emotion regulation scale short form (DERS-SF): Validation and replication in adolescent and adult samples. *Journal of Psychopathology and Behavioral Assessment*, doi:10.1007/s10862-015-9529-3

APPENDIX J

THREAT DETECTION TASK STIMULI

Figure A.1

Anger Displays, Organized By Race and Block Size

Stimulus Race	Block Size: 0	15	30	45	60
Asian					
	A0A	*A15A*	*A30A*	*A45A*	*A60A*
Black					
	A0B	*A15B*	*A30B*	*A45B*	*A60B*
Hispanic					
	A0H	*A15H*	*A30H*	*A45H*	*A60H*
White					
	A0W	*A15W*	*A30W*	*A45W*	*A60W*

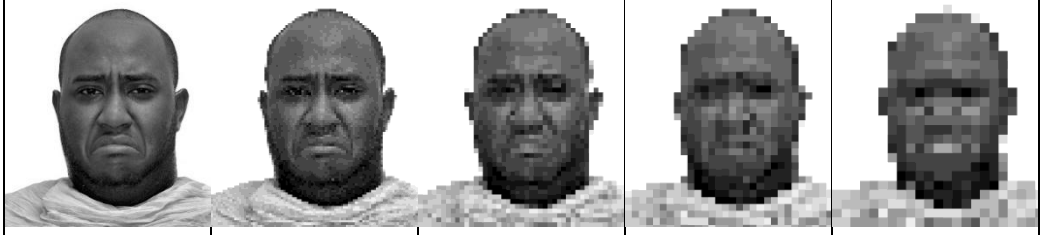
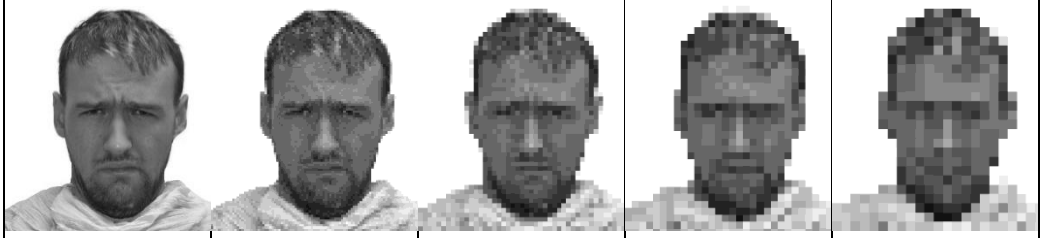
Note. Block size indicates level of pixelation, with higher numbners indicate greater pixelation, and thus distortion of the image.

Figure A.2
Neutral Displays, Organized By Race and Block Size

Stimulus Race		Block Size				
		0	15	30	45	60
	Asian					
		C0A	*C15A*	*C30A*	*C45A*	*C60A*
	Black					
		C0B	*C15B*	*C30B*	*C45B*	*C60B*
	Hispanic					
		C0H	*C15H*	*C30H*	*C45H*	*C60H*
	White					
		C0W	*C15W*	*C30W*	*C45W*	*C60W*

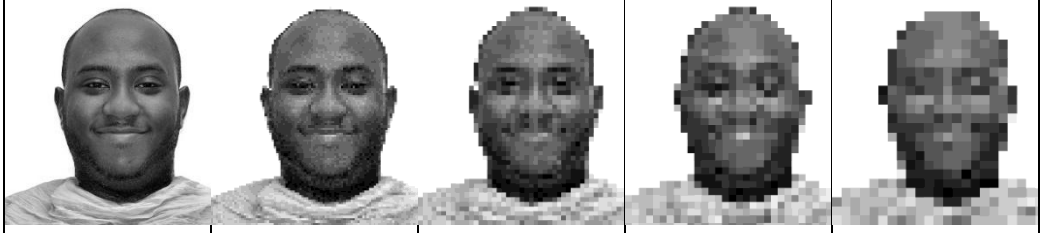
Note. Block size indicates level of pixelation, with higher numbners indicate greater pixelation, and thus distortion of the image.

Figure A.3
Disgust Displays, Organized By Race and Block Size

Stimulus Race		Block Size				
		0	15	30	45	60
	Asian					
		D0A	*D15A*	*D30A*	*D45A*	*D60A*
	Black					
		D0B	*D15B*	*D30B*	*D45B*	*D60B*
	Hispanic					
		D0H	*D15H*	*D30H*	*D45H*	*D60H*
	White					
		D0W	*D15W*	*D30W*	*D45W*	*D60W*

Note. Block size indicates level of pixelation, with higher numbners indicate greater pixelation, and thus distortion of the image.

Figure A.4
Happy Displays, Organized By Race and Block Size

Stimulus Race		Block Size				
		0	15	30	45	60
	Asian					
		H0A	*H15A*	*H30A*	*H45A*	*H60A*
	Black					
		H0B	*H15B*	*H30B*	*H45B*	*H60B*
	Hispanic					
		H0H	*H15H*	*H30H*	*H45H*	*H60H*
	White					
		H0W	*H15W*	*H30W*	*H45W*	*H60W*

Note. Block size indicates level of pixelation, with higher numbners indicate greater pixelation, and thus distortion of the image.

APPENDIX K

MULTIDIMENSIONAL ATTITUDES TOWARD AMBIGUITY SCALE

Multidimensional Attitudes Toward Ambiguity Scale (MAAS)

In this part, we are interested in how people respond when they confront particular situations in their lives. This questionnaire asks you to indicate what you generally do and feel when you experience these situations. Try to respond to each item independently from other items on the questionnaire. Choose your answers thoughtfully, making your responses as true for you as possible. There are no correct or incorrect answers, we are most interested in the response that is accurate for you, not what you think "most people" would feel.

I strongly disagree	I disagree enough	I mildly disagree	I neither agree nor disagree	I mildly agree	I agree enough	I strongly agree

1. There are two kinds of people in the world: the weak and the strong
2. I pursue problem situations that are so complex some people call them "mind boggling."
3. It intensely disturbs me when I am uncertain of how my actions will affect others
4. A person either knows the answer to a question or he doesn't.
5. I often find myself looking for something new, rather than trying to hold things constant in my life.
6. I don't feel comfortable with people until I can find out something about them.
7. There are two kinds of people: the "good" and the "bad."
8. I'm drawn to situations which can be interpreted in more than one way.
9. I am just a little uncomfortable with people unless I feel that I can understand their behavior.
10. You can classify almost all people as either honest or crooked.
11. I generally prefer novelty over familiarity.
12. I get pretty anxious when I'm in a social situation involving me which I have little control of.
13. Personally, I tend to think that there is a right way and a wrong way to do almost everything.
14. Vague and impressionistic pictures appeal to me more than realistic pictures.
15. It bothers me when I don't know how other people react to me.
16. Nothing gets accomplished in this world unless you stick to some basic rules.
17. I tend to like obscure or hidden symbolism.
18. I always want to know what people are laughing at.
19. There's a right way and a wrong way to do almost everything.

20. Some problems are so complex that just trying to understand them is fun.
21. I get pretty anxious when I'm in a social situation over which I have no control.
22. Generally, the more meanings a poem or story has, the better I like it.
23. If I am uncertain about the responsibilities of a job, I get very anxious.
24. A good job is one where what is to be done and how it is to be done are always clear.
25. It is more fun to tackle a complicated problem than to solve a simple one.
26. A person is either a 100% patriotic or he isn't.
27. I enjoy carefully rehashing my conversations in my mind afterwards.
28. I enjoy tackling problems which are complex enough to be ambiguous.
29. If I don't get the punch line of a joke, I don't feel right until I understand it.
30. Our thinking would be a lot better off if we would just forget about words like "probably," "approximately," "perhaps."

Scoring Criteria:

Discomfort with Ambiguity: 3, 6, 9, 12, 15, 23, 29

Moral Absolutism: 1, 4, 7, 10, 19, 26, 30

Need for Complexity: 2, 8, 14, 17, 20, 25, 28

Reference:

Lauriola, M., Foschi, R., Mosca, O., & Weller, J. (2015). Attitude Toward Ambiguity: Empirically Robust Factors in Self-Report Personality Scales. *Assessment*, *23*(3), 353-373. https://doi.org/10.1177/1073191115577188

APPENDIX L

DOMAIN-SPECIFIC INFORMATION SEEKING SCALE

Domain-Specific Information Seeking Scale (DSISS)

Below is a list of statements concerning scenarios you might find yourself in. Please rate each scenario on a scale of 1-5 based on the likelihood of how much you would agree or disagree with the statement. (1 being strongly disagree; 5 being strongly agree)

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

1. I need to seek real-world evidence to be certain that my religious beliefs are true.
2. I'm not interested in seeking other people's instruction on how I should raise my children
3. If my best friend told me that an acquaintance of mine was a liar, I would investigate the claim on my own.
4. I would seek other financial opportunities even if my current financial investments are successful.
5. If my doctor recommends a prescription, I would research more about the drug from other sources before taking it.
6. When I discuss politics with people who support a different political party than I do, I make a sincere effort to understand their points of view.
7. If my sexual partner suddenly lost interest in sex, I immediately assume they are seeing someone else.
8. If a member of my immediate family is accused of doing something terrible, I do not need outside information to know that they are innocent.
9. I answer job interview questions based on information about the company's expectations rather than my instincts
10. Even if a food item is advertised as a diet food, I would still investigate its nutritional value from other sources.
11. If new research emerged that was contrary to my moral views about stem cell research, I would be interested in reading more about it.
12. I would immediately end the relationship with my boyfriend/girlfriend if someone I respected told me that my partner was cheating on me.
13. If I heard from an anonymous person via e-mail that someone I know has been bad-mouthing me, I would decide to ask other opinions before I believe the rumor to be true.
14. If a company advertises a rare half-off sale on the latest cell phone and only three are left, I would still take the time to research and compare the phone to other options before thinking about buying it.
15. If my exercise routine doesn't feel good, I would ask a trainer to make sure I'm doing it correctly.

16. I am not interested in what others think about my cultural traditions if they are not from a similar background.
17. If my child was suspended for fighting at school, I would want to know the details of the incident from other sources before punishing him/her.
18. If I'm told by a good friend not to befriend someone because others don't like that person, I immediately take their advice.
19. If I read an article on the internet foreshadowing a serious drop in value for stock shares that I currently own, I would sell my shares right away.
20. I do not see my doctor for my annual physical if I feel healthy.
21. My religious faith is all I need to confirm that God is real.
22. I look for clues from my sexual partner about the best ways to sexually please them rather than relying on my own experiences.
23. If my sibling insists that they do not have something that belongs to me, I would be inclined to look among their belongings for it anyway.
24. If I heard informal rumors that the company I work for is going to lay people off, I would start searching for other jobs as soon as soon as possible.
25. If I am considering three different diet plans, I would immediately choose the one that looks the healthiest.
26. If a political candidate that I admire is proposing a new policy that aims to reform the education system, I would support the program without questioning it.
27. If my date never showed up to a scheduled meeting place, I would attempt to contact him/her before assuming that I was stood up.
28. When I meet a person for the first time, I judge their character based on what my instincts tell me about them rather than solely by their actions.\
29. If I am comparing three different laptops that are offered at the same price and have similar specifications, I would rely on my intuition to decide which one to buy.
30. When confronted with a new piece of exercise equipment, I would start using it based on how I think it should be used without reading through instructions.
31. I don't need to hear details about specific cases to decide whether the death penalty is right or wrong.
32. If I noticed an appliance wasn't working shortly after I saw my child touching it, I would search for other possible causes before blaming it on my child.
33. If my friends insist that I meet them at a fun party, I would explore information about the party instead of just trusting my friends.
34. If my bank introduces me to a new online account system that I am not familiar with, I would research more about it before deciding to switch to the new system.
35. If my doctor informs me that I have a fairly serious medical condition, I would look for second opinions from other medical sources before following the recommended treatment plan.
36. I follow cultural traditions of my family without questioning whether they make sense
37. If my sexual partner can't have an orgasm with me, I automatically conclude that it is because of their own issues.

38. If an immediate family member insists that I take their word for something, I still search for additional sources of information.
39. If I was offered a new job in a distant city, I would spend several days in the new city investigating the area before seriously considering the new position.
40. An unfamiliar website reported that a specific food causes weight gain, so I stop consuming that food.
41. When learning about a new religion, I want to explore its validity even if it contradicts my own religious beliefs.
42. I listen to my gut feeling when deciding the right time to flirt with someone I'm attracted to.
43. If I decide to invite a stranger to my home, I would do so based on only my intuitive feelings about them.
44. Before making a large purchase of an item at a store that is advertising having the best price, I will always check out comparison prices at other stores.
45. If my knees get sore from running daily, I investigate different ways I can alleviate the problem rather than waiting to see if it will clear up on its own.
46. I don't investigate the legitimacy of the political stories I read if they are consistent with my points of view.
47. I will decide the school I want my child to attend based on researching the candidates rather than by my own intuition.
48. When my friend gives me advice about something they are knowledgeable about, I have no intention of searching for advice elsewhere.
49. My long-term invested stock shares are plummeting, so I sell them off immediately.
50. If doctor puts me on an antibiotic plan but I'm not getting better, I would start looking into other ways to get better on my own.
51. From a moral standpoint, I have clear ideas about the use of recreational drugs so I am not interested in different opinions from others.
52. I would be open to investigating new sexual activities even if my sex life was already satisfying.
53. When family members are having a disagreement about something I already have an opinion about, I would seek out both points of view before taking sides.
54. If I receive two job offers, I would rely on my intuition in deciding which to choose.
55. If I heard that processed foods can cause cancer, I'd look at the research before eliminating frozen dinners from my diet.
56. Instead of accepting popular customs I am comfortable with, I would like to explore traditions from other cultures.
57. If a new romantic partner behaves jealously or too clingy, I try to see if they've been through something that would explain their behavior before determining them to be too "needy."
58. I don't judge strangers based on the first things I hear them say.
59. If I hear that a new TV company offers the lowest rates available for a limited time, I would purchase the TV immediately.

60. If someone suggests a way to break a bad health habit, I would try the new method immediately, no matter how crazy it sounds.

Scoring Criteria

Philosophical Beliefs and Traditions

Religious Beliefs: 1, 21, 41*

Political Beliefs: 6, 26, 46**

Moral Beliefs: 11, 31, 51**

Cultural Traditions: 16, 36*, 56*

Mating, Dating, and Child Care

Child Care: 2, 17, 32, 47*

Sex: 7, 22, 37*, 52*

Dating and Romance: 12, 27, 42*, 57*

Social Relationships

Relationships with Friends: 3, 18, 33, 48**

Relationships with Family: 8, 23, 38, 53*

Relationships with Strangers: 13, 28, 43*, 58*

Finance and Business

Financial Decisions: 4, 19, 34, 49**

Work-Related Behaviors: 9, 24, 39, 54**

Purchasing Items and Goods: 14, 29, 44, 59**

Health

Medical Health: 5, 20, 35, 50*

Dieting: 10, 25, 40, 55*

Exercising Habits: 15, 30, 45, 60**

*Note: * indicates item is reverse scored*

Reference:

Vonk, J., Brothers, B., & Zeigler-Hill, V. (2021). Ours is not to reason why: Information seeking across domains. *Psychology of Religion and Spirituality, 13*(3), 314–323. https://doi.org/10.1037/rel0000304

APPENDIX M

BEAD TASK STIMULI

Bead Task

For this next exercise, think about two jars full of beads:

Jar A is filled mostly with black (75% black, 25% white)
Jar B is filled mostly with white (25% black, 75% white).

For each stage of this exercise, you will be shown a sequence of beads pulled from one of these jars. You will then be given an option to:

(A) decide which jar the beads came from
OR
(B) request more information in the form of an additional bead

Figure A.5
Bead Task Stimuli

Trial #	**Stimulus**
1	See the most recent sequence below: ● Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
2	See the most recent sequence below: ●● Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

3	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
4	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
5	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
6	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
7	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

8	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
9	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
10	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
11	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
12	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

13	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
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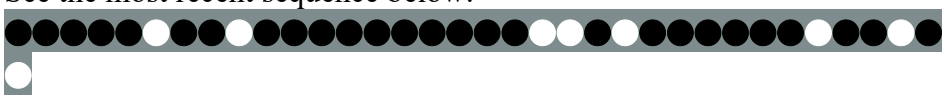
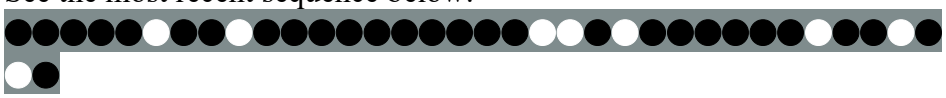
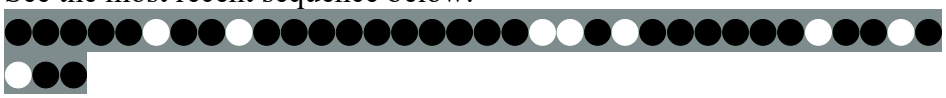
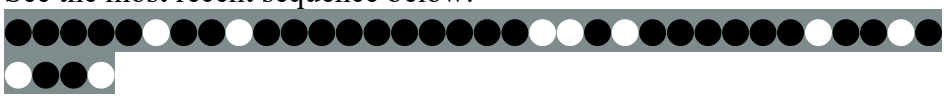
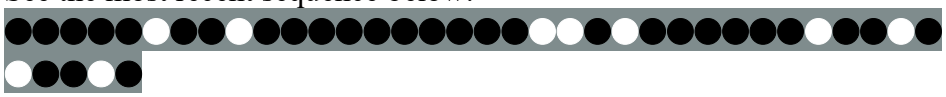
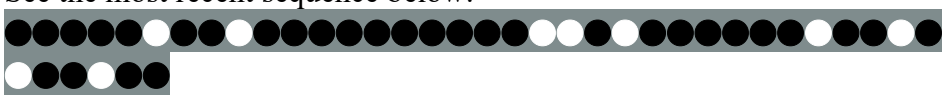
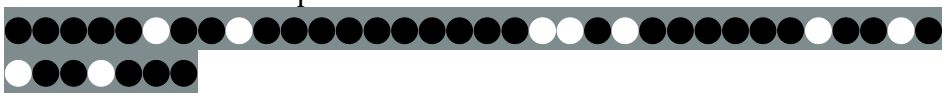
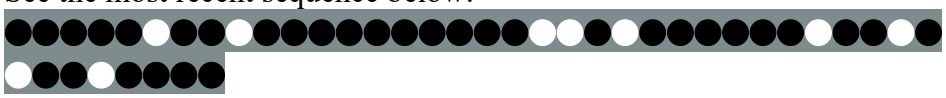
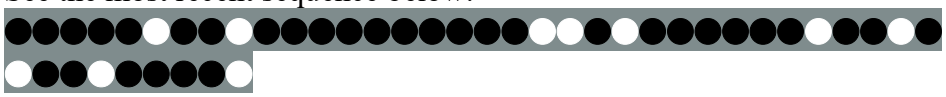
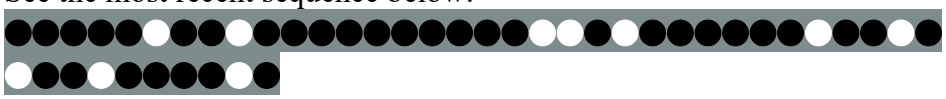
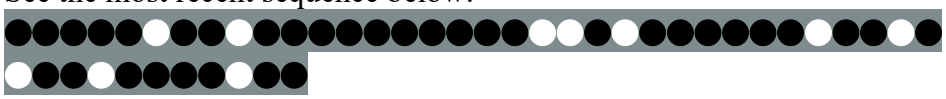
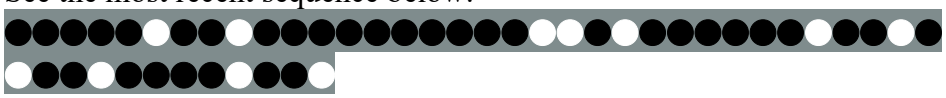
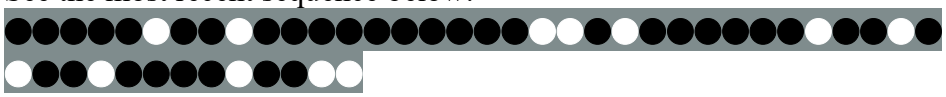
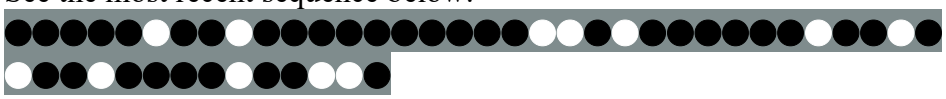
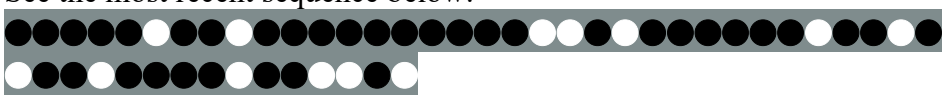
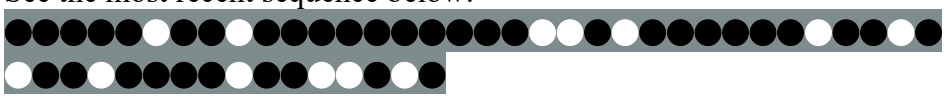
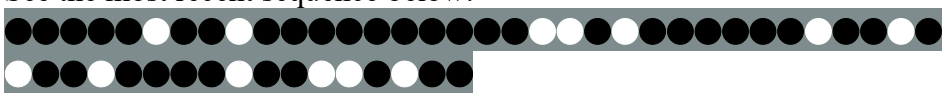
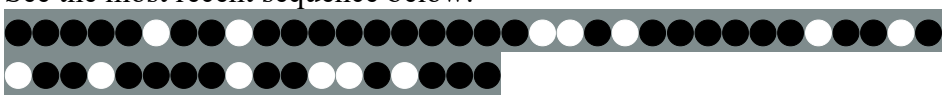
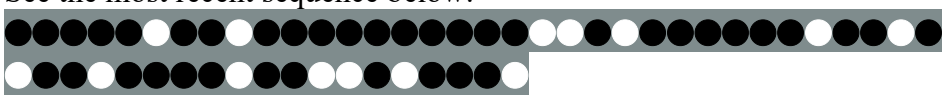
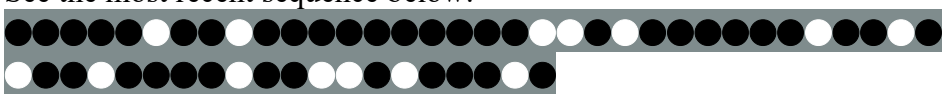
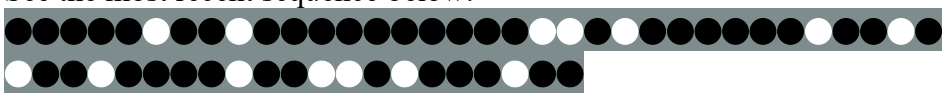
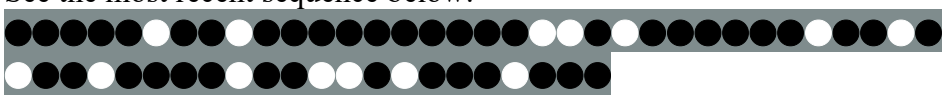
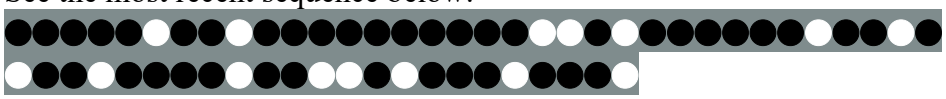
35	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
36	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
37	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

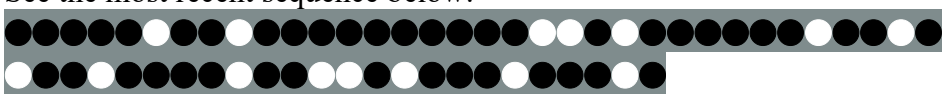
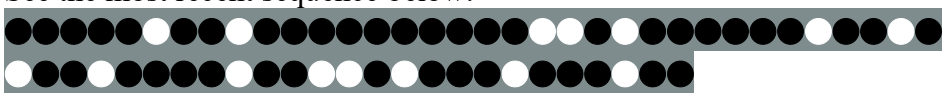
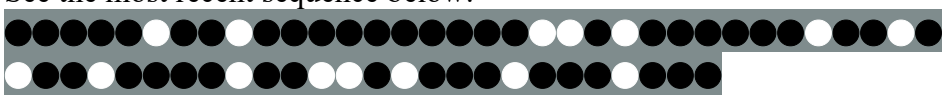
38	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
39	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
40	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
41	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

42	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
43	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
44	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
45	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

46	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
47	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
48	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
49	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

50	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
51	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
52	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
53	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

54	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
55	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
56	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
57	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)

58	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
59	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white) o I would like more information (Show another bead)
60	See the most recent sequence below:  Which jar are the beads being pulled from? o Jar A (75% black, 25% white) o Jar B (25% black, 75% white)

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