UNIVERSITY OF CALIFORNIA,
IRVINE

An Investigation of Affective Experiences in Schizophrenia-Spectrum Risk Through the Lens of Dynamic Systems Theory

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Psychological Science

by

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I would like to express my sincerest gratitude to several key people in my journey as a budding scientist. It takes a village to raise a PhD and I would not be where I am today without their guidance and support.

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VITA

LILIAN YANQING LI

EDUCATION

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Graduate Dean's Dissertation Fellowship, UCI [$5000]	2020
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APAGS Psychological Science Research Grant [$1000]	2019
Graduate Student Summer Mentor Fellowship, UCI [$1000]	2018
Graduate Student Mentoring Award, UCI [$200-300]	2018-2020
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PEER-REVIEWED PUBLICATIONS

9. **Li, L. Y.**, Cicero, D. C., Dodell-Feder, D., Germine, L., & Martin, E. A. (2021). Comparability of social anhedonia across epidemiological dimensions: A multi-national study of measurement invariance of the Revised Social Anhedonia Scale. *Psychological Assessment, 33*, 171-179.
8. Hu, D. K., **Li, L. Y.**, Lopour, B. A., & Martin, E. A. (2020). Schizotypy dimensions are associated with altered resting state alpha connectivity. *International Journal of Psychophysiology, 155*, 175-183.
7. **Li, L. Y.**, Castro, M. K., & Martin, E. A. (2020). What you want may not be what you like: A test of the aberrant salience hypothesis in schizophrenia risk. *Cognitive, Affective, & Behavioral Neuroscience, 20*, 873-887.
6. Martin, E. A., **Li, L. Y.**, & Castro, M. K. (2020). Electrophysiological responses to images ranging in motivational salience: Attentional abnormalities associated with schizophrenia-spectrum disorder risk. *Scientific Reports, 10*, 4578.

5. **Li, L. Y.**, Meyer, M. S., Martin, E. A., Gross, G. M., Kwapil, T. R., & Cicero, D. C. (2020). Differential item functioning of the Multidimensional Schizotypy Scale and Multidimensional Scale-Brief across ethnicity. *Psychological Assessment, 32*, 383-393.
4. **Li, L. Y.**, Fung, C. K., Moore, M. M., & Martin, E. A. (2019). Differential emotional abnormalities among schizotypy clusters. *Schizophrenia Research, 208*, 285-292.
3. Martin, E. A., Castro, M. K., **Li, L. Y.**, Urban, E. J., & Moore, M. M. (2019). Emotional response in schizophrenia to the "36 questions that lead to love": Predicted and experienced emotions regarding a live social interaction. *PLoS ONE, 14*, e0212069.
2. **Li, L. Y.**, Karcher, N. R., Kerns, J. G., Fung, C. K., & Martin, E. A. (2019). The subjective-objective deficit paradox in schizotypy extends to emotion regulation and awareness. *Journal of Psychiatric Research, 111*, 160-168.
1. Chan, J. L., Kobashigawa, J. A., Aintablian, T. L., **Li, Y.**, Luu, M., Perry, P. A., … Esmailian, F. (2017). Vasoplegia after heart transplantation: outcomes at one-year. *Interactive CardioVascular and Thoracic Surgery*, *25*, 212-217.

SELECTED CONFERENCE PRESENTATIONS

1. **Li, L. Y.**, & Martin, E. A. (2020, April). *Modeling the temporal affect dynamics of schizotypal ambivalence*. Poster to be presented at the 7th Annual Meeting of the Society for Affective Science, San Francisco, CA. (Cancelled due to COVID-19)
2. **Li, L. Y.**, Karcher, N. R., Kerns, J. G., Fung, C. K., & Martin, E. A. (2019, June). *The subjective-objective deficit paradox in schizotypy extends to emotion regulation and awareness*. Talk presented at the 3rd Biannual Meeting of the International Consortium on Schizotypy Research, New Orleans, LA.
3. **Li, L. Y.**, Cicero, D. C., Krieg, X., & Martin, E. A. (2017, June). *Differential item functioning of the full and brief Wisconsin Schizotypy Scales in Asian, White, Hispanic, and Multiethnic samples*. Talk presented at the 2nd Biannual Meeting of the International Consortium on Schizotypy Research, Beijing, China.
4. **Li, L. Y.**, & Berman, M. (2017, April). *Interference resolution in bipolar disorder*. Poster presented at the 4th Annual Meeting of the Society for Affective Science, Boston, MA.
5. **Li, Y.**, & Berenbaum, H. (2015, October). *Emotion and superstitious beliefs*. Poster presented at the 29th Annual Meeting of the Society for Research in Psychopathology, New Orleans, LA.

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Behaviors, Emotions, and Affective Neuroscience Lab, UCI 2016-Present
Graduate Student Researcher, Advisor: Dr. Elizabeth Martin
Examine affect processing in people at risk for schizophrenia-spectrum disorders using self-report, behavioral, and EEG methodologies. Recruit, train, and supervise undergraduate and post-baccalaureate research assistants.

Environmental Neuroscience Lab, UChicago 2014-2015
Graduate Student Researcher, Advisor: Dr. Marc Berman
Examined naturalness perception and its influence on cognition and behavior.

Berenbaum Lab, UIUC 2012-2014
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Examined emotion and cognitive correlates of superstitious beliefs.

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Social Ecology Honors Program, UCI — April, 2021
Invited Panelist — December, 2020
Presented common obstacles and strategies of academic research to students (17) enrolled in the Honors Program.

Department of Psychological Science, UCI — 2017-2020
Graduate Student Peer Mentor
Helped guide an incoming graduate student through the first year of graduate school.

Department of Psychological Science, UCI — September-December, 2018
Faculty Search Committee Member
Graduate student representative of the search committee for the director of clinical training position.

Society for Research in Psychopathology — September-November, 2018
Student Contributor, Publication Committee
Interviewed prominent SRP members and contributed to the publication of the interview in 2018 student-driven newsletter.

SELECTED TEACHING & TRAINING EXPERIENCE

Guest Lecturer — February, 2020
"Substance-related, Addictive, and Impulse-Control Disorders" in Abnormal Psychology (Instructor: Dr. Stephen Schueller)

Teaching Assistant — 2016-2020
Courses: Psychology Fundamentals (Intro to Psychology), Abnormal Psychology, Clinical Neuroscience, Cognitive-Behavioral Therapy, Behavioral Medicine, Health Psychology, Clinical Sport Psychology, The Hardiness Approach to Stress Management, Lifespan Developmental Psychology, Cognitive Development, and Naturalistic Field Research

Course Design Certificate — August, 2020
Participated four weekly sessions on designing a course using evidence-based pedagogical principles, including discussions on effective teaching practices and workshops on creating a syllabus.

Teaching of Psychology Seminar — 2016-2019
Participated four 1-quarter seminars on teaching a college-level psychology course.

Mentoring Excellence Certificate — May, 2017
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ABSTRACT OF THE DISSERTATION

An Investigation of Affective Experiences in Schizophrenia-Spectrum Risk Through the Lens of Dynamic Systems Theory

by

Lilian Yanqing Li

Doctor of Philosophy in Psychological Science

University of California, Irvine, 2021

Associate Professor Elizabeth A. Martin, Chair

Affective experience abnormalities represent a key area of dysfunction in individuals with, or at risk for, schizophrenia-spectrum disorders and severely limit broad domains of functioning in these populations. Nevertheless, much remains unknown about the nature of these abnormalities. Recent advances in the affective science literature suggests that conceptualizing affective processes as a dynamic system may provide valuable insights on affective experience abnormalities associated with schizophrenia-spectrum pathology. Like all natural systems, the system of affective processes involves ever-changing components in response to the ebb and flow of contextual inputs at micro-level (i.e., emotional state), meso-level (i.e., mood), and macro-level (i.e., affective trait) timescales. System variability at every timescale is bound by various stabilizing and destabilizing processes that may bring forth critical phase transitions from one steady state to a contrasting one. Adopting a dynamic systems perspective, the current dissertation undertook a comprehensive investigation of affective experience abnormalities in schizophrenia-spectrum risk in a series of four studies. Chapter 1 offers a systematic review and meta-analysis of the trait and state affective experiences across the full spectrum of high-risk

conditions. Findings reveal that high-risk individuals display robust negative affect elevations and nuanced positive affect reductions across trait and state. Trait-level abnormalities were more pronounced compared to state-level abnormalities, thereby demonstrating a trait-state disjunction in high-risk individuals similar to that of individuals with schizophrenia. Chapter 2 offers a three-study empirical examination of the dynamical patterns of affective experiences as they relate to schizophrenia-spectrum risk across varying timescales and contexts. Findings reveal that positive symptoms (e.g., perceptual aberration and magical ideation) and negative symptoms (e.g., social anhedonia) of the schizophrenia spectrum are signified by distinct alterations in affect dynamics. Whereas positive symptoms are linked to heightened magnitude and frequency of affective fluctuations in response to emotional materials, negative symptoms are characterized by heightened persistence of baseline states. Collectively, the current dissertation provides compelling evidence that affective experience abnormalities are vulnerability markers for schizophrenia-spectrum pathology and highlights the critical need to take into account the facet of time when examining affective experiences. Findings are situated within the broader empirical literature and theoretical perspectives of schizophrenia and related psychotic disorders to aid in the development of a unifying framework of psychosis. Important next steps on psychosis risk prediction and prevention are discussed.

INTRODUCTION

Impaired affective experience is fundamental to schizophrenia. Over a century ago, preeminent thinkers in psychopathology such as Kraepelin and Bleuler charted extensive disruptions in patients' affective life and considered them cardinal symptoms of schizophrenia (Bleuler, 1911/1950; Kraepelin, 1919/1971). Modern conceptualizations of schizophrenia continue to place dysfunctional affective experiences at the heart of symptom constellations. For example, the most recent edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) includes anhedonia, or the reduced experience of pleasure, as a key diagnostic feature for schizophrenia (American Psychiatric Association, 2013). Disturbances in affective experiences are by no means trivial as they detrimentally impact a swath of other life domains (Blanchard et al., 1998; Horan et al., 2008) and are refractory to available treatments (Correll & Schooler, 2020). Critically, affective experience disturbances are evident well before the onset of schizophrenia and confers specific risk for the development of psychotic disorders (Kwapil, 1998; Meehl, 1962, 1990; Myin-Germeys & van Os, 2007). Therefore, delineating affective experience abnormalities in at-risk populations offers a valuable window into understanding the etiology and development of schizophrenia without the confounds of patient research (e.g., medication usage, social isolation, and recurrent hospitalization). At the same time, at-risk populations serve as an important vehicle for testing preventative strategies that may prolong or prevent the onset of psychosis, which will be of great clinical and public health significance.

One of the biggest challenges to the study of risk for schizophrenia and related disorders is the heterogeneous nature of this construct. Depending on the level of analysis and theoretical orientation, numerous terms have been used to describe this risk, such as "schizotaxia", "schizotypy", "psychosis proneness", "schizotypal personality", and "prodrome", just to name a

few (Kwapil & Barrantes-Vidal, 2015; Lenzenweger, 2006, 2015). Increasing evidence suggests that schizophrenia and other psychotic disorders are better represented as a spectrum as opposed to discrete categorical diagnoses (Kotov et al., 2020). Conditions along the spectrum, spanning from normality to personality pathology to schizophrenia, share risk factors and symptom presentations, only differing in the degree of symptom severity (Kwapil & Barrantes-Vidal, 2015; Linscott & van Os, 2013). Individuals occupying the lower end of the spectrum are thus considered at risk for developing more severe forms of the spectrum pathology. As such, to emphasize the spectrum, rather than categorical, conceptualization, the current dissertation adopts the terms of "schizophrenia-spectrum risk" and "psychosis risk" when referring to at-risk individuals.

Heterogeneity also manifests in the multidimensional symptom structure, typically characterized by positive, negative, and disorganized dimensions (Kwapil & Barrantes-Vidal, 2015). The positive dimension includes sensory and cognitive anomalies, such as perceptual aberration, magical ideation, and paranoia. The negative dimension involves a diminution in experiences, such as anhedonia, avolition, and flat affect. The disorganized dimension involves disorganized thinking, speech, and behavior. A wealth of evidence suggests that positive and negative dimensions are independent, each associated with distinct etiology, developmental trajectory, and treatment response (Barrantes-Vidal et al., 2013; Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994; Christensen, Gross, Golino, Silvia, & Kwapil, 2018; Kwapil, 1998; Kwapil, Barrantes-Vidal, & Silvia, 2008). On the other hand, the disorganized dimension is often found to moderately overlap with the other two dimensions (Christensen et al., 2019; Kerns, 2006; Li et al., 2020). Hence, careful consideration of symptom severity and multidimensionality is essential for parsing the heterogeneity of schizophrenia-spectrum risk.

Over the past several decades, there has been a proliferation of research on affective experiences in relation to schizophrenia-spectrum risk. This flourishing interest has generated an impressive body of findings that greatly expanded our understanding on this topic, but the literature is also filled with conflicting results and gaps in knowledge (Cohen, Najolia, Brown, & Minor, 2011; Kring & Moran, 2008). For example, trait-based questionnaires and interview-related assessments have converged to show that at-risk individuals report severe abnormalities in affective experience (Horan et al., 2008; Li et al., 2019). However, self-reported emotional states evoked by laboratory stimuli as well as objects and events in the natural environments (as part of the experience sampling technique) are generally found to be relatively unremarkable (Cohen & Minor, 2010; Martin, Karcher, Bartholow, Siegle, & Kerns, 2017; Martin, Siegle, Steinhauer, & Condray, 2018; Oorschot et al., 2013). Overall, there appears to be a puzzling trait-state disjunction in self-reported affective experiences in at-risk individuals. Therefore, a necessary first step is to comprehensively integrate the extant literature on affective experiences across trait and state to fully explicate the nature of affective experience abnormalities associated with schizophrenia-spectrum risk.

Furthermore, a critical gap in prior studies is that they have predominately focused on the static outcome of affective processes. Researchers examine stable trait affective dispositions or take a snapshot of their participants' affective state. Variability from one question or trial to the next are assumed to be noise, and researchers devise numerous ways to eliminate this noise to reveal the best picture of participants' affective life. However, one of the fundamental characteristics of affect is that it fluctuates, evolves, and changes over time. The time-varying structures in an affective episode can perhaps tell us more about psychopathology than the actual affective content (Hollenstein et al., 2013). For example, it might not be important that anxiety

occurs, given that most people can quickly return to their baseline. Rather, it is the unstable, labile, and rigid forms of anxiety that bleeds through long stretches of time from which pathological states may emerge. Therefore, to fully understand vulnerability and resilience (i.e., the emergence of abnormality from normality and vice versa), focus should be shifted from studying the static outcome of affect to the actual process as it unfolds over time.

Adopting a dynamic systems perspective to investigate affective experiences in the schizophrenia-spectrum risk may offer a unique opportunity to reconcile divergent findings and provide novel insights. Recent advances in affective science suggest that affective processes function as a dynamic system whereby reciprocal interactions between micro-, meso-, and macro-level time scales evolve into patterns of dynamic stability (Hollenstein et al., 2013; Lewis, 2005). This dynamic systems perspective emphasizes two important concepts, namely circular causality and variability. Circular causality involves the bidirectional feedbacks between components at varying time scales: emotional episodes (micro-level) beget longer lasting mood states (meso-level), which then form enduring personality structures (macro-level). Simultaneously, higher-order components constrain the activation of lower-order constituents (e.g., neuroticism makes one prone to anxious moods and the experience of anxiety episodes when stressors occur). Within each of the timescales, fluctuations in response to various internal and external contexts provide crucial information on the dissolution and emergence of dynamic stability, as indicated by the concept of variability. Specifically, a number of temporal structures have been proposed to represent early warning signals that may gradually build up to bring forth drastic phase transitions (Scheffer et al., 2009). Thus, leveraging the dynamic systems account of affective processes into the examination of affective experience abnormalities as they relate to

the schizophrenia-spectrum risk provides an integrative framework that could synthesize the vast literature on this topic and may capture important pathways to vulnerability and resilience.

Collectively, the current dissertation undertook a comprehensive investigation of affective experiences in schizophrenia-spectrum risk that is grounded in theoretical and empirical advances of affective and clinical sciences. Chapter 1 quantitatively synthesized the literature on self-reported affective experience abnormalities among high-risk individuals in the schizophrenia spectrum across micro, meso, and macro temporal courses. Chapter 2 includes a series of three studies that examined how the dynamics of affective experience across varying timescales and contexts relate to positive and negative symptoms of the schizophrenia spectrum. In all, the current dissertation provides novel insights on the affective markers of schizophrenia-spectrum risk and offers theoretical and practical implications for further inquiry into the developmental trajectory towards schizophrenia.

CHAPTER 1

Trait and State Affective Experience Among High-Risk People in the Schizophrenia Spectrum: A Systematic Review and Meta-Analysis of Self-Reports

Abstract

Dysfunctional affective experiences are a prevalent, pernicious, and persistent feature of schizophrenia that are evident well before illness onset. Over the past decade, a puzzling phenomenon has captured much empirical and theoretical attention, where individuals with schizophrenia exhibit severe trait impairments but often show unremarkable state abnormalities. Yet, the extent to which this trait-state disjunction is observed among individuals at high risk (HR) in the schizophrenia spectrum remains unclear. Therefore, the objective of this systematic review and meta-analysis was to provide a critical synthesis of HR individuals' self-reported affective experience abnormalities across trait and state and to identify which, and for whom, abnormalities are most pronounced. A literature search yielded 186 independent studies, totaling 1,046 effect sizes across 9,656 HR and 15,322 controls. Results based on three-level random effects models showed that HR (vs. control) individuals had a moderate-to-large trait positive affect (PA) reduction (g = -0.45) and a large trait negative affect (NA) elevation (g = 0.74), with severity decreasing from trait to state. NA elevations largely generalize across methods used for eliciting and assessing affective experiences, whereas PA reductions are more variable and most severe for social-related processes. Lastly, the degree of PA and NA abnormalities increased with increasing levels of schizophrenia-spectrum risk. Overall, findings provide support for the trait-state disjunction in schizophrenia-spectrum HR, although some caveats were noted. An explanatory model and important implications were outlined to facilitate future research in further elucidating the role affective experience dysfunctions may play in the developmental pathway for schizophrenia.

Keywords: schizophrenia, risk, affective experience, self-report, trait-state disjunction

Public Significance Statement

This systematic review and meta-analysis reveals that high-risk individuals in the schizophrenia spectrum self-report experiences of robust negative affect elevations and nuanced positive affect reductions across trait and state. Trait-level abnormalities were more pronounced compared to state-level abnormalities, thereby demonstrating a trait-state disjunction in high-risk individuals similar to that of individuals with schizophrenia. Therefore, dysfunctional affective experiences may be considered a vulnerability factor for schizophrenia.

Trait and State Affective Experience Among High-Risk People in the Schizophrenia Spectrum: A Systematic Review and Meta-Analysis of Self-Reports

Disturbances in affective experience are a core and debilitating feature of schizophrenia-spectrum pathology. Since Kraepelin's conceptualization of dementia praecox, "emotional dullness" has been proposed as the central and most striking symptom of the disorder (Kraepelin, 1919/1971). Flat or inappropriate affect also figured prominently in Bleuler's theoretical model of schizophrenia, which, along with ambivalence–the simultaneous experience of contradictory feelings and thoughts, was considered a cardinal symptom of schizophrenia (Bleuler, 1911/1950). In Meehl's conceptualization, both ambivalence and anhedonia–the diminished experience of pleasure–were viewed as the fundamental manifestations of schizophrenia liability (Meehl, 1962, 1990). Not only crucial for understanding symptom presentation, dysfunctional affective experience detrimentally impacts functional outcomes and quality of life (Blanchard et al., 1998; Horan et al., 2008). More importantly, anhedonia, in conjunction with other negative symptoms of schizophrenia (asociality, avolition, blunted affect, and alogia), is most resistant to available pharmacological and psychosocial treatments and therefore responsible for much of the economic cost and personal as well as societal burden of this illness (Correll & Schooler, 2020).

However, our understanding of these affective experience abnormalities is limited. Perhaps the most perplexing phenomenon is that of a trait and state disjunction in self-reported affective experience. On one hand, largely in line with the historical characterizations, individuals with schizophrenia have been shown to report reduced levels of trait positive affect (PA) and elevated levels of trait negative affect (NA) compared to healthy controls (Horan et al., 2006, 2008). These findings are consistent across a wide range of assessment instruments, such as questionnaires measuring affective dispositions (e.g., NEO-Five Factor Inventory; Costa &

McCrae, 1992; Social and Physical Anhedonia Scales; Chapman et al., 1976) as well as interview-based evaluations of mood disturbances (e.g., the Scale for the Assessment of Negative Symptoms; Andreasen, 1983; the Positive and Negative Syndrome Scale; Kay et al., 1987), with studies typically finding medium to large effect sizes for PA and large effect sizes for NA (Horan et al., 2008). In contrast, individuals with schizophrenia generally report similar affective experience at the state level as controls in response to both pleasant and unpleasant stimuli and across a variety of affect elicitation methods (e.g., pictures, faces, films, and odors; Cohen et al., 2011; Kring & Elis, 2013). A meta-analysis on these studies supported patients' intact capacity to experience stimulus-congruent emotional states, showing small, nonsignificant effect sizes in PA to pleasant stimuli (Hedges' g = -0.16) as well as NA to unpleasant stimuli (Hedges' g = 0.24; Cohen & Minor, 2010). Interestingly, schizophrenia patients reported abnormally elevated NA in response to both pleasant and neutral stimuli (Hedges' g = 0.72 and 0.64, respectively). This stimulus-incongruent NA is in line with the notion of ambivalence and, together with the trait findings, reflects a deficit in inhibiting NA when it is uncalled for (Cohen & Minor, 2010; Cohen, Najolia, et al., 2011).

While a clearer picture of affective experience abnormalities in schizophrenia seems to emerge, it remains unclear the extent to which trait-state disjunction is found in less severe conditions along the schizophrenia spectrum. Specifically, the lower end of the spectrum is indicated by a constellation of maladaptive personality traits and subthreshold symptoms that share the etiology for schizophrenia (Kotov et al., 2020; Kwapil & Barrantes-Vidal, 2015). Individuals with these traits and symptoms are considered at high risk (HR) for developing more severe forms of the spectrum pathology (e.g., schizophrenia). Increasingly, HR individuals have become the focus of affective experience research. Similar to schizophrenia, relatively consistent

evidence demonstrates trait abnormalities in HR individuals (i.e., reduced trait PA and elevated trait NA; Gooding & Pflum, 2014; Horan et al., 2008; Li, Fung, et al., 2019). However, there exists a sizable amount of studies that did not find such abnormalities (e.g., Craver & Pogue-Geile, 1999; Laurent et al., 2000; Salisbury et al., 1996; Yan et al., 2016; Yee & Miller, 1994). Even more mixed are the findings for state-level experiences. Whereas some studies observed a significant impairment similar to, or even more severe than, that of individuals with schizophrenia (e.g., Cohen et al., 2012; Kerns, 2005; Kerns et al., 2008), others called into question the presence of state-level affective experience abnormalities among HR individuals (e.g., Cohen et al., 2016; Fung et al., 2017; Modinos et al., 2010). Elucidating affective experience abnormalities in HR individuals will be of significant import to theory, research, and clinical practice. In particular, understanding which, and for whom, affective experience abnormalities are most pronounced is essential for identifying specific affective markers of risk and clarifying the continuities and discontinuities in the developmental trajectory of schizophrenia.

The purpose of the current study was to meta-analytically synthesize research findings regarding self-reported trait and state affective experience abnormalities among HR individuals in the schizophrenia spectrum prior to the manifestation of full-blown psychosis. Past research suggests that the degree of affective dysfunction likely depends on elicitation/assessment and risk characteristics, which are subject to considerable heterogeneity. The following sections discuss four characteristics of theoretical and methodological significance, namely trait vs. state affective experiences, trait affective experience types, state affective experience procedures, and HR approaches.

Trait vs. State Affective Experiences

As previously discussed, affective experiences can be primarily categorized into trait and state levels. While both trait and state experiences are constructed based on episodic knowledge (i.e., loosely organized contextual details) and semantic knowledge (i.e., tightly organized beliefs about the situation or the self), they differ in the extent to which these two sources of self-knowledge are accessed (Robinson & Clore, 2002a). State-level ratings made immediately or shortly after an event (e.g., "right now" and over the past few minutes, hours, or days) primarily draw from episodic knowledge. In contrast, because of the difficulty in accessing and integrating episodic details (e.g., "in general" and over the past few weeks, months, or years), trait-level ratings primarily tap into semantic knowledge (Robinson & Clore, 2002b, 2002a). Given the long tradition of research linking dysfunctional beliefs to the schizophrenia spectrum (Beck et al., 2009; Beck & Rector, 2005) as well as the established trait-state disjunction in schizophrenia, we sought to examine whether HR individuals' trait-level abnormalities would be more severe than that of the state-level.

Among the dysfunctional beliefs, the negative self-referential bias is particularly striking and has been associated with elevated negative symptoms (e.g., anhedonia) and reduced perceived functional outcomes in both affected and HR populations (Campellone et al., 2016; Fervaha et al., 2015; Grant & Beck, 2009; Luther et al., 2016; Perivoliotis et al., 2009). Correspondingly, reviews on trait and state affective experiences consistently identified elevated NA as a core feature of HR individuals (Horan et al., 2008; Phillips & Seidman, 2008). Therefore, we additionally sought to test whether HR individuals' NA abnormalities would be more severe than PA abnormalities.

Trait Affective Experience Types

A diverse range of trait affective experience types have been studied in HR individuals, such as affective personality traits (e.g., neuroticism and extraversion) and temperaments (e.g., novelty seeking, reward dependence, and harm avoidance), the tendency to experience pleasure or lack thereof (i.e., anhedonia), and general mood. There are indications that trait PA abnormalities are sensitive to the type of experience assessed, with evidence being the weakest for PA-related temperaments and the strongest for anhedonia (Horan et al., 2008; Phillips & Seidman, 2008). Specifically, past theorizing suggests that anhedonia as a marker for schizophrenia liability is chiefly social in nature (Meehl, 1962, 1990). In accordance with Meehl's perspective, longitudinal work demonstrates that social anhedonia is a superior predictor of future schizophrenia-spectrum disorders than physical anhedonia (Chapman et al., 1994; Kwapil, 1998). Thus, deficits in experiencing pleasure within the social domain might be most pronounced for HR individuals.

Trait NA experiences, however, appear to be broadly elevated across types. There is some evidence that, paralleling with trait PA, NA-related temperaments are least disrupted (Horan et al., 2008). On the other hand, anxiety and depressive disorders are prevalent in HR individuals, suggesting that symptoms of anxiety and depression might be most pronounced (Phillips & Seidman, 2008; van Os, 2013; Van Os & Reininghaus, 2016). However, anxiety and depressive symptoms might also result from elevated neuroticism, which is commonly observed in those at HR (Horan et al., 2008). Thus, although there are some nuances in different types of trait NA abnormalities, HR individuals are primarily characterized by a broad trait NA elevation. We therefore sought to test whether types of trait PA and trait NA would moderate HR individuals' affective experience abnormalities.

State Affective Experience Procedures

While state affective experiences have been mostly studied in the context of broad PA and NA categories, they have been measured using various procedures that can be distinguished based on the use of unipolar vs. bipolar scales. These two scale types are based on fundamentally distinct models of affective structure that are subject to tremendous debate (e.g., Cacioppo & Berntson, 1994; Diener & Emmons, 1985; Russell, 1980; Russell & Carroll, 1999; Watson & Tellegen, 1985). Unipolar scales measure positive and negative emotions separately, in which participants are typically asked to rate the intensity of each emotion word (e.g., from "not at all" to "extremely"). They are based on the conceptualization that the experiences of positivity and negativity are independent (e.g., the evaluative space model; Cacioppo & Berntson, 1994). Conversely, bipolar scales place positive and negative emotions on the opposing end of a single bipolar continuum (e.g., Self-Assessment Manikin scale; Bradley & Lang, 1994). They are based on the conceptualization that the experiences of positivity and negativity are mutually exclusive (e.g.., the valence-arousal model; Russell, 1980). Critically, bipolar scales do not allow for the co-occurrence of positive and negative emotions, which may mask the true emotional experience abnormalities in HR individuals given their tendency to simultaneously experience contradictory emotions as indicated by ambivalence. Therefore, we sought to test whether the use of bipolar scales would result in attenuated state affective abnormalities compared to that of unipolar scales.

In addition to distinct scale types, state experience procedures can also be distinguished based on a number of other methodological factors. For example, baseline states have been studied either as an one-time assessment in the lab or as repeated assessments in daily life using experience sampling methods. Additionally, induced states have been elicited by different types

of stimulus (e.g., pictures, faces, films, and odors) and rated in reference to the self (e.g., "How pleasant do you feel in response to the stimulus?") or the stimulus (e.g., "How pleasant is the stimulus?"). Distinctions between these different procedures have been emphasized (Kring & Elis, 2013), but it is currently unclear how they may produce different state affective experience abnormalities in HR individuals as there are no systematic research in these areas. One meta-analysis on induced state affective experiences in schizophrenia patients found no significant difference in the type of induction stimulus or rating reference used (Cohen & Minor, 2010). However, the analysis might be underpowered due to the small number of studies included. Further, there is evidence suggesting important discontinuities between affected and HR individuals in state affective experience abnormalities (Cohen et al., 2012; Strauss & Cohen, 2018). Therefore, we sought to explore the moderating influence of the aforementioned procedure types.

High-Risk Approaches

In addition to the diversity in eliciting and assessing affective experiences, studies have relied on different approaches in identifying HR individuals that broadly fall into familial HR (FHR), HR trait, and clinical HR (CHR) state (see Phillips & Seidman, 2008 for a brief overview). The FHR approach involves biological first-degree relatives of individuals with schizophrenia or schizoaffective disorder regardless of their symptom presentation. The HR trait approach identifies individuals with elevated schizotypal personality traits, which are similar to the symptoms of schizophrenia, but in an attenuated form (e.g., social anhedonia, perceptual aberration, and magical ideation). This approach predominately involves the use of psychometric measures, such as the Schizotypal Personality Questionnaire (Raine, 1991) and the Wisconsin Schizotypy Scales (Chapman et al., 1978; Eckblad et al., 1982; Eckblad & Chapman, 1983).

Individuals whose responses are considerably elevated (e.g., > 1.96 *SD* above the mean) are thereby included in the HR group, typically referred to as at psychometric HR. Relatedly, individuals who meet the threshold for a personality disorder (PD) as determined by clinical interviews also belong to the HR trait approach, including schizotypal, paranoid, and schizoid PDs that are collectively subsumed under Cluster A PD in the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013). Lastly, the CHR approach (also known as "at-risk mental state", "prodromal", and "ultra-high-risk"; Fusar-Poli et al., 2013) involves help-seeking individuals presenting psychotic-like experiences who are believed to be at incipient risk for psychosis. This approach typically involves the use of clinical interview, such as the Structured Interview for Prodromal Syndromes (Miller et al., 2003). Individuals identified under all three approaches have been found to exhibit an elevated rate of conversion to psychosis: compared to the 1% prevalence rate of schizophrenia in the general population (American Psychiatric Association, 2013), 6-13% of FHR (Phillips & Seidman, 2008), 5-21% of HR trait (Chapman et al., 1994; Kwapil, 1998), and 22-36% of CHR individuals (Fusar-Poli et al., 2013) will transition into a psychotic disorder during their lifetime.

Of note, these three approaches are somewhat overlapping yet largely complementary. For instance, there is a large degree of phenomenological overlap between CHR and HR trait criteria. For example, Cicero and colleagues (2014) found that 77% of individuals identified as psychometric HR also showed clinically meaningful psychotic-like experiences, a criterion for CHR. Nevertheless, these two approaches notably differ in their trait-state characteristic of risk. Whereas the HR trait approach emphasizes stable personality traits, the CHR approach requires a relatively short onset and/or worsening function (i.e., HR state; Debbané et al., 2015). At the same time, the trait-state characteristics have been found to interact, with their coexistence

associated with the greatest rate of conversion to psychosis (Debbané et al., 2015). Overall, these three approaches seem to represent a gradient of schizophrenia-spectrum risk with FHR being the lowest, followed by HR trait, and CHR being the highest. Therefore, we sought to test whether the severity of affective experience abnormalities would approximate the degree of schizophrenia-spectrum risk. That is, FHR would be associated with the least affective experience abnormalities, followed by HR trait (psychometric HR and Cluster A PD), and CHR would be associated with the greatest abnormalities.

The heterogeneity of schizophrenia-spectrum risk is not only apparent in terms of symptom severity. Mounting research suggests that this risk is also characterized by a multidimensional factor structure. Although multiple factors have been proposed, studies typically support a three-factor model consisting of a positive dimension (i.e., sensory and cognitive abnormalities), a negative dimension (i.e., diminished experiences in emotion and behavior), and a disorganized dimension (i.e., disorganized thinking, speech, and behavior) that mirror the symptoms of schizophrenia (Kwapil & Barrantes-Vidal, 2015). These three dimensions are characterized by unique symptom presentation, with positive and negative dimensions being largely independent while the disorganized dimension showing moderate associations with the other two dimensions (Christensen et al., 2019; Kerns, 2006; Li et al., 2020). Additional evidence points to distinct etiology, developmental trajectory, and treatment responses between positive and negative dimensions (Barrantes-Vidal et al., 2013; Chapman et al., 1994; Kwapil, 1998; Sarkar et al., 2015). Given these considerations, it appears important to separate these dimensions when examining affective experience abnormalities in HR individuals.

Indeed, there has been some evidence supporting differential associations between symptom dimensions and affective experience abnormalities, with this work primarily relying on

the psychometric HR approach. For instance, whereas individuals with high positive and negative symptoms are both associated with elevated trait NA, only those with high negative symptoms are associated with reduced trait PA (Gooding & Pflum, 2014; Gooding & Tallent, 2003; Horan et al., 2008; Li, Fung, et al., 2019). While studies examining the disorganized dimension have been scant, there is initial evidence for the disorganized dimension being associated with elevated trait affect intensity (both PA and NA) and ambivalence (Kerns, 2006; Kerns & Becker, 2008; Loas et al., 2014). Therefore, when examining the association between HR approach and affective experience abnormalities, we separated the psychometric HR group by the defining symptom dimension. That is, positive, negative, disorganized, or total when two or more dimensions were used to identify HR individuals. We sought to test whether elevated NA would be associated with all symptom dimensions, whereas reduced and elevated PA would be respectively associated with the negative and disorganized dimensions.

Overview of the Current Meta-Analysis

This meta-analysis aimed to comprehensively and systematically synthesize research findings regarding trait and state affective experience abnormalities across the full spectrum of HR conditions. Empirical studies that compared participants fulfilling the criteria of FHR, HR trait (psychometric HR or Cluster A PD), or CHR with control participants on self-reported affective experiences were reviewed. Additionally, possible moderators pertaining to the elicitation/assessment of affective experiences and HR approaches were investigated. Following previous reviews (Cohen & Minor, 2010; Horan et al., 2008), mean effect sizes were estimated separately for trait PA, trait NA, and state experience (unipolar PA, unipolar NA, and bipolar) measured at baseline as well as in response to neutral, pleasant, and unpleasant stimuli. To our knowledge, this meta-analysis represents the largest undertaking to synthesize affective

experience abnormalities in HR individuals. Findings would provide novel insights on the factors most relevant for understanding the etiology and development of schizophrenia.

Method

The current meta-analysis aimed to include all studies, published or unpublished, that reported at least one cross-sectional relation between self-reported affective experience and HR condition, regardless of their specific aims. To facilitate transparency and reproducibility of our results, we followed the PRISMA 2020 reporting guidelines (Page et al., 2021). The PRISMA checklist can be found in Appendix A. Coding manual, dataset, and reproducible R code are available online at the Open Science Framework (OSF; https://osf.io/bvrxs/?view_only=7c996e4edbae47d1839e5f7573f956a0).

Inclusion and Exclusion Criteria

A study had to satisfy the following three criteria in order to be included in the meta-analysis. First, participants must meet at least one of the three HR definitions as described above (i.e., FHR, HR trait, and CHR) without meeting the criteria for a diagnosis of schizophrenia or schizoaffective disorder. More specifically, with the exception of FHR, risk had to be assessed using well-validated self-report and/or interview measures and specific criteria were applied to define the HR group. In the case of psychometric HR, studies have employed a variety of HR cutoffs, such as mean/standard deviation, percentage of the sample, and cluster analysis. We followed the original study's psychometric HR criterion, but if raw dataset was available, redefined the HR group as those scoring in the top 10% of the sample based on current prevalence estimates (Linscott & van Os, 2013; Meehl, 1990; Nuevo et al., 2012). Studies using nontraditional risk approaches, such as environmental factors (e.g., antenatal maternal viral infections and cannabis use; Barrantes-Vidal et al., 2015) and neurodevelopmental disorders

(e.g., fragile X and 22q11 deletion syndrome; Mason, 2015), were excluded because there were too few to be meaningfully integrated.

Second, an appropriate control group must be included, defined as individuals not at HR for developing a schizophrenia-spectrum disorder. People in the control group did not need to be free of all psychotic and nonpsychotic symptoms or matched with the HR group in demographic characteristics.

Third, affective experience must be assessed via self-report questionnaires. Affective experience was broadly defined to include multiple types of valenced processes, such as affective personality traits, pleasure, anhedonia, and discrete emotional states. However, scales that measured symptoms specifically related to a clinical disorder (most commonly, anxiety and depression) were deemed inappropriate because they captured experiences beyond the scope of affect (e.g., suicidal thoughts and biased beliefs). Although these scales did include items measuring affective experiences (e.g., anhedonia), responses on relevant items were rarely reported in isolation. In a similar vein, anhedonia was examined for all HR approaches except for psychometric HR because the anhedonia measures were frequently used to identify the HR group.

Literature Search

Several complementary search strategies were used to ensure a comprehensive coverage of the extant literature. First, electronic databases were searched on July, 2018 and July, 2020, including PsycINFO, ProQuest Dissertations & Theses A&I, and MEDLINE. Keyword search terms were derived from published review protocols on schizophrenia-spectrum risk (e.g., PROSPERO record ID: CRD42017077470), supplemented with terms relevant to trait and state affective experience based on two systematic reviews (Cohen & Minor, 2010; Horan et al.,

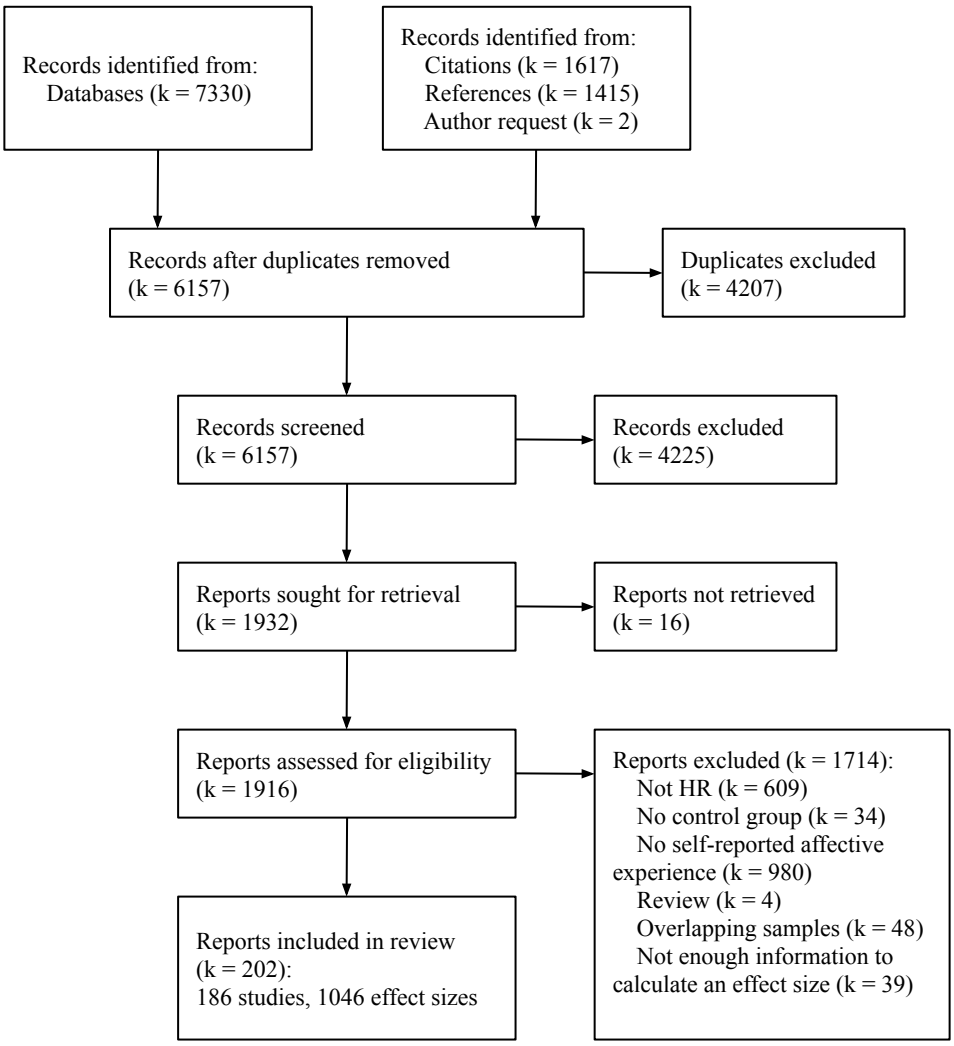
2008). In addition, search terms were tailored in consultation with an information expert to maximize coverage. Finalized search terms were used to scan the abstract of articles and involved every combination of HR approach and trait/state affective experience, across conceptual and methodological domains (see Appendix B). Taken together, online database search yielded 7,330 articles.

Besides the keyword search, three additional search strategies were conducted. First, any articles that cited prominent reviews on trait and state affective experiences in schizophrenia and/or schizophrenia-spectrum risk were searched using Web of Science Citation Indexes on July, 2020 (Cho et al., 2017; Cohen et al., 2011, 2015; Cohen & Minor, 2010; Horan et al., 2008; Kohler & Martin, 2006; Kring & Elis, 2013; Kring & Moran, 2008; Phillips & Seidman, 2008; Strauss, 2013; Strauss & Gold, 2012; Trémeau, 2006; Yan et al., 2012). This strategy yielded 1,617 articles. Second, the reference section of reviews on affect processing in schizophrenia-spectrum risk (Cohen et al., 2015; Horan et al., 2008; Phillips & Seidman, 2008; Visser et al., 2020) as well as all included articles was scanned for relevant articles. This strategy yielded 1,415 articles. Lastly, to improve the likelihood of gathering relevant but unpublished studies that qualify for the meta-analysis, individual emails were sent to 17 researchers who authored at least two qualified publications and/or major reviews in this field within the past 10 years (from 2008 to 2018). This direct-contact strategy yielded two additional articles.

Overall, 10,364 articles were included after merging all search results. After removing duplicate records, 6,157 articles remained. See Figure 1.1 for the full PRISMA flowchart.

Figure 1.1

PRISMA Flowchart



Study Selection

All 6,157 articles were evaluated by LYL according to the inclusion and exclusion criteria outlined above in two steps. First, an initial screening of titles and abstracts was performed using a broadened version of the criteria. Specifically, an article was retained as long as it satisfied the following: (a) was written in or could be translated into English (using Google Translate), (b) appeared to contain empirical findings, (c) examined human participants that were

not exclusively limited to neurological and/or medical conditions (e.g., ketamine induced psychosis), and (d) mentioned the comparison of HR groups of any kind to a control group. Affective experience was not set as an initial screening criterion because it was frequently not a key study objective and subsequently not mentioned in the title and abstract. The initial title/abstract screening step was carried out in Abstracker, an online software that orders articles based on machine learning prediction of relevance that is updated daily (Wallace et al., 2012). Based on these criteria, 1,932 articles were retained and sought for full-text retrieval for the second step of screening. After extensive use of internet searches and interlibrary loan as well as contacting the corresponding author when necessary, 1,916 full-text articles were retrieved (16 articles were not retrievable). For these full-text articles, the Method and Results sections were read to their entirety and were evaluated according to the full inclusion/exclusion criteria. In all, 202 articles were included in the current meta-analysis; the reasons for exclusion can be found in the PRISMA flowchart (Figure 1.1). Studies that met the inclusion criteria but were excluded due to insufficient information were listed in Appendix C.

Coding Procedure

A coding manual was developed by LYL that included five primary sections: article characteristics, setting characteristics, sample characteristics, information regarding the affective experience variable, and effect sizes. Each study was independently coded by LYL and one of two trained research assistants (RD and NM). All coders underwent rigorous training sessions, practiced independent coding on at least six studies (or until above 90% agreement was achieved), and participated weekly check-in meetings. After superficial discrepancies were resolved (e.g., typo), the interrater agreement across all codes was excellent (M = 95.97%, SD =

3.07%, range = 84.52%-100%). Any discrepancy was resolved through extensive discussion between coders.

From the 202 articles, we identified 186 independent studies contributing to 1,046 effect sizes. A study was considered independent if the sample was unique to a particular set of analyses. Alternatively, studies based on overlapping samples, such as when they draw from the same larger-scale project or when multiple HR groups were compared to the same control group, were considered as one "study." Below, we discuss the information coded and constructed in more detail. Unless otherwise specified, all information was coded/constructed at the effect-size level.

Primary Outcome Variables: Affective Experience Categories

Affective experiences were categorized by whether the measures assessed (a) trait or state affect, (b) at baseline or after affect induction (i.e., neutral, pleasant, or unpleasant), and (c) using unipolar PA, unipolar NA, or bipolar scale. In total, there were 14 categories. That is, trait PA, trait NA, and state experience (unipolar PA, unipolar NA, and bipolar) measured at baseline as well as in response to neutral, pleasant, and unpleasant stimuli.

An affective experience was considered to be trait-level when participants were asked to indicate their emotions generally or, if a time frame was specified, more than two weeks into the past. Conversely, an affective experience was considered to be state-level when participants were asked to indicate their emotions at the moment or over the duration of no more than two weeks. The two-week cutoff was based on the findings by Robinson and Clore (2002), showing that people switched from an episodic retrieval strategy to a semantic one for time frames longer than a few weeks. Momentary affective experiences measured using experience sampling methods

were also considered to be state-level, given that ratings were made from episodic knowledge despite being aggregated by the study authors over longer durations.

For state measures only, they were categorized by whether they assessed baseline vs. induced states. Induced states were defined by ratings made immediately following and/or in reference to an induction stimulus, whereas baseline states referred to the absence of induction materials. Further, state measures were categorized by the use of unipolar vs. bipolar scales. Unipolar scales were defined as those that assessed positive and negative states separately, whereas bipolar scales placed positive and negative states on the opposing end of a single bipolar continuum.

Trait Affective Experience Types

We coded author provided label and scale used for each affective experience variable. There were a wide range of trait affective experiences reported in the literature that could be categorized into the several theoretically and empirically derived types. For trait PA, we constructed the following types: (a) hedonia, including anticipatory physical pleasure, consummatory physical pleasure, social pleasure, and trait positive mood; (b) anhedonia, including physical anhedonia and social anhedonia; and (c) personality, including extraversion, novelty seeking, and reward dependence. For trait NA, we constructed the following types: (a) trait negative mood, including anxiety-related and others; and (b) personality, including neuroticism, harm avoidance, and other temperament.

State Affective Experience Procedures

For baseline state experiences, we coded whether they were based on daily life experience sampling methods. For induced state experiences, we coded the type of induction stimulus following commonly used categorizations (Quigley et al., 2014). Induction stimulus

types included video clips, images (e.g., pictures and faces), behavioral tasks (e.g., motivated performance tasks and social interactions), imagery and recall, sounds and voices (e.g., sound clips and vocal stimuli), and other sensory stimuli (olfactory, gustatory, and somatosensory). We also coded whether participants were asked to rate in reference to their own experience or the stimulus itself.

Sample Characteristics

Sample characteristics included sample type (e.g., college students), HR approach (FHR, psychometric HR positive, psychometric HR negative, psychometric HR disorganized, psychometric HR total, Cluster A PD, vs. CHR), presence of clinical diagnosis, presence of psychotropic medication, percentage of males, mean age, percentages of White and non-White participants, mean education level (high school or less vs. college or more), and whether HR and control groups were matched on demographic characteristics (i.e., sex, age, race/ethnicity, and education). Of note, when demographic information was not explicitly reported, we used other information to derive a well-reasoned estimate whenever possible. For example, if the authors stated that the sample consisted of college freshman, we coded the average age as 18.5 years old. Only a small portion of demographic information was estimated (sex: 0.67%; age: 11.71%; race/ethnicity: 17.72%; education: 0.21%).

Quality Bias Indices

We coded the following information to assess risk of bias arising from quality of method and reporting: whether the affective experience measure was validated, whether reliability was reported for the affective experience measure, whether the induction stimulus was validated (for induced states only), and whether effect size was reported for the outcome.

Study Characteristics

Study-level information included publication status, year of appearance (i.e., publication or work completion), and country of origin (e.g., U.S.). We constructed an English-speaking variable based on whether the country's official and/or most commonly used language was English.

Effect Size Calculation

Hedges' *g* was selected as the effect size estimate for the difference between HR and control groups in self-reported affective experience. Given that the relation of interest represents group differences on a continuous variable that is commonly measured using different scales, the standardized mean difference (i.e., Cohen's *d* and Hedges' *g*) is most appropriate to capture this relation while also being comparable across studies (Borenstein et al., 2009). Hedges' *g*, rather than Cohen's *d*, was chosen because Cohen's *d* tends to overestimate the absolute value of the standardized mean difference in studies with a small sample size (Borenstein et al., 2009). To calculate Hedges' *g*, we first calculated Cohen's *d* from the descriptive statistics whenever possible (i.e., mean, standard deviation, and sample size). Inferential statistics were used if descriptive statistics were not available. Effect size estimates were reverse coded when necessary, so that greater unipolar scores reflect higher PA or NA, while greater bipolar scores reflect higher PA. A correction factor was then be applied to convert Cohen's *d* to the unbiased Hedges' *g*.

When information was unclear or insufficient to calculate an effect size, we contacted the corresponding author of the article to provide further details. In particular, we thoroughly checked the calculated effect size with other information reported in the article and reached out

for clarification if any inconsistency was identified (e.g., the authors reported a nonsignificant result, but the calculated effect size was extremely large).

Statistical Analysis

Analyses were conducted using random-effects models, as they assume that variability in effect sizes result from both sampling error and true population variability (Borenstein et al., 2009). There is a consensus that schizophrenia is the result of polygenic risk, which contributes to highly heterogeneous profiles in terms of severity and symptom presentation (Giegling et al., 2017; Henriksen et al., 2017). As a result, there are likely genuine differences in affective experience across different populations of HR individuals, which is conceptually aligned with the theoretical assumption underlying the random-effects model. Another advantage of the random-effects model is that it allows for generalizations beyond included studies (Raudenbush, 1994). In addition, because a number of studies provided multiple assessments of affective experience based on the same sample, this creates dependency between effect sizes coming from the same study. Dependency between effect sizes violates the assumption of traditional univariate meta-analysis that only accounts for sampling variance of individual studies and between-study heterogeneity. To address this, a three-level random-effects analysis was conducted to separately model sampling-level, effect-size-level, and study-level random effects (Assink & Wibbelink, 2016; Borenstein et al., 2009; Van den Noortgate et al., 2013).

Specifically, separate three-level models with restricted maximum likelihood estimator were conducted to estimate the inverse-variance weighted effect size for each affective experience category. Forest plots were used to graphically display the individual effect sizes (ordered by magnitude) and overall effect size estimates. Heterogeneity of effect sizes was examined via the Q statistic for statistical significance as well as τ^2 and I^2 statistics separately at

the effect-size and study levels. The τ^2 statistic represents the amount of true heterogeneity rather than sampling error and was estimated as the variance across individual effect sizes or across individual studies. The I^2 statistic describes the proportion of total variance that is due to true heterogeneity and can be broken into effect-size-level and study-level components. Following conventions, an I^2 statistic of 25%, 50%, and 75% represents small, moderate, and substantial heterogeneity, respectively (Higgins et al., 2003). To evaluate the potential impact of outliers, we conducted sensitivity analyses using the leave-one-out method in which the overall effect sizes were re-estimated with one study excluded each time. To evaluate the possibility of publication bias, we visually inspected the asymmetry of funnel plots displaying the relation between effect size magnitude and sample size. If there is no publication bias, all effect sizes should lie symmetrically around the overall effect size estimate in the shape of a funnel (i.e., larger variability in the effect size magnitude for effect sizes with smaller sample sizes). Further, publication bias was tested by examining whether sample size and publication status were significantly associated with the overall effect sizes using moderator analysis (described below).

Given significant heterogeneity, we conducted moderator analysis using meta-regression to explain this variability. First, we examined bias, sample, and study characteristics to identify potential covariates. If multiple covariates were identified, they were then simultaneously entered into a model to determine the unique variables to include as covariates in the subsequent analysis. Next, we examined the association between substantive moderators (i.e., trait affective experience types, state affective experience procedures, and HR approach) and overall effect sizes. For categorical substantive moderators with more than two categories, a significant omnibus test was followed up with pairwise contrast analyses with Tukey adjustment for multiple comparisons.

We used *t* statistics to test the significance of individual model coefficients and the corresponding confidence intervals, and *F* statistics for the omnibus tests. Significance threshold was set at $p < .05$. Prior to analysis, we conducted an a priori power analysis based on the median sample size (26 HR and 30 controls) and assumed a random-effects model with moderate heterogeneity. Results indicated that four studies were needed to achieve 80% power to detect $d = 0.5$. Thus, any analysis involving fewer than four studies was excluded. All analyses were run in R (R Core Team, 2020) using the *dmetar* package, version 0.0.9000 (Harrer et al., 2019) and *metafor* package, version 2.5-75 (Viechtbauer, 2010).

Results

Descriptive Characteristics

Overall, the 186 independent studies included a total of 9,656 HR and 15,322 controls. The average study sample size was 43.69 HR (*SD* = 42.14, range = 3-281) and 82.38 controls (*SD* = 173.41, range = 10-1724). Further descriptive information is reported separately for each affective experience category (see Appendix F and Appendix G). Individual study's characteristics can be found in Appendix D as well as in the raw dataset at our OSF page.

Overall Effect Size

The overall effect size for each affective experience category is shown in Table 1.1 and the forest plots are shown in Appendix E. Relative to controls, HR individuals reported a moderate reduction in trait PA ($g = -0.45$, leave-one-out range = -0.46 to -0.44) and a large elevation in trait NA ($g = 0.74$, leave-one-out range = 0.71 to 0.75). Mirroring the results for trait affect, state baseline experiences showed a small-to-moderate reduction in PA ($g = -0.33$, leave-one-out range = -0.35 to -0.30) and a moderate elevation in NA ($g = 0.59$, leave-one-out range = 0.57 to 0.61). Again, a similar pattern was observed for state experiences in response to

induction stimuli. Individuals who are at HR (vs. controls) reported a small reduction in state PA in response to both neutral (g = -0.20, leave-one-out range = -0.23 to -0.17) and pleasant (g = -0.27, leave-one-out range = -0.30 to -0.25) stimuli, but not in response to unpleasant stimuli (g = 0.00030, leave-one-out range = -0.030 to 0.050). On the other hand, individuals who are at HR (vs. controls) reported a small elevation in state NA in response to neutral stimuli (g = 0.24, leave-one-out range = 0.19 to 0.26), and a small-to-moderate elevation in NA for pleasant (g = 0.38, leave-one-out range = 0.32 to 0.41) and unpleasant (g = 0.33, leave-one-out range = 0.29 to 0.36) stimuli. Similarly, when induced state experiences were measured using bipolar scales, HR (vs. controls) reported a small effect of reduced PA/elevated NA in response to neutral (g = -0.22, leave-one-out range = -0.24 to -0.20), pleasant (g = -0.20, leave-one-out range = -0.23 to -0.17), but not unpleasant (g = 0.018, leave-one-out range = 0.00039 to 0.044) stimuli. The robustness of these findings is confirmed by the results of sensitivity analyses. Thus, HR individuals displayed deficient PA (except when reacting to unpleasant stimuli) and heightened NA across trait and state.

Heterogeneity analyses indicated significant variation for all affective experience categories except for one, namely state bipolar experiences in response to neutral stimuli. This indicates that moderator analyses were appropriate for the rest of the categories. Before examining potential moderators within each affective experience category, three patterns of the overall effect sizes are notable.

First, as hypothesized, it appears that the overall effect sizes decreased in magnitude from trait to state. To formerly test these differences, we conducted a moderator analysis examining the relation between broad affective experience categories (i.e., trait, state baseline, vs. state induction) and effect sizes. Effect sizes for unipolar NA were first reverse-coded, so that a

positive effect size represents HR reporting greater PA/lower NA than controls (i.e., less abnormality) and a negative effect size represents HR reporting lower PA/greater NA than controls (i.e., more abnormality). Results partially supported our hypothesis: abnormalities for trait (g = -0.55, SE = 0.034, 95% CI [-0.62, -0.48], t(1043) = -15.98, p < .001) and state baseline (g = -0.47, SE = 0.045, 95% CI [-0.56, -0.38], t(1043) = -10.54, p < .001) were significantly greater than that of state induction (g = -0.23, SE = 0.039, 95% CI [-0.30, -0.15], t(1043) = -5.83, p < .001) at p < .001. Trait and state baseline abnormalities did not significantly differ from each other, p = .22.

Second, as hypothesized, it appears that the overall effect size magnitude was greater for NA than PA. To formerly test this difference, we conducted a moderator analysis examining the relation between valence (i.e., PA vs. NA) and effect sizes. Again, effect sizes for unipolar NA were first reverse-coded. Results supported our hypothesis: NA abnormalities (g = -0.61, SE = 0.037, 95% CI [-0.69, -0.54], t(854) = -16.68, p < .001) were greater than PA abnormalities (g = -0.38, SE = 0.035, 95% CI [-0.44, -0.31], t(854) = -10.73, p < .001) at p < .001.

Third, as hypothesized, it appears that the use of bipolar (vs. unipolar) scales resulted in lower state abnormalities. To formerly test this difference, we conducted a moderator analysis examining the relation between scale types (i.e., unipolar vs. bipolar) and effect sizes. Again, effect sizes for unipolar NA were first reverse-coded. Results supported our hypothesis: state abnormalities measured using bipolar scales (g = -0.14, SE = 0.050, 95% CI [-0.24, -0.044], t(665) = -2.85, p = .0045) were significantly lower than those measured using unipolar scales (g = -0.39, SE = 0.034, 95% CI [-0.46, -0.32], t(665) = -11.44, p < .001) at p < .001.

Table 1.1

Overall Effect Size

Affective experience	$N_{studies}$	$N_{effects}$	N_{HR}	$N_{Control}$	Hedges' *g* (*SE*)	95% CI	*Q* (*df*)	L2: τ^2, I^2	L3: τ^2, I^2
Trait affect									
PA	108	267	7185	11560	-0.45 (0.043)***	-0.54, -0.37	1856.71 (266)***	0.094, 37.64	0.12, 48.33
NA	79	112	4726	5484	0.74 (0.070)***	0.60, 0.88	1006.07 (111)***	0.094, 24.97	0.24, 64.86
State baseline									
PA	38	64	1690	2419	-0.33 (0.064)***	-0.46, -0.20	183.21 (63)***	0.032, 19.58	0.078, 47.62
NA	59	114	2226	3272	0.59 (0.055)***	0.48, 0.70	302.56 (113)***	0.018, 9.11	0.11, 56.90
State induction									
Neutral stimuli									
PA	23	29	782	868	-0.20 (0.074)*	-0.35, -0.051	64.89 (28)***	0.074, 52.21	<0.001, <0.001
NA	24	39	774	923	0.24 (0.065)***	0.11, 0.38	54.96 (38)*	0.012, 9.74	0.032, 26.18
Bipolar	26	56	670	806	-0.22 (0.050)***	-0.32, -0.12	54.54 (55)	0.0035, 3.21	0.013, 11.96
Pleasant stimuli									
PA	29	46	970	982	-0.27 (0.063)***	-0.40, -0.14	73.76 (45)**	<0.001, <0.001	0.062, 47.32
NA	17	33	497	605	0.38 (0.098)***	0.18, 0.58	64.82 (32)***	<0.001, <0.001	0.11, 58.20
Bipolar	27	61	763	785	-0.20 (0.085)*	-0.37, -0.030	137.72 (60)***	0.014, 5.98	0.12, 54.48
Unpleasant stimuli									
PA	21	48	552	664	0.00030 (0.068)	-0.14, 0.14	65.05 (47)*	0.0032, 2.54	0.034, 26.87
NA	31	104	940	994	0.33 (0.092)***	0.14, 0.51	269.26 (103)***	<0.001, <0.001	0.21, 68.89
Bipolar	28	64	780	875	0.018 (0.058)	-0.097, 0.13	97.16 (63)**	<0.001, <0.001	0.039, 30.47

Note. State bipolar baseline was excluded because there were fewer than four studies. The sample size for high-risk (HR) and control groups was calculated at the study level (sum of averaged effect-size level sample size). L2 = level 2 (effect-size level), L3 = level 3 (study level), PA = positive affect, NA = negative affect.

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

Bias, Study, and Sample Characteristics

We investigated whether bias, study, and sample characteristics were associated the effect size for their potential inclusion as covariates. Bias indicators were examined for all affective experience categories, while study and sample moderators were examined for those that showed significant heterogeneity due to the exploratory nature of these analyses. We have identified at least one significant covariate for all affective experience categories examined except for state PA measured at baseline, state bipolar experiences in response to neutral stimuli, and state bipolar experiences in response to pleasant stimuli. Results for moderators that showed a unique association with effect sizes are shown in Table 1.2 to 1.14. Full results are reported in Appendix G.

Bias Indicators

With respect to publication bias, a funnel shape can be detected for all categories (see Appendix E). Significant funnel plot asymmetry, as indicated by a significant, negative association between sample size and effect size, was found for state PA in response to pleasant (B = -0.0054) and unpleasant (B = -0.0081) stimuli. Additionally, publication status was a significant moderator for state PA in response to pleasant stimuli, such that published studies reported a stronger PA reduction (g = -0.34) compared to unpublished ones (g = 0.11). Thus, in the published literature, there appears to be an underreporting of PA elevation in response to both pleasant and unpleasant stimuli.

With respect to quality bias, only whether reliability was reported showed a significant association with state NA in response to unpleasant stimuli. Specifically, effect sizes for which reliability was reported had a stronger NA elevation (g = 0.72) compared to those without reliability reported (g = 0.24).

Study and Sample Moderators

In general, there were few study and sample moderators that showed consistent relations across affective experience categories. The most common moderators are mean age (trait PA: B = 0.0084; trait NA: B = -0.025) and the percentage of White participants (trait NA: B = -0.0089; state NA in response to neutral stimuli: B = -0.0071). That is, relations were weaker for increasing age and increasing percentage of White participants.

Year of appearance was a significant moderator for state NA in response to pleasant stimuli, with studies reporting stronger NA elevations over time (B = 0.027). Whether the study was conducted in the U.S. was a significant moderator for state NA measured at baseline, with non-U.S. studies reporting a stronger NA elevation (g = 0.76) than U.S. studies (g = 0.46). The percentage of males was a significant moderator for state bipolar experiences in response to unpleasant stimuli, with effect sizes showing stronger PA elevations/NA reductions for increasing percentage of males (B = 0.0063). Clinical diagnosis status was a significant moderator for state PA in response to neutral stimuli, with diagnosis-free samples having a stronger PA reduction (g = -0.28) than those with a diagnosis (g = 0.12). Psychotropic medication status was a significant moderator for trait PA, with samples taking medications having a stronger PA reduction (g = -0.78) than medication-free samples (g = -0.42).

Substantive Moderators

Trait Affective Experience Types

Trait PA. With respect to broadly defined types of hedonia, anhedonia, and personality, the omnibus test indicated a significant effect (Table 1.2). Subsequent contrast analyses showed that measures assessing anhedonia had a stronger PA reduction (g = -0.63) than those assessing personality (g = -0.36) and a marginally stronger PA reduction than those assessing hedonia (g =

-0.43; p = .081). This marginal difference became significant after the inclusion of covariates (B = -0.31, SE = 0.11, p = .010, 95% CI = [-0.56, -0.060]).

Further analyses within the narrow types indicated a significant omnibus effect. Specifically, measures assessing social pleasure (g = -1.03) and social anhedonia (g = -0.79) had the strongest PA reduction, while measures assessing reward dependence (g = -0.077) and novelty seeking (g = -0.067) had the weakest and nonsignificant effect. In addition, measures assessing consummatory pleasure (g = -0.26) were weaker than those assessing anticipatory pleasure (g = -0.48). The inclusion of covariates did not change any results. Thus, HR individuals had the greatest trait PA deficit within the social domain and were comparable with controls in PA-related temperaments.

Trait NA. The broad types of trait NA were significantly associated with the effect size, such that measures assessing mood (g = 0.84) had a stronger NA elevation than those assessing personality (g = 0.59; Table 1.3). Further analyses within the narrow types indicated a marginally significant omnibus effect. All narrow types showed a significant NA elevation except for other temperament (g = 0.38). Subsequent contrast analyses showed that measures assessing anxiety (g = 0.90) had a marginally stronger NA elevation than those assessing harm avoidance (g = 0.40; p = .087). The (marginally) significant differences within broad and narrow types became nonsignificant after the inclusion of covariates. However, it should be noted that one of the covariates – the percentage of White participants – contained substantial missing data, which resulted in few effect sizes included in the analyses involving covariates. Thus, HR individuals had heightened trait NA across domains, and this abnormality is relatively greater for anxiety and lower for NA-related temperaments.

State Affective Experience Procedures

Experience Sampling. Whether state baseline experiences were based on experience sampling methods was not significantly associated with either PA (Table 1.4) or NA (Table 1.5) effect sizes. After including the covariate, however, experience sampling methods had a significantly weaker NA elevation than those not based on experience sampling (B = -0.28, SE = 0.12, p = .022, 95% CI = [-0.52, -0.042]). Thus, HR individuals experienced lower NA abnormality in daily life compared to one-time, laboratory-based reports.

Stimulus Types. The type of induction stimulus used were not significantly associated with any effect size, except for state bipolar experiences in response to pleasant stimuli (Table 1.11), state PA in response to unpleasant stimuli (Table 1.12), and a marginally significant effect for state bipolar experiences in response to unpleasant stimuli (Table 1.14). For state bipolar experiences in response to pleasant stimuli, image had the strongest PA reduction/NA elevation (g = -0.38) than all other stimulus types, which showed a small, nonsignificant PA elevation/NA reduction. For state PA in response to unpleasant stimuli, video clip had the strongest PA elevation (g = 0.20) that significantly differed from imagery and recall, which showed a small, nonsignificant PA reduction (g = -0.18). This difference, however, went away after including the covariate. Lastly, for state bipolar experiences in response to unpleasant stimuli, the other category, including behavioral and sounds/voices, had the strongest PA reduction/NA elevation (g = -0.20) that marginally differed from the other sensory based stimuli (p = .072), which showed a small, nonsignificant PA elevation/NA reduction (g = 0.22). Again, this difference went away after including the covariate. Thus, the use of different stimulus types does not appear to produce demonstrable differences in induced state abnormalities.

Rating Reference. Whether induced state experiences were rated in reference to the self or the stimulus could not be examined in most categories (six out of nine) because participants were predominately asked to rate their own experiences. For categories that we did examine this moderator, the only significant association was observed for state bipolar experiences in response to pleasant stimuli (Table 1.11). Specifically, self-reference had a stronger PA reduction/NA elevation (g = -0.30) than stimulus-reference, which showed a small, nonsignificant PA elevation/NA reduction (g = 0.070). Thus, the use of different rating references does not appear to produce demonstrable differences in induced state abnormalities, although more studies using stimulus-reference are needed before firm conclusions can be drawn.

HR Approaches. Effect sizes are graphically summarized in Figure 1.2 to aid in the interpretation. In general, with the exception of psychometric HR positive and negative, at least one affective experience category cannot be examined for all other HR approaches due to the insufficient number of studies. This is particularly true for psychometric HR disorganized, where no affective experience category contained enough studies for a reliable estimate. Results are most complete for trait PA and trait NA.

With respect to trait PA (Table 1.2), all HR approaches showed a significant PA reduction except for psychometric HR positive (g = -0.0052). The omnibus test indicated a significant difference between HR approaches. Subsequent contrast analyses showed that psychometric HR positive had a marginally weaker PA reduction than FHR (g = -0.25; p = .085), with both having a weaker PA reduction than the rest (psychometric HR negative: g = -0.66; psychometric HR total: g = -0.56; Cluster A PD: g = -0.79; CHR: g = -0.88). The inclusion of covariates did not alter any significant results, except that psychometric HR total now only had a

nonsignificantly stronger PA reduction than FHR (B = -0.27, SE = 0.13, p = .30, 95% CI = [-0.64, 0.10]). Thus, all HR approaches except for psychometric HR positive showed trait PA deficits. The abnormality was least severe for FHR, followed by psychometric HR total, and most severe for psychometric HR negative, Cluster A PD, and CHR.

With respect to trait NA (Table 1.3), all HR approaches showed a significant NA elevation except for FHR (g = 0.15). The omnibus test indicated a significant difference between HR approaches. Subsequent contrast analyses showed that FHR had the weakest NA elevation than the rest (psychometric HR positive: g = 0.83; psychometric HR negative: g = 0.70; psychometric HR total: g = 1.14; Cluster A PD: g = 1.67; CHR: g = 1.23). Additionally, Cluster A PD, psychometric HR total, and CHR had a stronger NA elevation than psychometric HR negative, with this difference being marginal for CHR (p = .094). Cluster A PD also had a marginally stronger NA elevation than psychometric HR positive (p = .052). After including the covariates, only psychometric HR total and CHR remained significantly stronger than FHR (psychometric HR total: B = 0.91, SE = 0.27, p = .0056, 95% CI = [0.19, 1.64]; CHR: B = 0.83, SE = 0.29, p = .030, 95% CI = [0.052, 1.61]). Psychometric HR total was also marginally stronger than psychometric HR negative (B = 0.51, SE = 0.19, p = .052, 95% CI = [-0.0020, 1.02]) and positive (B = 0.50, SE = 0.19, p = .058, 95% CI = [-0.0098, 1.01]). However, this change could be attributable to the substantial missing data in one of the covariates (e.g., no data were available for Cluster A PD after including the covariates). Thus, all HR approaches except for FHR showed large elevations in trait NA, with the abnormality being most pronounced for Cluster A PD, psychometric HR total, and CHR.

Results for baseline and induced state affective experience categories were less complete, but generally follow a similar pattern as trait PA and trait NA findings. That is, for state PA,

psychometric HR positive was not significantly associated with any deficits. With the exception of state PA in response to unpleasant stimuli where none of the HR approaches examined showed any significant abnormalities, state PA deficits were the weakest for FHR and the strongest for psychometric HR negative and CHR. For state NA, FHR again had the weakest NA elevation, followed by psychometric HR negative; psychometric HR positive and CHR had the strongest NA elevation. Due to the methodological confound, state bipolar experiences only showed small and mostly nonsignificant effect sizes for all HR approaches examined. The only significant results are a PA reduction/NA elevation for psychometric HR negative in response to neutral and pleasant stimuli, and a PA reduction/NA elevation for psychometric HR total in response to neutral stimuli.

Overall, in line with our hypothesis, FHR displayed the least affective abnormalities, followed by psychometric HR. Cluster A PD and CHR displayed the greatest abnormalities. Also, mostly consistent with our hypothesis, heightened NA was found for all HR approaches, whereas PA deficits were more varied and did not characterized the psychometric HR positive approach or when HR individuals were reacting to unpleasant stimuli.

Table 1.2

Trait Positive Affect (PA): Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)	
						Unadjusted	Adjusted
Covariates							
M age	108	267	0.0084 (0.0038)	.026	0.00099, 0.016	4.98 (1, 265)*	--
Psychotropic medication						7.03 (1, 265)**	--
Yes	13	34	-0.78 (0.13)	<.001	-1.04, -0.52		
No	95	233	-0.42 (0.044)	<.001	-0.50, -0.33		
Substantive moderators							
Broad types of PA						3.98 (2, 264)*	4.94 (2, 262)**
Hedonia	58	163	-0.43 (0.056)[a,b]	<.001	-0.54, -0.32		
Anhedonia	30	54	-0.63 (0.082)[a]	<.001	-0.80, -0.47		
Personality	33	50	-0.36 (0.076)[b]	<.001	-0.51, -0.21		
Narrow types of PA						5.86 (9, 257)***	5.60 (9, 255)***
Anticipatory pleasure	36	57	-0.48 (0.075)[a]	<.001	-0.63, -0.34		
Consummatory pleasure	36	57	-0.26 (0.074)[b]	<.001	-0.41, -0.12		
Social pleasure	7	8	-1.03 (0.17)[a,c]	<.001	-1.38, -0.69		
Mood	19	31	-0.48 (0.098)[a,b,c]	<.001	-0.67, -0.29		
Physical anhedonia	23	29	-0.48 (0.092)[a,b,c]	<.001	-0.66, -0.29		
Social anhedonia	15	22	-0.79 (0.10)[a,c]	<.001	-1.00, -0.59		
Extraversion	18	23	-0.54 (0.10)[a,b,c]	<.001	-0.74, -0.34		
Novelty seeking	11	11	-0.067 (0.13)[a,b]	.61	-0.33, 0.20		
Reward dependence	11	11	-0.077 (0.13)[a,b]	.56	-0.34, 0.19		
Other	11	18	-0.52 (0.13)[a,b,c]	<.001	-0.79, -0.26		

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)	
						Unadjusted	Adjusted
High-risk approach[i]						23.63 (5, 259)***	20.44 (5, 257)***
FHR	37	67	-0.25 (0.061)[a]	<.001	-0.37, -0.13		
Psychometric positive	21	37	-0.0052 (0.073)[a]	.94	-0.15, 0.14		
Psychometric negative	29	66	-0.66 (0.063)[b]	<.001	-0.78, -0.54		
Psychometric total	21	48	-0.56 (0.073)[b]	<.001	-0.70, -0.41		
Cluster A PD	10	18	-0.79 (0.14)[b]	<.001	-1.06, -0.52		
CHR	10	29	-0.88 (0.12)[b]	<.001	-1.11, -0.64		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for the continuous moderator (*M* age).

Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. FHR = familial high-risk, Cluster A PD = Cluster A personality disorder, CHR = clinical high-risk.

[i] Psychometric HR disorganized was excluded because there were fewer than four studies.

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

Table 1.3

Trait Negative Affect (NA): Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)	
						Unadjusted	Adjusted
Covariates							
M age	79	112	-0.025 (0.0056)	<.001	-0.036, -0.014	19.66 (1, 110)***	--
% White	40	65	-0.0089 (0.0024)	<.001	-0.014, -0.0041	13.88 (1, 63)***	--
Substantive moderators							
Broad types of NA						5.12 (1, 110)*	0.12 (1, 61)
Mood	48	69	0.84 (0.082)	<.001	0.68, 1.01		
Personality	36	43	0.59 (0.092)	<.001	0.41, 0.77		
Narrow types of NA						2.14 (4, 107)†	0.46 (4, 58)
Anxiety	30	36	0.90 (0.11)	<.001	0.69, 1.11		
Other mood	20	33	0.82 (0.12)	<.001	0.59, 1.05		
Neuroticism	21	26	0.71 (0.12)	<.001	0.48, 0.94		
Harm avoidance	11	11	0.40 (0.17)	.024	0.053, 0.74		
Other temperament	5	6	0.38 (0.26)	.15	-0.14, 0.90		
High-risk approach[i]						13.31 (5, 105)***	4.23 (4, 57)**
FHR	22	24	0.15 (0.098)[a]	.12	-0.043, 0.35		
Psychometric positive	29	32	0.83 (0.089)[b,c]	<.001	0.65,1.01		
Psychometric negative	18	25	0.70 (0.10)[b]	<.001	0.49, 0.90		
Psychometric total	12	18	1.14 (0.13)[c]	<.001	0.89, 1.39		
Cluster A PD	4	4	1.67 (0.29)[c]	<.001	1.10, 2.24		
CHR	7	8	1.23 (0.18)[b,c]	<.001	0.87, 1.59		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators (*M* age and % White). Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. FHR = familial high-risk, Cluster A PD = Cluster A personality disorder, CHR = clinical high-risk.

[i] Psychometric HR disorganized was excluded because there were fewer than four studies.

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 1.4

State Positive Affect (PA) Measured at Baseline: Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Hedges' *g* (*SE*)	*p*	95% CI	$F_{Unadjusted}$ (*df1*, *df2*)
Experience sampling						0.022 (1, 62)
Yes	7	10	-0.35 (0.14)	.014	-0.62, -0.072	
No	32	54	-0.32 (0.070)	<.001	-0.46, -0.19	
High-risk approach[i]						11.72 (3, 58)***
FHR	12	14	-0.24 (0.096)[a,b]	.017	-0.43, -0.044	
Psychometric positive	16	24	-0.079 (0.071)[a]	.27	-0.22, 0.063	
Psychometric negative	14	20	-0.44 (0.074)[b]	<.001	-0.58, -0.29	
CHR	4	4	-0.86 (0.16)[b,c]	<.001	-1.18, -0.52	

Note. Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. FHR = familial high-risk, CHR = clinical high-risk.

[i] Psychometric HR total was excluded because there were fewer than four studies. No data were available for psychometric HR disorganized and Cluster A PD.

*** $p < .001$.

Table 1.5

State Negative Affect (NA) Measured at Baseline: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Hedges' *g* (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)	
						Unadjusted	Adjusted
Covariate							
Country						7.84 (1, 112)**	--
US	32	75	0.46 (0.070)	<.001	0.32, 0.60		
Non-US	27	39	0.76 (0.079)	<.001	0.60, 0.91		
Substantive moderators							
Experience sampling						1.69 (1, 112)	5.40 (1, 111)*
Yes	12	15	0.46 (0.11)	<.001	0.24, 0.69		
No	49	99	0.62 (0.060)	<.001	0.50, 0.74		
High-risk approach[i]						11.60 (3, 106)***	8.58 (3, 105)***
FHR	13	28	0.31 (0.089)[a]	<.001	0.14, 0.49		
Psychometric positive	25	43	0.57 (0.062)[a]	<.001	0.44, 0.69		
Psychometric negative	17	30	0.46 (0.070)[a]	<.001	0.32, 0.60		
CHR	9	9	1.18 (0.13)[b]	<.001	0.92, 1.43		

Note. Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. FHR = familial high-risk, CHR = clinical high-risk.

[i] Psychometric HR total and Cluster A PD were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

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

Table 1.6

State Positive Affect (PA) in Response to Neutral Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Hedges' *g* (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariate							
Clinical diagnosis						5.54 (1, 27)*	--
Yes	5	6	0.12 (0.15)	.45	-0.19, 0.43		
No	18	23	-0.28 (0.076)	<.001	-0.44, -0.13		
Substantive moderators							
Stimulus type[i]						0.36 (3, 25)	0.37 (3, 24)
Video clip	6	7	-0.20 (0.15)	.20	-0.50, 0.11		
Image	5	6	-0.32 (0.17)	.070	-0.67, 0.028		
Behavioral	5	6	-0.26 (0.19)	.19	-0.66, 0.14		
Other	7	10	-0.11 (0.13)	.39	-0.37, 0.15		
High-risk approach[ii]						1.26 (2, 20)	3.44 (2, 19)†
Psychometric positive	9	10	-0.068 (0.12)	.58	-0.32, 0.19		
Psychometric negative	7	8	-0.35 (0.13)	.016	-0.62, -0.071		
CHR	5	5	-0.28 (0.21)	.19	-0.71, 0.15		

Note. Rating reference was not examined because stimulus was used as a reference for fewer than four studies. CHR = clinical high-risk.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] FHR, psychometric HR total, and Cluster A PD were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

† $p < .10$. * $p < .05$.

Table 1.7

State Negative Affect (NA) in Response to Neutral Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariate							
% White	15	21	-0.0071 (0.0025)	.010	-0.012, -0.0019	8.13 (1, 19)*	--
Substantive moderators							
Stimulus type[i]						0.86 (3, 35)	1.05 (3, 16)
Video clip	6	7	0.14 (0.14)	.33	-0.14, 0.42		
Image	6	6	0.13 (0.16)	.42	-0.19, 0.44		
Behavioral	5	8	0.44 (0.17)	.015	0.091, 0.78		
Other	7	18	0.29 (0.11)	.014	0.061, 0.51		
High-risk approach[ii]						3.43 (2, 27)*	2.88 (2, 13)†
Psychometric positive	10	17	0.27 (0.11)[a]	.019	0.048, 0.50		
Psychometric negative	5	5	-0.021 (0.13)[a]	.88	-0.30, 0.26		
CHR	5	8	0.49 (0.19)[a]	.017	0.094, 0.88		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for the continuous moderator (% White). Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. Rating reference was not examined because stimulus was used as a reference for fewer than four studies. CHR = clinical high-risk.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] FHR, psychometric HR total, and Cluster A PD were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

† $p < .10$. * $p < .05$.

Table 1.8

State Bipolar Experience in Response to Neutral Induction: Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Hedges' *g* (*SE*)	*p*	95% CI	$F_{Unadjusted}$ (*df1*, *df2*)
Stimulus type[i]						1.74 (2, 53)
Image	18	25	-0.25 (0.071)	<.001	-0.40, -0.11	
Imagery and recall	4	13	-0.022 (0.12)	.85	-0.26, 0.22	
Other	9	18	-0.23 (0.094)	.016	-0.42, -0.044	
Rating reference						0.13 (1, 54)
Self	21	47	-0.23 (0.058)	<.001	-0.34, -0.11	
Stimulus	7	9	-0.19 (0.10)	.080	-0.40, 0.023	
High-risk approach[ii]						1.49 (3, 49)
FHR	4	4	-0.17 (0.15)	.25	-0.47, 0.13	
Psychometric positive	7	19	-0.093 (0.088)	.30	-0.27, 0.085	
Psychometric negative	10	18	-0.19 (0.077)	.016	-0.34, -0.038	
Psychometric total	4	12	-0.33 (0.077)	<.001	-0.49, -0.18	

Note. FHR = familial high-risk.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] CHR was excluded because there were fewer than four studies. No data were available for psychometric HR disorganized and Cluster A PD.

Table 1.9

State Positive Affect (PA) in Response to Pleasant Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariates							
Sample size	29	46	-0.0054 (0.0017)	.0029	-0.0088, -0.0019	9.95 (1, 44)**	--
Published						8.10 (1, 44)**	--
Yes	25	40	-0.34 (0.059)	<.001	-0.46, -0.22		
No	4	6	0.11 (0.15)	.45	-0.18, 0.41		
Substantive moderators							
Stimulus type[i]						1.54 (4, 41)	1.27 (4, 39)
Video clip	9	12	-0.11 (0.11)	.30	-0.33, 0.10		
Image	7	11	-0.47 (0.12)	<.001	-0.73, -0.22		
Behavioral	5	8	-0.39 (0.13)	.0053	-0.65, -0.12		
Imagery and recall	9	10	-0.26 (0.11)	.019	-0.48, -0.046		
Other	4	5	-0.17 (0.17)	.33	-0.52, 0.18		
High-risk approach[ii]						5.18 (1, 32)*	4.34 (1, 30)*
Psychometric positive	10	11	-0.092 (0.098)	.35	-0.29, 0.11		
Psychometric negative	12	23	-0.36 (0.072)	<.001	-0.50, -0.21		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for the continuous moderator (sample size). Rating reference was not examined because stimulus was used as a reference for fewer than four studies.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] FHR, psychometric HR total, Cluster A PD, and CHR were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

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

Table 1.10

State Negative Affect (NA) in Response to Pleasant Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariate							
Year appeared	17	33	0.027 (0.0098)	.0095	0.0071, 0.047	7.64 (1, 31)**	--
Substantive moderators							
Stimulus type[i]						1.52 (2, 30)	0.25 (2, 29)
Video clip	7	11	0.20 (0.15)	.18	-0.10, 0.50		
Imagery and recall	5	12	0.59 (0.17)	.0014	0.25, 0.94		
Other	6	10	0.41 (0.15)	.012	0.099, 0.73		
High-risk approach[ii]						1.78 (1, 23)	0.58 (1, 22)
Psychometric positive	7	15	0.58 (0.16)	.0015	0.24, 0.91		
Psychometric negative	6	10	0.29 (0.17)	.10	-0.060, 0.64		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for the continuous moderator (year appeared). Rating reference was not examined because no data were available for stimulus.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] FHR, psychometric HR total, Cluster A PD, and CHR were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

** $p < .01$.

Table 1.11

State Bipolar Experience in Response to Pleasant Induction: Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Hedges' *g* (*SE*)	*p*	95% CI	$F_{Unadjusted}$ (*df1*, *df2*)
Stimulus type[i]						5.38 (3, 57)**
Image	18	24	-0.38 (0.084)[a]	<.001	-0.55, -0.21	
Imagery and recall	4	13	0.15 (0.13)[b]	.25	-0.11, 0.42	
Other sensory	4	7	0.13 (0.18)[b]	.45	-0.22, 0.48	
Other	7	17	0.040 (0.11)[b]	.73	-0.19, 0.27	
Rating reference						5.37 (1, 59)*
Self	22	52	-0.30 (0.098)	.0037	-0.49, -0.10	
Stimulus	8	9	0.070 (0.15)	.64	-0.23, 0.37	
High-risk approach[ii]						12.29 (2, 43)***
FHR	4	5	0.26 (0.17)[a]	.12	-0.072, 0.60	
Psychometric positive	9	19	0.16 (0.090)[a]	.079	-0.020, 0.34	
Psychometric negative	14	22	-0.36 (0.079)[b]	<.001	-0.52, -0.20	

Note. Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. FHR = familial high-risk.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] Psychometric HR total and CHR were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized and Cluster A PD.

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

Table 1.12

State Positive Affect (PA) in Response to Unpleasant Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariate							
Sample size	21	48	-0.0081 (0.0021)	<.001	-0.012, -0.0039	14.99 (1, 46)***	--
Substantive moderators							
Stimulus type[i]						2.94 (3, 44)*	0.68 (3, 43)
Video clip	6	24	0.20 (0.070)[a]	.0067	0.058, 0.34		
Behavioral	6	9	0.093 (0.11)[a,b]	.41	-0.13, 0.32		
Imagery and recall	5	6	-0.18 (0.12)[b]	.15	-0.43, 0.067		
Other	6	9	-0.045 (0.10)[a,b]	.67	-0.26, 0.17		
High-risk approach[ii]						0.54 (2, 36)	1.46 (2, 35)
Psychometric positive	9	19	0.12 (0.086)	.17	-0.055, 0.29		
Psychometric negative	5	16	0.039 (0.096)	.69	-0.16, 0.23		
CHR	4	4	-0.074 (0.20)	.71	-0.47, 0.33		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for the continuous moderator (sample size). Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. Rating reference was not examined because stimulus was used as a reference for fewer than four studies. CHR = clinical high-risk.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] FHR, psychometric HR total, and Cluster A PD were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

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

Table 1.13

State Negative Affect (NA) in Response to Unpleasant Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Hedges' *g* (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariate							
Reliability reported						5.69 (1, 102)*	--
Yes	6	9	0.72 (0.19)	<.001	0.35, 1.10		
No	26	95	0.24 (0.095)	.013	0.051, 0.43		
Substantive moderators							
Stimulus type[i]						1.15 (4, 92)	0.88 (4, 91)
Video clip	6	49	0.41 (0.23)	.080	-0.050, 0.87		
Image	7	10	0.088 (0.22)	.69	-0.35, 0.53		
Behavioral	7	13	0.24 (0.20)	.21	-0.14, 0.63		
Imagery and recall	6	13	0.36 (0.23)	.11	-0.086, 0.81		
Sounds and voices	5	12	0.62 (0.21)	.0035	0.21, 1.03		
High-risk approach[ii]						10.22 (2, 88)***	10.09 (2, 87)***
Psychometric positive	14	51	0.48 (0.13)[a]	<.001	0.22, 0.75		
Psychometric negative	5	27	0.10 (0.15)[b]	.50	-0.19, 0.39		
CHR	9	13	0.18 (0.19)[a,b]	.34	-0.19, 0.55		

Note. Effect sizes that do not share superscripts differ at $p < .05$ after Tukey adjustment for multiple comparisons. Rating reference was not examined because stimulus was used as a reference for fewer than four studies. CHR = clinical high-risk.

[i] Other sensory was excluded because there were fewer than four studies.

[ii] FHR, psychometric HR total, and Cluster A PD were excluded because there were fewer than four studies. No data were available for psychometric HR disorganized.

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

Table 1.14

State Bipolar Experience in Response to Unpleasant Induction: Covariate and Substantive Moderator Analyses

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1, df2*)	
						Unadjusted	Adjusted
Covariate							
% Male	28	64	0.0063 (0.0024)	.011	0.0015, 0.011	6.86 (1, 62)*	--
Substantive moderators							
Stimulus type[i]						2.42 (3, 60)†	1.52 (3, 59)
Image	18	24	0.060 (0.070)	.39	-0.080, 0.20		
Imagery and recall	4	13	-0.073 (0.11)	.51	-0.29, 0.15		
Other sensory	5	8	0.22 (0.14)	.13	-0.067, 0.51		
Other	6	19	-0.20 (0.098)	.050	-0.39, 0.00027		
Rating reference						1.38 (1, 62)	1.33 (1, 61)
Self	23	53	-0.014 (0.065)	.84	-0.14, 0.12		
Stimulus	8	11	0.12 (0.11)	.25	-0.088, 0.34		
High-risk approach[ii]						2.57 (3, 57)†	1.50 (3, 56)
FHR	4	5	0.15 (0.16)	.35	-0.17, 0.47		
Psychometric positive	10	21	-0.076 (0.093)	.42	-0.26, 0.11		
Psychometric negative	12	19	0.12 (0.090)	.19	-0.062, 0.30		
Psychometric total	4	16	-0.21 (0.11)	.051	-0.43, 0.0011		

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for the continuous moderator (% Male). FHR = familial high-risk.

[i] Stimulus types with fewer than four studies were combined to form the "Other" type.

[ii] CHR was excluded because there were fewer than four studies. No data were available for psychometric HR disorganized and Cluster A PD.

† $p < .10$. * $p < .05$.

Figure 1.2

Heatmap of Effect Sizes for the Relation Between High-Risk (HR) Approach and Affective Experience Category

Note. PA = positive affect, NA = negative affect. FHR = familial high-risk, Cluster A PD = Cluster A personality disorder, CHR = clinical high-risk.

Discussion

There is a clear consensus that dysfunctional affective experiences are an integral component of the schizophrenia spectrum, but our understanding of the nature of this dysfunction has remained elusive thus far. Delineating affective experience dysfunctions in HR individuals offers a valuable window into understanding the underlying affective vulnerability markers for schizophrenia that may inform the development of tailored preventative and treatment strategies. Consequently, the goal of the present meta-analysis was to estimate the overall magnitude of self-reported affective experience abnormalities in HR individuals along the schizophrenia spectrum and identify moderators that may help parse the heterogeneity in extant studies. A total of 1,046 effect sizes from 186 independent studies was extracted and three-level random-effects models were conducted to separately synthesize distinct affective experience categories at trait and state. In the following sections, we start by summarizing results for the overall analyses and important moderators. These findings are then evaluated against several theoretical models proposed to explain affective experience dysfunctions in schizophrenia. We end by discussing limitations of the current work and outlining suggestions for future research.

Summary of Findings

The current findings reveal that HR individuals are characterized by profoundly heightened trait NA, with impairment becoming more modest, though still notable, from trait to state baseline to state induction. Results for NA abnormalities are robust, showed minimal bias, and largely generalize across trait experience types, state experience procedures, and HR approaches. One exception is that state baseline NA as measured by experience sampling methods was less elevated than that of one-time laboratory reports. Compared to momentary

daily life reports, one-time laboratory reports involve more noncurrent experiences (e.g., some studies assessed experiences over the past week). It is possible that, by recalling noncurrent experiences, missing episodic details are filled in with negative semantic beliefs. Retrospective state reports are also susceptible to biases within the episodic knowledge such as the recency and saliency effects (Robinson & Clore, 2002a). It is thus likely that greater frequency and/or intensity of negative events experienced by HR (vs. control) individuals in their daily life exerts a disproportionate influence on retrospective estimations. Additionally, NA abnormalities, although observed for all HR approaches, typify individual approaches to varying degrees. As the degree of schizophrenia-spectrum risk increased from FHR to psychometric HR to Cluster A PD and CHR, the severity of NA abnormalities increased accordingly. Therefore, consistent with previous narrative reviews on this topic (Horan et al., 2008; Phillips & Seidman, 2008), evidence overwhelmingly indicates that heightened NA is a vulnerability marker for schizophrenia.

To a lesser extent, HR individuals exhibited trait PA deficits with severity following the same decreasing pattern from trait to state. When reacting to unpleasant materials, HR individuals failed to any significant PA deficits. However, results for PA abnormalities in response to both pleasant and unpleasant materials are less certain due to the presence of publication bias, where an underreporting of PA elevations was found. This publication bias is perhaps not surprising given that a PA elevation is inconsistent with the well-documented PA reduction at the trait level (e.g., anhedonia) as well as arguments of a "schizophrenia spectrum anhedonia paradox" that HR individuals, in contrast to individuals with schizophrenia, do show state anhedonia (Strauss & Cohen, 2018). Further, PA abnormalities largely generalize across state experience procedures, but are relatively more variable across trait experience types and HR approaches. HR individuals showed a severe trait PA deficit within the social domain, therefore

substantiating previous theories of a social-specific hedonic dysfunction (Cohen et al., 2011; Meehl, 1962, 1990). With respect to individual HR approaches, PA abnormalities follow a severity gradient that corresponds well with the levels of schizophrenia-spectrum risk but showed differential relations with different symptom dimensions. Only the negative, but not positive, dimension is characterized by PA deficits across trait and state. Therefore, evidence moderately indicates that select PA deficits (e.g., social) play a contributing role to the development of some aspects of schizophrenia (e.g., negative symptoms).

For state affective experiences based on bipolar scales, abnormalities mirror that of unipolar scales but showed a general reduction in magnitude. A closer examination of effect sizes within each HR approach reveals that compared to unipolar effect sizes, bipolar effect sizes are not only smaller in magnitude, but in some cases point to the opposite direction. For example, psychometric HR individuals with elevated positive symptoms reported a small, nonsignificant PA reduction and a moderate NA elevation in response to pleasant stimuli, but the corresponding bipolar effect size showed a small and marginally significant PA elevation/NA reduction. These differences between bipolar and unipolar scales, together with evidence for an underreporting of state PA elevation, further weaken the overall finding that HR individuals consistently display a state PA deficit. Particularly in response to pleasant and unpleasant materials, there appears to be an elevation in both PA and NA at least for subgroups of HR individuals. Therefore, to afford a clearer understanding of state affective experiences in HR individuals, it behooves future research to use unipolar, rather than bipolar, scales.

Generally speaking, study and sample characteristics moderate the observed affective experience abnormalities to a limited extent, often showing weak relations with a specific affective experience category. The more consistent relations are that abnormalities, particularly

for NA, were lower for older samples and samples with greater percentages of White participants. Both findings are in line with previous epidemiological evidence that younger age and racial/ethnic minority status are risk factors for schizophrenia (Linscott & van Os, 2013). However, it should be noted that the majority of older samples were at FHR, who are characterized by less remarkable affective experience abnormalities compared to other HR approaches. Notably absent from the list of significant moderators is the use of college samples. Researchers frequently cast doubt on the generalizability of findings based on college students given their potential high functioning status. Still, college students, in addition to being more accessible for research purposes, are at a critical transition period that coincides with the window of peak risk for schizophrenia and indeed do display clinically meaningful psychotic-like experiences (Cicero et al., 2014). Our findings further buttress the utility of college samples. At least for self-reported affective experiences, college students who are at HR do display abnormalities comparable to those ascertained from community and clinical settings.

Collectively, findings illustrate that dysfunctions in affective experience precede the onset of schizophrenia and become more severe as one moves up the risk ladder. Therefore, affective experience dysfunctions play a contributing role to the development of schizophrenia as opposed to a concomitant or scar of illness onset. In the next section, we situate the current findings within the empirical literature and theoretical framework of affective experience dysfunctions in schizophrenia.

Support for Trait-State Disjunction Across the Schizophrenia Spectrum

The current findings provide strong evidence of a continuity in trait impairment across conditions along the schizophrenia spectrum that is characterized by considerable reduction in trait PA and elevation in trait NA. Critically, findings demonstrate a discontinuity in state

impairment. At the state level, whereas HR individuals largely show an attenuated version of trait abnormalities, those affected with schizophrenia display intact stimulus-congruent state experiences coupled with a stimulus-incongruent NA elevation with severity on par with trait NA abnormality (Cohen & Minor, 2010; Horan et al., 2008). Thus, we may speculate that the transition from HR to schizophrenia is marked by a prominent increase in NA when reacting to materials commonly perceived to be pleasant or otherwise not unpleasant. This pattern could be taken as evidence for the Meehlian conjecture of an "aversive drift"–a pervasive developmental progression towards the negative affective tone where things "start out to be fairly rewarding…begin to take on a burdensome, threatening, gloomy, negative emotional charge" (Meehl, 1990, p. 21). Still, to fully explicate the aversive drift concept, longitudinal investigations following HR individuals as they progress through the illness course are needed.

Despite important distinctions, the current findings imply that trait-state disjunction applies to HR individuals to the extent that trait experience abnormalities are stronger than state experience abnormalities. The stimulus-congruent state abnormalities observed among HR individuals, although statistically significant, are not dissimilar in magnitude to those observed among individuals with schizophrenia (Cohen & Minor, 2010). Further, there is reason to believe that this difference may be even smaller than observed (e.g., due to underreporting of PA elevations). What might explain the trait-state disjunction manifested across the schizophrenia spectrum? As previously mentioned, one of the theoretical models assigns a center role to the deficient regulatory ability in inhibiting NA (Cohen et al., 2011). While this model could sufficiently explain the abnormalities observed for schizophrenia patients who display heightened NA across trait and state with comparable severity, it does not account for HR individuals' substantially stronger trait (vs. state) NA abnormalities. Alternatively, on the basis

that people rely on different levels of episodic and semantic knowledge in making trait vs. state self-reports (Robinson & Clore, 2002a), an inability to access episodic emotional details contributing to an overreliance on negative semantic beliefs emerge as a better explanatory model. This accessibility account of trait-state disjunction was borne out of findings showing robustly compromised episodic memory in patient and HR populations and has been discussed at length in many previous reviews (Cohen et al., 2011; Kring & Elis, 2013; Strauss & Gold, 2012). Here, we highlight two important details that haven't been enumerated but are useful for the explanation of trait-state disjunction in the schizophrenia spectrum.

First, although episodic details are preferentially used whenever available, all reports of affective experience, be it trait or state, tap into some degrees of semantic beliefs. Indeed, there is evidence that all human mental states, as basic as perception, are predicated on the ratio top-down (e.g., semantic beliefs) vs. bottom-up (e.g., episodic details) processing (Bar, 2021; Herz et al., 2020). It is possible that individuals with, or at risk for, schizophrenia have a greater top-down vs. bottom-up ratio that is compounded with episodic memory deficits. This way, induced state affective experiences even when rated in the presence of eliciting materials are expected to produce elevated NA, which is precisely what we observed. Nevertheless, reports on noncurrent experiences (e.g., retrospective, trait, prospective, and hypothetical) are more vulnerable to top-down influences. Especially for prospective and hypothetical reports, episodic details are solely lacking, so top-down influences would be more apparent than retrospective ones (Robinson & Clore, 2002a). In line with this idea, we showed that trait pleasure deficits were stronger for anticipatory than consummatory reports.

Second, the accessibility model, or broadly speaking, the ratio of top-down vs. bottom-up processing, is a domain-general framework that has been extensively employed to explain

various social, cognitive, and affective phenomena (e.g., why gender and cultural stereotypes are primarily observed in trait reports). This opens up a wide array of testable hypotheses and experimental paradigms that can be extrapolated to investigate affective experience dysfunctions in the schizophrenia spectrum. For example, the diverse mental states underpinned by an overarching top-down vs. bottom-up ratio are thought to be interdependent (Herz et al., 2020). Therefore, reducing top-down influences on affect may correspondingly broaden attention as well as perception and induce more exploratory (as opposed to withdrawn) behaviors. It is perceivable that actionable insights can be gained from testing these predictions.

Limitations and Future Directions

Findings of the current meta-analysis should be considered within the confines of several limitations. First, although the three HR approaches are well defined in research and practice, there still exists a sizable heterogeneity in the HR criteria within each approach. For example, an individual considered as at CHR can meet one of the three criteria that are assessed somewhat differently across instruments (Fusar-Poli et al., 2013, 2016). In addition, there are no established criteria for determining psychometric HR status. As a result, studies vary in their use of HR cutoffs, but are more likely to use a less stringent cutoff to include more participants. Thus, the current estimates should be considered as relatively conservative, which makes the observed significant impairments all the more impressive. Second, we are unable to provide a reliable estimate for several HR approaches under specific affective experience categories due to their low availability in the literature. This issue is particularly severe for psychometric HR disorganized, which was only examined in two studies on trait affect. It should be noted that the incompleteness of our findings has less to do with our literature search process, as significant efforts were made to ensure the exhaustiveness of the review. Rather, it points to the dearth in

knowledge pertaining to affective experiences in the disorganized dimension. It would be crucial for future work to focus on these less-studied areas. Lastly, we focused on self-reports because they are the most widely used method and are suggested to be the only way to meaningfully probe the content of subjective experiences (Barrett, 2006a, 2006b; Quigley et al., 2014). This is not to say, however, that other components of emotion (e.g., physiology and behavior) are unimportant or that findings on the experiential component would apply to others (indeed, there are indications that they do not; Cohen et al., 2017; Li, Karcher, et al., 2019). It would be necessary for further research to discern similarities and differences between experiential, physiological, and behavioral components to gain a holistic understanding of affective dysfunctions in the schizophrenia spectrum. We hope to have provided a useful point of reference for such work.

Conclusions

To date, this meta-analysis represents the most comprehensive synthesis of self-reported affective experience abnormalities among HR individuals in the schizophrenia spectrum. Based on the findings, we offer the following general conclusions: (a) HR individuals' NA is robustly heightened whereas PA deficits are more nuanced; (b) trait-state disjunction manifests at the HR stage and could be explained by the accessibility model; and (c) the degree of abnormalities tracks levels of schizophrenia-spectrum risk. Findings strongly indicates that disturbances in affective experience are implicated in the etiological pathway towards schizophrenia, but our understanding is far from complete. We believe that continued investigation on lesser understood areas highlighted in this review will be a fruitful direction for future research.

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CHAPTER 2

Affect Dynamic Signatures of Psychosis Risk Across Multiple Timescales and Contexts

The following manuscript is currently under review for publication:

Li, L. Y., Schiffman, J., & Martin, E. A. (2021). Affect dynamic signatures of psychosis risk across multiple timescales and contexts. *Under review*.

Abstract

There is a critical need for identifying time-sensitive and cost-effective markers of psychosis risk early in the illness course. One solution may lie in affect dynamics, or the fluctuations of affect across time, which have been demonstrated to predict transitions in psychopathology. Across three studies, the current research is the first to comprehensively investigate affect dynamics in relation to subthreshold positive symptoms (perceptual aberration and magical ideation) and negative symptoms (social anhedonia) of the psychosis spectrum. Across multiple timescales and contexts, affect dynamics were modeled from inexpensive laboratory paradigms and social media text. Findings provided strong evidence for positive symptoms linked to heightened magnitude and frequency of affective fluctuations in response to emotional materials. Alternatively, negative symptoms showed modest association with heightened persistence of baseline states. These affect dynamic signatures of psychosis risk provide insight on the distinct developmental pathways to psychosis and could facilitate current risk detection approaches.

Keywords: psychosis, risk detection, affect dynamics, sentiment analysis, networks

Affect Dynamic Signatures of Psychosis Risk Across Multiple Timescales and Contexts

Psychotic disorders, such as schizophrenia, affect approximately 0.4% of the population (Moreno-Küstner et al., 2018), yet are a leading contributor to disability and economic burden worldwide (Chong et al., 2016; GBD 2019 Diseases and Injuries Collaborators, 2020). A much larger segment of the population—estimates ranging from 7-12% (Linscott & van Os, 2013; Meehl, 1990; Nuevo et al., 2012)—experiences subthreshold psychosis, including positive symptoms (e.g., perceptual disturbance and magical thinking) and negative symptoms (i.e., diminution in experiences such as social anhedonia) that are less severe variants of full-blown psychosis (Kwapil & Barrantes-Vidal, 2015). Subthreshold experiences of psychosis are associated with an elevated risk for more severe forms of psychosis and nonpsychotic psychopathology (Kaymaz et al., 2012; Kelleher et al., 2014). Although the majority of people with subthreshold psychosis do not develop a clinically significant psychotic disorder, individuals along the psychosis severity spectrum share risk factors across biopsychosocial domains (Kwapil & Barrantes-Vidal, 2015; Linscott & van Os, 2013). Additionally, subthreshold psychosis can be distressing, and has been associated with worse physical health, poor daily functioning, and suicidality (DeVylder & Hilimire, 2015; Kelleher et al., 2014; Nuevo et al., 2012). Given the phenotypic and risk factor overlap with clinical psychosis, and the inherent associated impairment and distress, research on people with subthreshold psychosis informs the psychosis spectrum and may provide insight into risk factors for illness progression.

Affective abnormalities emerge as a key indicator of risk, given their central role in the presentation, etiology, and maintenance of psychopathology in general (Kring & Mote, 2016) and psychotic disorders in particular (Horan et al., 2008; Myin-Germeys & van Os, 2007). Importantly, there is a burgeoning body of research showing that beyond mean levels of affect,

affect dynamics, or the fluctuations of affect across time, can provide a mechanistic understanding of the risk and resilience for psychopathology (Bringmann et al., 2016; Houben et al., 2015; Trull et al., 2015; Wichers et al., 2015). In particular, recent theorizing about the dynamics of complex systems such as affect has proposed a set of indices that typically precede the critical transition from normality to abnormality (Scheffer et al., 2009, 2012; see Table 2.1 for a brief overview).

In the affect system, the dynamic systems theory posits that a few densely connected positive affect (PA) and negative affect (NA) states can make an individual less able to adapt to various internal and external demands (e.g., a vicious cycle of sadness, guilt, and unhappiness). Over time, these emotional states may become more persistent and unstable until only a slight perturbation (e.g., an unpleasant work meeting) may be enough to precipitate a synchronized shift from typical functioning to a pathological state. Indeed, these theoretically important affect dynamic indices have been linked to a wide range of psychopathological conditions (Houben et al., 2015), most notably, predicting future transitions in symptom severity (Van De Leemput et al., 2014; Wichers et al., 2020; Wichers & Groot, 2016). As such, examining affect dynamics in relation to the spectrum of positive and negative psychosis symptoms may uncover novel affective signatures useful for the prediction of psychosis risk.

Table 2.1

The Definition and Operationalization of Affect Dynamic Indices

Affect Dynamics	Theoretical Relevance	Statistical Operationalization	Substantive Interpretation
Emodiversity	Low diversity and high connectivity density are structural indicators of resistance to change, reflecting a system that is vulnerable for critical transitions (as opposed to gradual adaptations) (Scheffer et al., 2012).	Shannon's entropy (Quoidbach et al., 2014). Shannon's entropy for person $j = -\sum_{i=1}^{s} p_{ij} \times \ln(p_{ij})$, where s is the total number of emotions experienced and p_{ij} is the proportion of the ith emotion in all instances of s.	Lower emodiversity indicates lower variety and relative abundance of the emotional repertoire.
Density		The mean of all absolute within-person centered auto- and cross-regressive slopes in a multilevel vector autoregressive model, in which an emotion (i.e., positive or negative) at $time_i$ is predicted from its past state at $time_{i-1}$ as well as the past state of the other emotion (i.e., negative or positive) (Bringmann et al., 2016).	Greater density indicates greater temporal interdependency, and thus resistance to change, of the emotional network.
Inertia	High inertia, variability, and synchrony are features of a system that is slow to recover from minor perturbations (i.e., critical slowing down) when at the vicinity of a critical transition (Scheffer et al., 2009, 2012).	The within-person centered autoregressive slope in a multilevel model, in which an emotion at $time_i$ is predicted from its past state at $time_{i-1}$ (Kuppens et al., 2010).	Greater autocorrelation indicates greater temporal interdependency, and thus resistance to change, of the emotion.
Variability (Overall)		The standard deviation of a person's emotion across time (Eid & Diener, 1999).	Greater standard deviation indicates greater overall amplitude or range of emotional changes.
Instability (Moment-to-Moment Variability)		Mean square successive difference (MSSD) and probability of acute change (PAC; Jahng et al., 2008). For both indices of instability, successive differences (SDs) between $time_i$ and $time_{i-1}$ are first calculated. For each person, MSSD is computed as the average of the squared SDs; PAC is calculated as the proportion of SDs exceeding a meaningful threshold, with the 90th percentile being the recommended cutoff (Jahng et al., 2008).	Greater MSSD indicates greater amplitude and frequency of emotional changes, while greater PAC indicates greater acute increase in emotions.

Affect Dynamics	Theoretical Relevance	Statistical Operationalization	Substantive Interpretation
Synchrony		The correlation between within-person centered positive and negative emotions (Dejonckheere et al., 2018).	Given that positive and negative emotions are typically negatively correlated (Russell, 1980; Russell & Carroll, 1999), a more negative correlation thus indicates greater synchrony or greater inhibition of opposite-valenced emotions.

Despite ample historical accounts linking psychosis to altered affect dynamics (e.g., affective lability and ambivalence; Bleuler, 1911/1950; Meehl, 1990), few studies to date have empirically tested affect dynamic indices as they relate to the psychosis spectrum. Previous studies have relied on the experience sampling method (ESM) to assess naturally occurring affect. Findings have converged to indicate that positive symptoms are tied to elevated NA variability overall, as well as from one moment to the next (i.e., instability), and, to a lesser extent, elevated instability in PA (Kwapil et al., 2012; Myin-Germeys et al., 2000; Nittel et al., 2018, 2019; Oorschot et al., 2013; Westermann et al., 2017). Variability and instability in either NA or PA do not appear to characterize negative symptoms, with the majority of studies failing to find any significant associations (Kwapil et al., 2012; Oorschot et al., 2013; Westermann et al., 2017). Instead, one study found that negative symptoms were related to a greater pull of affect to baseline (i.e., affective comfort zone), suggesting elevated inertia of baseline states and elevated down-regulatory tendencies following emotional events (Westermann et al., 2017). Overall, evidence points to positive and negative symptoms conveying the opposite patterns of affect dynamics, with the former related to an increased magnitude and frequency of change whereas the latter related to an increased resistance to change from baseline.

Nevertheless, as previous studies have typically only focused on variability or instability in NA, it is relatively unclear how other affect dynamic indices (e.g., emodiversity, density, and synchrony) relate to symptoms of the psychosis spectrum. A comprehensive examination of affect dynamics is needed, in light of findings showing that a combination of different indices enhanced the predictive sensitivity and specificity for depressive symptom transition (Van De Leemput et al., 2014; Wichers et al., 2020; Wichers & Groot, 2016). The extant literature is not only sparse, but also suffers from a critical limitation. Past studies have not controlled for mean

levels of affect, which have considerable influence on affect dynamics (Dejonckheere et al., 2019). For example, greater mean score usually leads to greater variability (Dejonckheere et al., 2019; Ebner-Priemer et al., 2009). Since high NA is a core feature of the psychosis spectrum (Horan et al., 2008), it is possible that the observed elevated NA variability could be a by-product of elevated mean-level NA. Thus, to clarify whether altered affect dynamics are a specific feature of the psychosis spectrum, it is important to partial out the influence of mean affect.

The following three studies comprehensively examined affect dynamic indices in relation to psychosis spectrum symptoms over and above mean levels of affect. To replicate and expand prior ESM findings, Study 1 modeled affect dynamics from naturally occurring linguistic expressions on a social media platform (i.e., Twitter). Study 2 and Study 3 further probed the effects of timescales and contexts, as the dynamical phenomena at varying timescales and contexts are likely governed by different processes and could show differential relations with psychopathology (Ebner-Priemer & Sawitzki, 2007; Hollenstein, 2015; Hollenstein et al., 2013; Koval et al., 2013; Lapate & Heller, 2020). Specifically, Study 2 anchored affect dynamics to a wide range of internal contexts, including a baseline state as well as subjectively meaningful pleasant and unpleasant events. Study 3 applied a finer temporal resolution and stricter control of external contexts by investigating moment-to-moment affective experiences in response to a standardized emotional film clip. All three studies separately examined subthreshold positive and negative symptoms of the psychosis spectrum, as respectively measured by perceptual aberration and magical ideation (Chapman et al., 1994) and social anhedonia (Kwapil, 1998). Overall, the current research represents an essential step towards uncovering the affect dynamic signatures of psychosis risk.

Study 1

The objective of Study 1 was to test the association between psychosis spectrum symptoms and naturally occurring affect dynamics in spontaneous language expressions on Twitter. For many people, especially young adults, social media has become a part of the daily routine (Hootsuite & We Are Social, 2020). Of particular relevance is the social media language usage, which has been abundantly demonstrated to reveal psychological states of the user. For example, the extent to which social media posts express positive or negative feelings, or text sentiments, provides a sensitive reflection of the user's emotional states (Fan et al., 2019; Jones et al., 2016; Liu et al., 2017) and has concurrent and predictive validity in tracking mental and physical health conditions (De Choudhury et al., 2013; Eichstaedt et al., 2015, 2018; Reece et al., 2017). This, together with the time-sensitive and low-cost features, makes social media language a rich resource for identifying affect dynamic risk markers of psychosis.

In Study 1, we downloaded posts (i.e., tweets) from participants' Twitter timelines and utilized text sentiment of the tweet as a proxy for their affective experience in that moment. Based on previous ESM findings, we expected that positive symptoms would be associated with greater sentiment variability and instability, particularly for NA, while social anhedonia would be associated with greater sentiment inertia. We also explored the association of positive symptoms and social anhedonia with three other dynamic indices due to their theoretical relevance, namely emodiversity, density, and synchrony.

Method

Participants

Participants were 129 undergraduate students who, as part of a larger online study, provided a valid Twitter username and completed scales for psychosis spectrum symptoms (see

Table 2.2 for participant characteristics for Study 1-3). They received course extra credit for completing the study that was administered via Qualtrics (Qualtrics, Provo, UT). Power analysis indicated that the current sample size had 80% power to detect a small-to-medium effect of *r* = .24. This is sufficient to test the primary hypotheses of the current study based on previous ESM findings using nonclinical samples (e.g., *r* = .24 for the association between positive symptoms and NA variability; Kwapil et al., 2012). In addition, meta-analytic effect sizes ranged from *r* = .24 to *r* = .36 for the association of various psychopathological symptoms with NA variability and instability (Houben et al., 2015). This study was approved by the University's Institutional Review Board.

Table 2.2

Participant Demographic Characteristics and Psychosis Spectrum Symptoms

	Study 1	Study 2	Study 3
N	129	154	154
Female *n* (%)	108 (83.72)	114 (74.02)	130 (84.42)
Age *M* (*SD*)	20.27 (3.08)	21.32 (4.24)	20.92 (4.42)
Race *n* (%)			
African American	6 (4.65)	4 (2.60)	2 (1.30)
Asian	45 (34.88)	66 (42.86)	63 (40.91)
European American	25 (19.38)	25 (16.23)	32 (20.78)
Latinx	37 (28.68)	47 (30.52)	38 (24.68)
Other	16 (12.40)	12 (7.79)	19 (12.34)
Country of Origin: U.S. *n* (%)	107 (82.94)	121 (78.57)	110 (71.43)
Psychosis Spectrum Symptoms			
Perceptual Aberration *M* (*SD*) [range]	1.13 (1.90) [0-10]	1.09 (2.16) [0-13]	1.71 (2.78) [0-11]
Magical Ideation *M* (*SD*) [range]	3.18 (2.65) [0-11]	2.69 (2.81) [0-13]	3.76 (3.41) [0-13]
Social Anhedonia *M* (*SD*) [range]	2.37 (2.35) [0-12]	2.28 (2.41) [0-10]	3.28 (3.35) [0-12]

Materials

Psychosis Spectrum Symptoms

Psychosis spectrum symptoms were assessed with the short versions of the Wisconsin Schizotypy Scales (Winterstein et al., 2011). The 15-item Short Perceptual Aberration Scale (α = .76) and the 15-item Short Magical Ideation Scale (α = .72) measure perceptual distortions and unusual beliefs, respectively (e.g., "Parts of my body occasionally seem dead or unreal"; "I have occasionally had the silly feeling that a TV or radio broadcaster knew I was listening to him"). As in previous research (e.g., Kerns et al., 2008), a single positive symptom score was calculated by summing the standardized scores of perceptual aberration and magical ideation. The 15-item Short Revised Social Anhedonia Scale (α = 0.72) measures lack of relationships and lack of pleasure from relationships (e.g., "Having close friends is not as important as many people say"). Scores on the Wisconsin Schizotypy Scales have shown high correspondence with clinician-rated psychosis spectrum symptoms (i.e., the Structured Interview for Prodromal Syndromes; Cicero et al., 2014) and are predictive of future psychosis development (Chapman et al., 1994; Gooding et al., 2005; Kwapil, 1998). The short, rather than full, versions of these scales were chosen due to their superior psychometric properties (Cicero et al., 2019; Li et al., 2020).

Twitter Data Processing

Using Twitter's Application Programming Interface (API), tweets (up to the most recent 3200) were downloaded on November 1, 2020. On average, participants contributed 644.59 tweets (*SD* = 670.85, range = 11-2713) elapsing across 210.24 weeks (*SD* = 113.14, range = 8.71-516.71). There was a large variation in the frequency of posting tweets, with the average time interval between successive tweets ranging from 2.21 hours to 24.24 weeks (*M* = 1.42 weeks, *SD* = 2.91 weeks).

After basic preprocessing (Silge & Robinson, 2017; see Appendix H for details), sentiment analysis was conducted using the Valence Aware Dictionary and sEntiment Reasoner (VADER; Hutto & Gilbert, 2014). VADER uses dictionary and rule-based model to extract sentiment polarity and intensity and is especially sensitive to social media text. It has been shown to outperform other established automatic sentiment analytic tools (e.g., Linguistic Inquiry and Word Count) and even individual human raters (Hutto & Gilbert, 2014). For each tweet, an overall sentiment valence score was estimated by summing the valence scores of each word in the VADER dictionary, adjusted by rules such as negations (e.g., "not" and "wasn't") and degree modifiers (e.g., "very" and "kind of"), and normalized to be between -1 (most negative) and 1 (most positive). The proportion of text that were positive or negative was also estimated. Lastly, the frequency of unique sentiment-expressing words (i.e., those that matched words in the VADER dictionary) was tallied for each participant. All processing steps were carried out in Python using custom scripts (available online at https://osf.io/bu2rs/?view_only=1f87c52bb9c946d7a2e6ef60407190fb).

Affect Dynamic Indices

Affect dynamic indices were computed using the methods described in Table 2.1. All indices were computed separately for overall sentiment, positive sentiment only, and negative sentiment only, except for density and synchrony, which were computed based on the relations between positive and negative sentiments. Of note, due to the unequal time intervals between successive tweets, adjustments were made for time-reliant indices, namely instability, inertia, and density. For instability measures, each successive difference (SD) was divided by the time interval (i.e., $time_i$ - $time_{i-1}$) and this adjusted SD was used for the subsequent calculation. For inertia and density, time since first tweet was added as a covariate in the multilevel model.

Data Analytic Strategy

All analyses were performed using R (R Core Team, 2020). Separate linear regressions were fitted to examine the effect of positive symptoms and social anhedonia (entered simultaneously) on mean-level sentiments and affect dynamic indices. To test a specific relation with psychosis spectrum symptoms, all models included demographic variables (i.e., gender, age, and race/ethnicity) as covariates. In models involving dynamic indices, mean-level sentiment was also added as a covariate. The semipartial correlation (*sr*) was reported as an effect size estimate, with .1, .3, and .5 considered a small, medium, and large effect, respectively (Cohen, 1988).

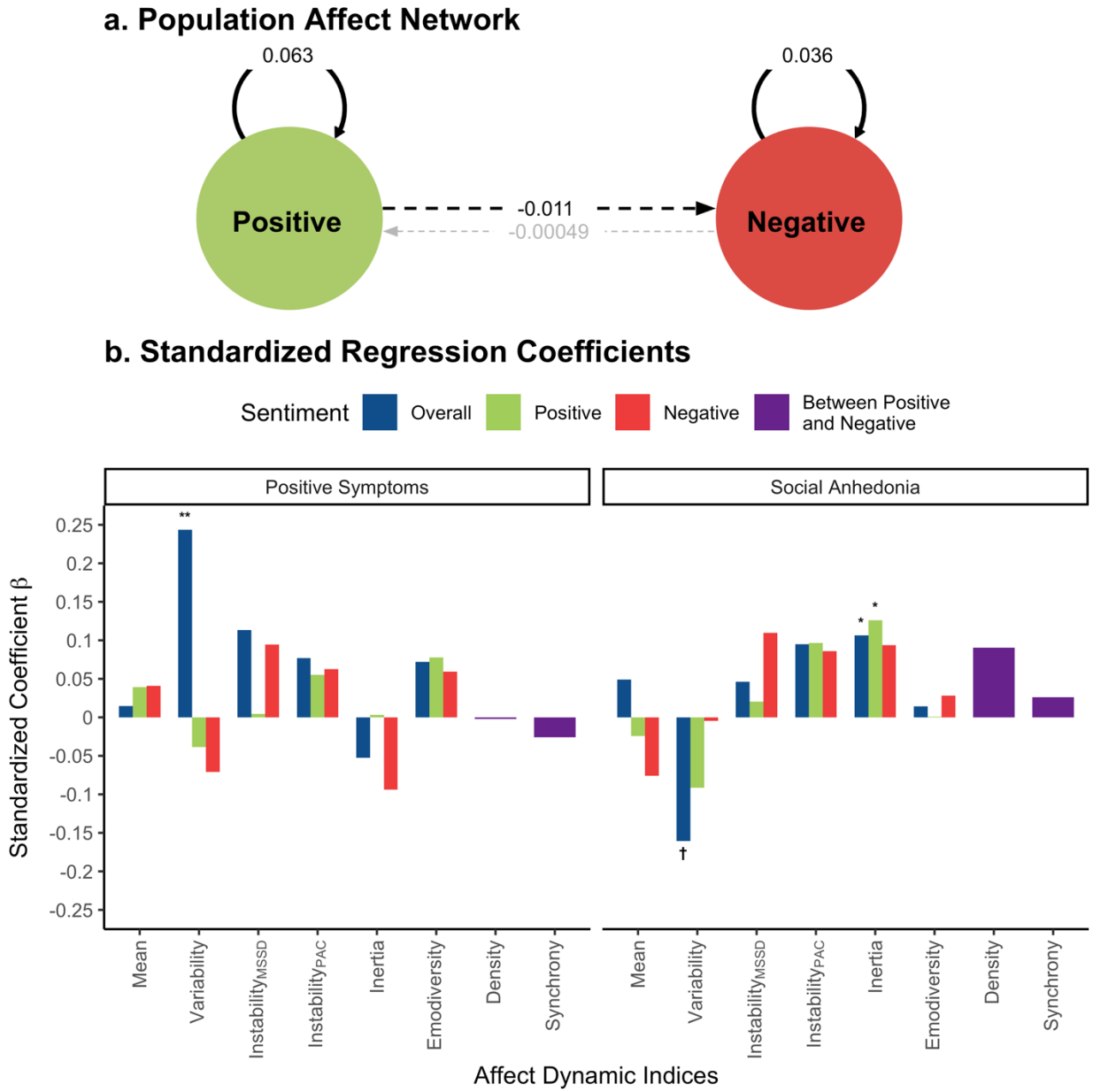
Results

Population Sentiment Network

Figure 2.1a shows the population or average sentiment network. Similar to affect ratings collected using ESM (e.g., Bringmann et al., 2016), the expressed sentiments on Twitter exhibited excitatory self-loops and an inhibitory edge from positive to negative sentiment (but not vice versa). Thus, the expression of positive sentiment at one tweet was linked to greater expression of positive sentiment and lower expression of negative sentiment at the next tweet. In contrast, the expression of negative sentiment at one tweet was linked to greater expression of negative sentiment at the next tweet, but did not significantly influence the subsequent expression of positive sentiment.

Figure 2.1

Population Sentiment Network of the Twitter Data (a) and Standardized Regression Coefficients for the Association of Positive Symptoms and Social Anhedonia With Twitter Affect Dynamics (b)



Note. For the population affect network, numbers represent standardized coefficients β. Solid edges correspond to excitatory relations and dashed edges correspond to inhibitory relations. The thickness of the edges represents the size of the effect. Significant relations ($p < .05$) are shown in solid black color, while nonsignificant relations are shown in gray.

** $p < .01$. * $p < .05$. † $p < .10$.

Affect Dynamics and Psychosis Spectrum Symptoms

Standardized regression coefficients are displayed in Figure 2.1b and Appendix I. Greater positive symptom scores were associated with elevated overall sentiment variability (*sr* = .24), whereas greater social anhedonia scores were associated with marginally reduced overall sentiment variability (*sr* = -.15) as well as elevated overall (*sr* = .17) and positive sentiment inertia (*sr* = .21). None of the other affect dynamics approached significance. Thus, people who are high in positive symptoms exhibit a greater range of sentiment valence. On the other hand, those who are high in social anhedonia exhibit a greater resistance to change, primarily for positive sentiment.

Discussion

This is the first study to examine affect dynamics in relation to the psychosis spectrum using natural language expressions on Twitter. Building on work by previous ESM studies, the present findings provide evidence that positive and negative symptoms of the psychosis spectrum are respectively characterized by more and less changeable affect in daily life. Findings also demonstrate that the dynamics of affect can be captured by Twitter data and they behave in a similar fashion as data collected using established naturalistic methods. Together, social media data have proved feasible in providing a time-sensitive and cost-effective assessment of affect dynamic markers of psychosis risk and may be a useful supplement to existing screening and monitoring approaches.

Largely consistent with our hypotheses, positive symptoms were associated with elevated variability in overall sentiment valence, whereas social anhedonia was associated with elevated

inertia that was driven by the positive sentiment. This suggests that, in terms of longer-timescale mood fluctuations in daily life across various contexts, positive symptoms of the psychosis spectrum are related to a larger range of valence, whereas negative symptoms are related to a greater resistance to change in PA. However, we did not find a significant association between positive symptoms and elevated instability as originally hypothesized, although the results seem to trend in that direction. This could be due to two sources of noise inherent in the Twitter data. In the time domain, there is a large variation in the interval between successive tweets and thus necessitates adjustment for the calculation of time-reliant indices. This adjustment by time, however, might lead to an underestimation for longer time intervals (Jahng et al., 2008). Additionally, people share their thoughts and feelings via tweets for a variety of reasons, from reacting to emotional events to simply describing their daily routine. This mixture of contexts may attenuate the association between affect dynamics and psychosis spectrum symptoms that might be only apparent under emotional provocations (Lapate & Heller, 2020; Myin-Germeys & van Os, 2007). At the same time, there may be individual differences in the tendency to post tweets under one type of situations versus another, potentially meddling the interpretation of the current results. For example, the elevated inertia associated with social anhedonia could be driven by the possibility that people who are high in social anhedonia tend to post about less emotional contents under relatively neutral, baseline states, rather than a resistance to change *per se*. Disentangling the effects of timescales and contexts is therefore crucial in parsing the noise in people's affective time series (Dejonckheere et al., 2019; Lapate & Heller, 2020). This was what we sought to do in Study 2.

Study 2

The objective of Study 2 was to examine the relations between psychosis spectrum symptoms and momentary affect dynamics under baseline, pleasant, and unpleasant contexts. These contexts were experimentally induced in the lab, where participants were asked to provide an unprompted response about their current thoughts (i.e., baseline state) as well as the most pleasant and unpleasant events in their lives. We used sentence-level sentiment as a proxy for their affective experience in that moment and modeled affect dynamics across sentences within each context. In addition, participants were preselected to represent a wide range of positive and negative psychosis spectrum symptoms. Because psychosis risk has been linked to heightened affective reactivity (Myin-Germeys & van Os, 2007), we expected that positive symptoms' elevated variability and instability as well as social anhedonia's elevated inertia would be particularly pronounced under emotionally charged contexts compared to the baseline state. As in Study 1, we also conducted exploratory analyses for the association of positive symptoms and social anhedonia with other affect dynamic indices.

Method

Participants

Participants completed an online battery consisting of scales for psychosis spectrum symptoms. To ensure adequate variation in psychosis spectrum symptoms, those who scored high and low on psychosis-related personality characteristics were invited to the lab. A total of 154 participants completed the laboratory session (see Table 2.2 for participant characteristics). Power analysis indicated that the current sample size had 80% power to detect a small-to-medium effect of $r = .22$, which is sufficient to test the primary hypotheses of the current study.

Materials and Procedure

During the laboratory session, participants rated their baseline mood, followed by a free writing task and two autobiographical memory recall tasks (i.e., pleasant and unpleasant). Participants rated their current mood again immediately following each writing task. Subsequent to mood ratings after the autobiographical memory recall tasks, participants performed a simple cognitive task (i.e., 80-trial Stroop color word task) to minimize the emotion carryover. Upon completion of both the online screening battery and the laboratory session, participants received course extra credit as compensation. Online questionnaires were administered via Qualtrics (Qualtrics, Provo, UT) and the in-lab tasks were administered via MediaLab (Empirisoft Corporation, New York, NY). This study was approved by the University's Institutional Review Board.

Psychosis Spectrum Symptoms

Same as Study 1, psychosis spectrum symptoms were assessed with the short versions of the Wisconsin Schizotypy Scales (Winterstein et al., 2011; all αs > .72).

Writing Tasks

For the free writing task, participants were instructed to write "whatever comes to mind" (e.g., Fung et al., 2017). The autobiographical memory recall tasks were adapted from expressive writing paradigms (e.g., Burton & King, 2004) that instructed participants to write about the most pleasant/unpleasant event they have experienced in their lives. The order of the pleasant and unpleasant conditions was counterbalanced across participants. For all three writing tasks, participants typed their response in a text box that was programmed to be visible for only six minutes. However, participants were told that they had 10 minutes to encourage them to write for the entire time period.

Text entries were segmented into sentences after basic preprocessing (Silge & Robinson, 2017; see Appendix H for details). On average, participants contributed 13.29 sentences (*SD* = 6.91, range = 1-39) for the free writing condition, 12.15 sentences (*SD* = 5.40, range = 2-31) for the pleasant condition, and 12.99 sentences (*SD* = 5.96, range = 2-32) for the unpleasant condition. Then, sentence-level sentiments (i.e., overall sentiment valence and proportions of positive and negative sentiments) were estimated using VADER and the frequency of unique sentiment-expressing words was tallied. The calculation of affect dynamic indices were carried out in the same way as Study 1, except that (a) no adjustment of time was made, and (b) for participants who only expressed one sentiment valence (e.g., only expressed positive sentiment in the pleasant condition), their emodiversity for the non-expressed valence (e.g., negative sentiment) and synchrony were set to zero.

Current Mood

Current mood was assessed at baseline and immediately after each writing task (i.e., four times). Participants were given 16 positively and negatively valenced words with both high arousal and low arousal levels (e.g., serene, elated, sad, anger). The words have been frequently used in previous research to assess self-reported mood (e.g., Martin et al., 2011). Participants were instructed to rate their feelings at the moment using a 5-point scale (1 = *Not at all*; 5 = *Very strongly*). Ratings within each valence category were averaged to yield a composite score for PA (all αs > .82) and NA (all αs > .85).

Data Analytic Strategy

All analyses were performed using R (R Core Team, 2020). First, as a manipulation check, separate multilevel models (MLMs) were fitted to examine the effect of writing condition on (a) mood ratings (PA and NA) and (b) sentiment expressions (overall, positive, and negative

sentiment). Next, separate MLMs were fitted to examine the effect of positive symptoms and social anhedonia (entered simultaneously) as well as their interactions with writing condition on mean-level sentiments and affect dynamic indices. All models included demographic variables (i.e., gender, age, and race/ethnicity) as covariates and random intercepts of participants. In models involving dynamic indices, mean-level sentiment was also added as a covariate.

Results

Manipulation Check

Overall, the writing tasks were successful in eliciting the desired emotion and sentiment expression. With respect to current mood, relative to baseline, free writing did not significantly change PA ($p = .27$) or NA ($p = .19$). The pleasant condition increased PA ($p = .04$) and decreased NA ($p < .001$), whereas the unpleasant condition decreased PA ($p < .001$) and increased NA ($p < .001$). With respect to sentiment expressions, relative to the free writing condition, the pleasant condition showed increased overall sentiment valence, increased positive sentiment, and decreased negative sentiment (all ps $< .001$). On the other hand, the unpleasant condition showed decreased overall sentiment valence, decreased positive sentiment, and increased negative sentiment (all ps $< .001$).

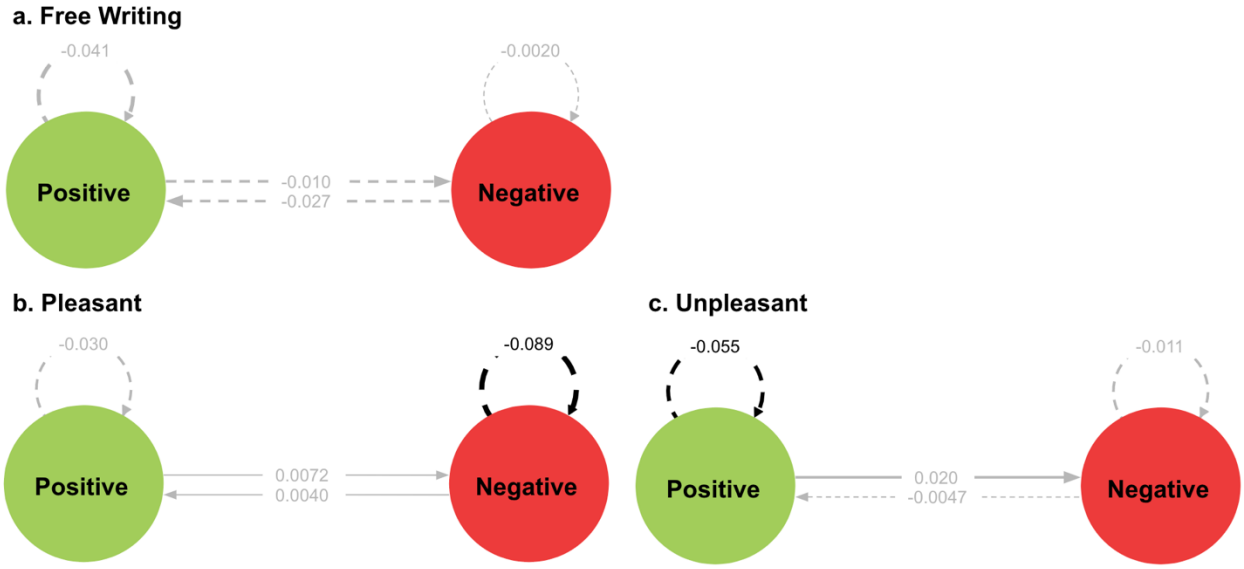
Population Sentiment Network

Figure 2.2 shows the population sentiment network for each writing condition. Overall, the sentiment expressed at one sentence was generally unrelated to the sentiment expressed at the next sentence. There is one notable exception: an inhibitory self-loop was observed for the nontarget emotion in the induction conditions. That is, for the pleasant condition, the expression of negative sentiment at one sentence was linked to lower subsequent expression of negative sentiment; for the unpleasant condition, the expression of positive sentiment at one sentence was

linked to lower subsequent expression of positive sentiment. Closer examination of the text entries showed that participants tend to adopt a narrative form that consisted of multiple points of inflections for the induction conditions (e.g., an event was particularly pleasant/unpleasant during a bad/good day; illustrative examples are provided in Appendix J). On the other hand, freely expressed thoughts did not convey predictable patterns of sentiments.

Figure 2.2

Population Sentiment Networks for Free Writing (a), Pleasant (b), and Unpleasant (c) Conditions



Note. Numbers represent standardized coefficients β. Solid edges correspond to excitatory relations and dashed edges correspond to inhibitory relations. The thickness of the edges represents the size of the effect. Significant relations ($p < .05$) are shown in solid black color, while nonsignificant relations are shown in gray.

Affect Dynamics and Psychosis Spectrum Symptoms

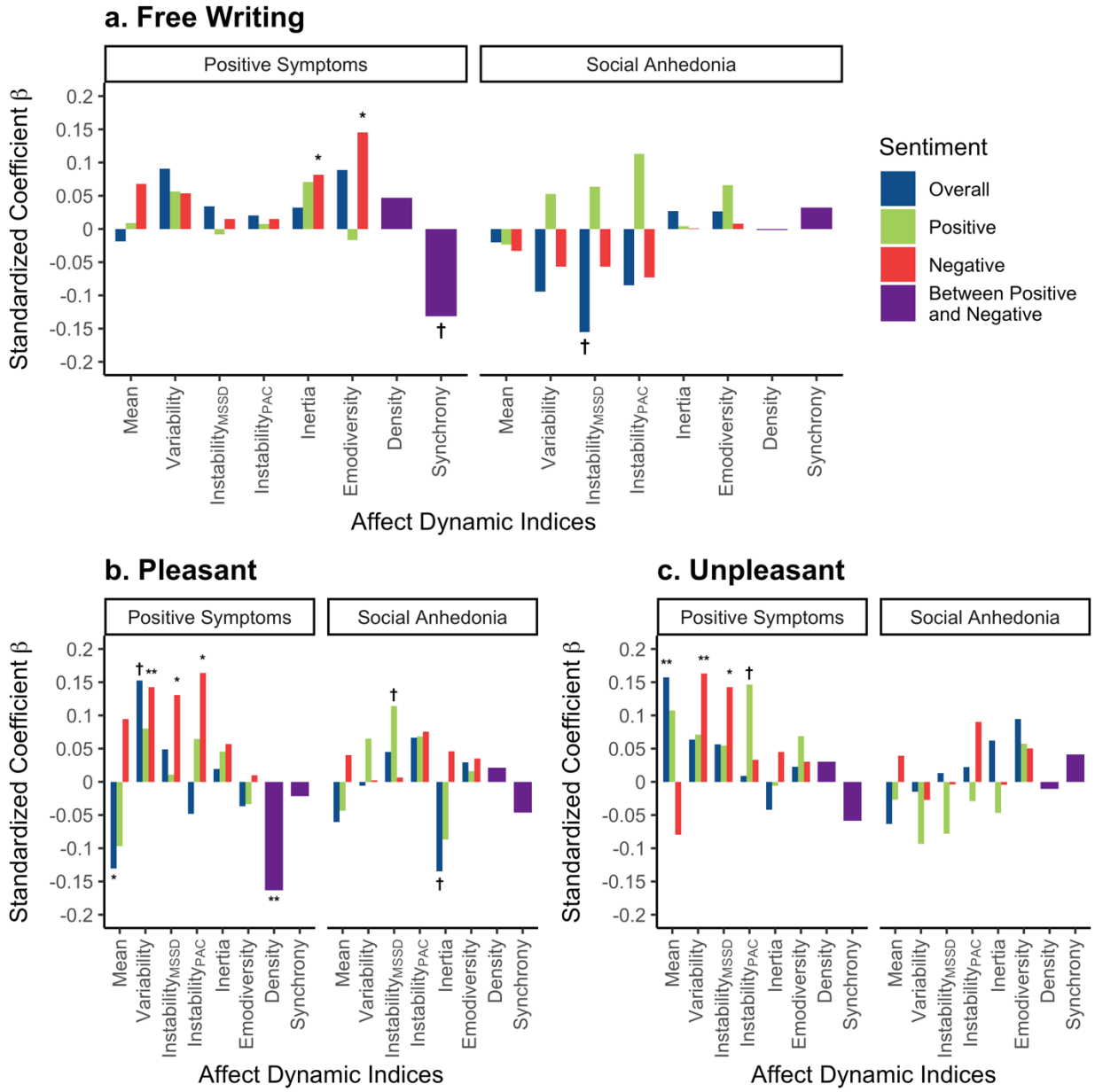
The standardized simple slope estimates for positive symptoms and social anhedonia are displayed in Figure 2.3 and Appendix L, with the full MLM results shown in Appendix K. For the free writing condition (Figure 2.3a), greater positive symptom scores were associated with elevated negative sentiment inertia, elevated negative sentiment emodiversity, and marginally elevated synchrony between positive and negative sentiments. On the other hand, greater social anhedonia scores were associated with marginally reduced overall sentiment instability. Thus, at baseline, people who are high in positive symptoms express diverse negative sentiments that linger and inhibit positive sentiments, while people who are high in social anhedonia tend to express reduced sentiment valence fluctuations across time.

The pattern observed for the free writing condition is in stark contrast to those observed under emotionally charged contexts. For the pleasant condition (Figure 2.3b), greater positive symptom scores were associated with reduced overall sentiment, marginally elevated overall sentiment variability, elevated negative sentiment variability, instability, as well as unstable increase, and reduced density. For the unpleasant condition (Figure 2.3c), greater positive symptom scores were associated with elevated overall sentiment, elevated negative sentiment variability as well as instability, and marginally elevated unstable increase in positive sentiment. In contrast, significant associations with social anhedonia were observed for the pleasant, but not unpleasant, condition, where greater social anhedonia scores were marginally associated with elevated positive sentiment instability and reduced overall sentiment inertia. Thus, people who are high in positive symptoms exhibit drastic and ambivalent fluctuations when induced to feel and express both positive and negative emotions, while people who are high in social anhedonia

tend to exhibit elevated fluctuations of positive sentiment when induced to feel and express positive emotions.

Figure 2.3

Standardized Simple Slope Estimates for the Association of Positive Symptoms and Social Anhedonia With Affect Dynamics Under Free Writing (a), Pleasant (b), and Unpleasant (c) Conditions



** $p < .01$. * $p < .05$. † $p < .10$.

Discussion

Study 2 extended Study 1 by taking into account the effect of emotional contexts on momentary affect dynamics. Consistent with our hypotheses, positive symptoms' more changeable sentiments, demonstrated by elevated variability, instability, and reduced network density, are primarily tied to emotionally charged contexts. This is consistent with a large body of literature showing that positive symptoms of the psychosis spectrum are linked to increased affective reactivity (Myin-Germeys & van Os, 2007). Surprisingly, positive symptoms' baseline sentiment expressions are characterized by the reverse pattern, showing diverse negative sentiments that are persistent over time. This suggests that people who are high in positive symptoms spontaneously engage in prolonged processing of negative information, which is in line with prior self-report findings of increased trait attention to negative emotions (Li et al., 2019; Martin et al., 2011). Overall, the present findings provide strong evidence for more changeable affect in response to emotional provocations as a risk signature for positive symptoms of the psychosis spectrum.

At the same time, there were only relatively modest associations for social anhedonia across all contexts. It appears that social anhedonia's less changeable sentiments, demonstrated by reduced instability, are primarily tied to the baseline state. Interestingly, social anhedonia's sentiment expressions under the pleasant context are characterized by unstable fluctuations in positive sentiment that fails to persist across time. This suggests that people who are high in social anhedonia do experience PA in response to pleasant materials, but in short bursts that cannot be maintained for extended periods. This is consistent with prior work linking social

anhedonia to deficits in the sustained processing of pleasant stimuli (Martin et al., 2020) as well as greater down-regulation tendency to baseline (Westermann et al., 2017). Nevertheless, findings for negative symptoms are relatively weak and thus await further replications.

Although automatic sentiment analytic tools such as VADER have been extensively validated (Fan et al., 2019; Hutto & Gilbert, 2014), there are nuances to people's subjective feelings that cannot be captured by text. Mainly, sentiment analysis takes people's linguistic expressions "at face value," yet the same words can be used to communicate very different feelings. For example, one of our participants wrote "this girl quickly became a friend with my best friend!", which seemingly conveyed positive feelings and indeed received a highly positive overall sentiment valence score (0.8977). However, this participant was most likely expressing a negative feeling (e.g., anger and annoyance) because her best friend was pried away from her. Findings, therefore, need to be validated against self-reports, the *sine qua non* assessment of subjective feelings (Quigley et al., 2014). Further, although the same writing prompts were used across participants, they nonetheless generated responses that vary greatly in content. It could be argued that the characteristics of the event, rather than people's emotional reaction to the event, drive the observed findings (or lack thereof). To address these remaining questions, Study 3 assessed momentary self-reports of affective experiences in response to a standardized emotional stimulus.

Study 3

The objective of Study 3 was to examine momentary affect dynamics in the psychosis spectrum during a standardized emotional film clip that contained a fixed sequence of pleasant and unpleasant scenes. We used a novel paradigm that continuously assessed affective experiences over the duration of the film clip. In addition, participants were preselected to

represent a wide range of positive and negative symptoms of the psychosis spectrum. We expected that results would replicate those obtained in Study 2 under emotional contexts, that is positive symptoms would be associated with elevated variability and instability. Due to the observed modest relations between affect dynamic indices and social anhedonia under emotional contexts, we did not have specific hypothesis for social anhedonia. The association of positive symptoms and social anhedonia with other affect dynamic indices were also explored.

Method

Participants

Participants were recruited based on their scores on the short versions of the Wisconsin Schizotypy Scales (Winterstein et al., 2011; all αs > .83). Specifically, those who scored low (i.e., < 0.5 *SD* above the mean) and high (i.e., > 1.5 *SD* above the mean) on the three scales were invited to complete a continuous affect assessment task either in the lab or online (detailed below). Upon completion, participants received course extra credit and monetary compensation. All measures were administered via Qualtrics (Qualtrics, Provo, UT). This study was approved by the University's Institutional Review Board.

Out of the 167 participants who started the task, 13 (7.78 %) were excluded due to (a) failing to watch the film clip to its entirety (8 excluded), and (b) having > 50% missing data (5 excluded). The final sample size consisted of 154 participants (see Table 2.2 for participant characteristics). Power analysis indicated that the current sample size had 80% power to detect a small-to-medium effect of $r = .22$, which is sufficient to test the primary hypotheses of the current study.

Materials

Continuous Affect Assessment Task

Participants watched a 12-minute film clip from the tragicomic movie *Life is Beautiful*, depicting a father's humorous attempts to shield his son from the horrors of a Nazi concentration camp. To provide a coherent story, the film clip included emotionally evocative excerpts from the beginning, middle, and end of the movie that have been shown to elicit positive and negative emotions (Cohen et al., 2016; Larsen & McGraw, 2011; Schaefer et al., 2010; available upon request).

Affective experiences were assessed using the evaluative space grid (Larsen et al., 2009). This 5 by 5 grid was composed of PA ratings on the x-axis ("How POSITIVE do you feel?") and NA ratings on the y-axis ("How NEGATIVE do you feel?"), with both ratings made on a 5-point scale (0 = *Not at all*; 4 = *Extremely*). Participants were instructed to use the mouse cursor to continuously indicate their affective experiences in that moment. The cursor appeared outside of the grid at the beginning of the film clip, after which participants were instructed to use the mouse to move the cursor throughout the grid as fast or slow as they wished. The cell location of the cursor was recorded every 100 ms. Immediately after the film clip, participants were asked if they were experiencing any emotions right now and, if they indicated yes, to list all emotions in a text box.

Affect ratings were down-sampled to every 1s offline for the current analysis. Out of the 723 possible assessments (12.05 minutes x 60 seconds/minute x 1 assessment/second), participants contributed 702.98 on average (*SD* = 57.47, range = 433-723). Affect dynamic indices were calculated using the same methods described in Study 1 based on affect ratings and open-ended responses, except that no adjustment of time was made. Additionally, a more

stringent cutoff was used for PAC. Because the majority of affect ratings did not change from one moment to the next (PA: 93.54%; NA: 93.03%), the cutoff for acute increase was set as any positive change in affect ratings (i.e., PA: top 3.68%; NA: top 3.60%). Lastly, emodiversity was set to zero for participants who did not provide any sentiment-expressing words, and synchrony was set to zero for one participant who did not show any variability in PA.

The majority of participants (80.52%) completed the task in the lab. Task format was not significantly related to any outcome measures, except for a marginal difference in NA MSSD, $t(152) = 1.88$, $p = .062$, $d = 0.38$ and a marginal difference in density, $t(151) = -1.67$, $p = .096$, $d = 0.34$. Participants who completed the task in the lab displayed marginally greater NA MSSD ($M = 0.052$, $SD = 0.044$) and lower density ($M = 0.49$, $SD = 0.0024$) than those who completed online (MSSD: $M = 0.037$, $SD = 0.027$; density: $M = 0.50$, $SD = 0.0020$).

Data Analytic Strategy

All analyses were performed using R (R Core Team, 2020). Separate linear regressions were fitted to examine the effect of positive symptoms and social anhedonia (entered simultaneously) on mean-level affect and affect dynamic indices. All models included demographic variables (i.e., gender, age, and race/ethnicity) as covariates. In models involving dynamic indices, mean-level affect was also added as a covariate. The semipartial correlation (*sr*) was reported as an effect size estimate, with .1, .3, and .5 considered a small, medium, and large effect, respectively (Cohen, 1988).

Results

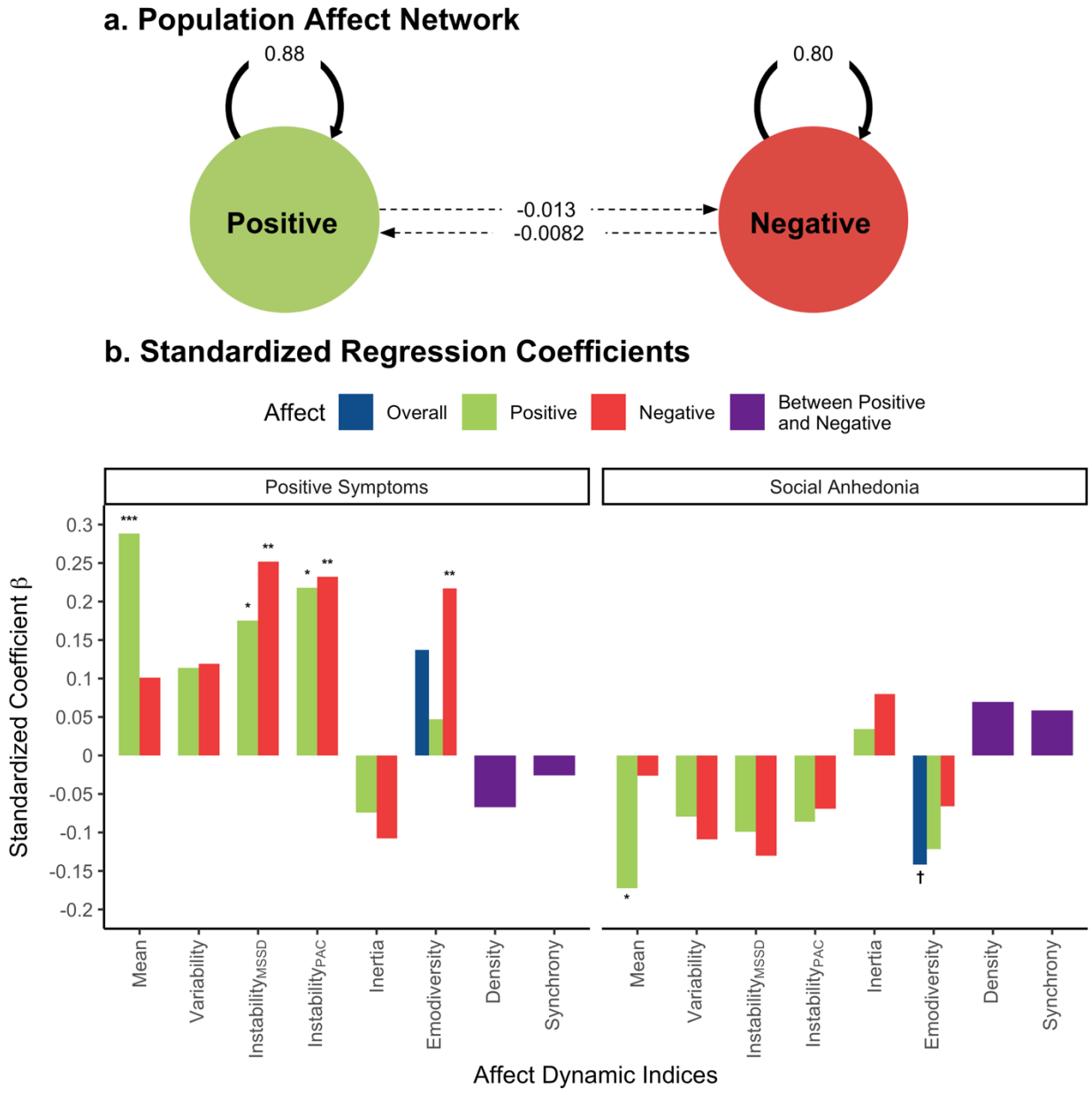
Population Affect Network

Average affect ratings showed that the film clip was successful in inducing PA and NA that were largely alternating over the entire duration (see Appendix M). Correspondingly, the

population affect network (Figure 2.4a) showed strong excitatory self-loops and weaker inhibitory edges between PA and NA.

Figure 2.4

Population Sentiment Network of the Film Clip Data (a) and Standardized Regression Coefficients for the Association of Positive Symptoms and Social Anhedonia With Film Clip Affect Dynamics (b)



Note. For the population affect network, numbers represent standardized coefficients β. Solid edges correspond to excitatory relations and dashed edges correspond to inhibitory relations. The thickness of the edges represents the size of the effect. Significant relations ($p < .05$) are shown in solid black color, while nonsignificant relations are shown in gray.

*** $p < .001$. ** $p < .01$. * $p < .05$. † $p < .10$.

Affect Dynamics and Psychosis Spectrum Symptoms

Standardized regression coefficients are displayed in Figure 2.4b and Appendix N. Greater positive symptom scores were associated with elevated PA (*sr* = .29), elevated instability in PA (*sr* = .16) and NA (*sr* = .24) as well as their unstable increase (PA: *sr* = .19; NA: *sr* = .22), and elevated NA emodiversity (*sr* = .21). On the other hand, greater social anhedonia scores were associated with reduced PA (*sr* = -.18) and marginally reduced overall emodiversity (*sr* = -.14). Thus, mirroring Study 2 findings under emotionally charged contexts, people who are high in positive symptoms exhibit drastic and ambivalent fluctuations in their affective experiences during the film clip. People who are high in social anhedonia primarily focused on the unpleasant aspect of the film clip and, similar to Study 2 under the unpleasant context, did not show strong patterns of affect dynamics.

Discussion

Study 3 provided the strictest test of the momentary affect dynamics in the psychosis spectrum by tapping into self-reports of affective experiences in response to a standardized emotional stimulus. Largely replicating Study 2 under emotionally charged contexts, Study 3 showed that positive symptoms were associated with elevated variability, instability, and NA emodiversity, whereas social anhedonia was not strongly related to any dynamics in affect.

Extending Study 2, Study 3 has the added experimental control of external inputs and directly assessed people's subjective feelings. Thus, positive symptoms' more changeable affect in response to emotional provocations is likely due to endogenous processes that are specific to the pathophysiology of positive symptoms. On the other hand, social anhedonia is chiefly characterized by deficits in mean-level PA without substantial disturbances in affect dynamics when reacting to emotional materials.

General Discussion

There is a long tradition of research identifying risk markers in the service of the goal of anticipating and preventing transitions towards psychotic disorders. Nevertheless, current approaches have proved to be less than satisfactory (Fusar-Poli et al., 2019). This insufficiency has recently been brought to the forefront with the $99-million initiative calling to "further define early stages of risk and predict the likelihood of progression to psychosis and other outcomes" (National Institutes of Health, 2020). Given the substantial theoretical and empirical support for affect dynamics in anticipating transitions in psychopathology, the current research provided an initial inquiry into identifying affect dynamic signatures of psychosis risk. Across three studies, we comprehensively examined affect dynamic indices as they relate to positive and negative symptoms of the psychosis spectrum under varying timescales and contexts both in daily life and in laboratory settings. Collectively, findings provided (a) strong support for heightened magnitude and frequency of affective fluctuations following emotional provocations as a hallmark for positive symptoms, and (b) modest support for greater persistence of baseline states as a hallmark for negative symptoms. Further, these findings are observed over and above mean-level affect, and even in nonclinical samples, underscoring the utility of affect dynamics in capturing, and perhaps predicting, risk for psychosis.

Heightened Affective Fluctuations: Strong Risk Signature for Positive Symptoms

Extending previous ESM findings into the digital space of social media, we showed that positive symptoms are associated with elevated affect variability in daily life. Subsequent studies further showed that elevated variability and instability in both PA and NA are tied to emotional, rather than baseline, contexts. These findings add to the growing knowledge of the affect-reactive profile of positive symptoms, substantiating the affective pathway to psychosis (Myin-Germeys & van Os, 2007). Mounting research has shown that people with high positive symptoms display marked response to emotional materials (Cohen & Minor, 2010; Myin-Germeys & van Os, 2007). Not only observed at the group-level, the increased affective reactivity has been associated with greater concurrent and future experience of positive symptoms within a person (Kasanova et al., 2020; Klippel et al., 2017; Kramer et al., 2014; Krkovic et al., 2020; Simor et al., 2019). We provided additional insights on the role of altered affect-reactive dynamics in the developmental trajectory of psychosis. Specifically, elevated variability and instability may progressively build up to trigger the onset of clinically significant psychosis. In order to leverage affect dynamics into building individualized prediction models, future research on within-subject affect time series is needed, such as testing whether windows of rising fluctuations predict exacerbation in positive symptoms down the line.

Interestingly, people who are high in positive symptoms showed a paradoxical increase of nontarget emotions. That is, lower sentiment valence for the pleasant condition, greater sentiment valence for the unpleasant condition, and greater PA and a trend towards greater NA for the mixed-valence film clip. This experience of contradictory emotions at close temporal proximity supports the notion of "schizotypal ambivalence," a construct that has been assigned considerable theoretical importance but has yet received much empirical attention (Bleuler,

1911/1950; Kwapil et al., 2002; Meehl, 1962, 1990). Specifically, ambivalence has been suggested to reflect two distinct processes, either (a) simultaneous coactivation of contradictory emotions or (b) rapid change of emotions over time (Raulin & Brenner, 1993). It is currently unclear which process gives rise to ambivalence, contributing to the difficulty and inconsistency in operationalizing this construct in research (Docherty et al., 2014; Kwapil et al., 2002; MacAulay et al., 2014; Trémeau et al., 2009). Our findings of altered affect intensity, in conjunction with elevated fluctuations in both PA and NA, imply that ambivalence is likely the result of high frequency changes, rather than simultaneous coactivation, for people with high positive symptoms. Thus, the present findings fill an important gap in elucidating the nature of schizotypal ambivalence.

Persistent Baseline States: Modest Risk Signature for Negative Symptoms

In contrast to positive symptoms' profound alterations in affect dynamics, social anhedonia only showed relatively weak associations, displaying a pattern of reduced variability, instability, and elevated inertia at baseline as well as a tendency towards elevated instability and reduced inertia under the pleasant context. This general lack of significant associations is consistent with the handful of studies that examined negative symptoms in relation to affect dynamics in daily life (Kwapil et al., 2012; Oorschot et al., 2013; Westermann et al., 2017). Although we urge caution in interpreting trend-level findings, results seem to indicate that negative symptoms are associated with more persistent affect at baseline and a failure to maintain PA when reacting to pleasant materials. These findings correspond well with one previous study showing that negative symptoms in individuals with schizophrenia were associated with a greater pull of affect to baseline, which the authors interpreted as a greater down-regulation tendency (Westermann et al., 2017). Overall, our findings, and that of others,

suggest that people with high negative symptoms could only generate short-lived positive feelings, perhaps not powerful enough to serve the function of altering to, and preparing for, potential opportunities in the environment (Ellsworth & Scherer, 2003). As such, a persistent baseline state may underlie motivational and social deficits associated with negative symptoms and thus may be a useful target for improving functional outcomes.

Future Directions

Several important questions remain for future research. Chiefly, we focused on the broad categories of PA and NA and did not examine the myriad of discrete emotions subsumed under these categories. Although examining broad PA and NA dynamics is the commonly adopted approach for past studies, it nonetheless limits our understanding of the dynamics within each valence. For example, there is reason to believe that certain discrete emotions (e.g., anxiety and fear) might be a central node in eliciting positive symptoms (Krkovic et al., 2020). Therefore, mapping the multivariate space of discrete emotions, within and between broad categories of PA and NA, will be a necessary next step in providing a fine-grained understanding of affect dynamic signatures of psychosis risk. Further, we focused on nonclinical individuals because the interaction between affective and psychotic symptoms are hypothesized to be particularly relevant for the early stage of psychopathology (van Os, 2013). It remains unclear the extent to which current findings generalize to clinical samples. While it has been suggested that the same dynamical pattern underlie both the development and maintenance of psychosis (Ciompi, 2015), future research is clearly warranted.

Conclusions

The current research provides initial evidence that positive and negative psychosis spectrum pathology are signified by distinct alterations in affect dynamics. Findings highlight the

importance of distinguishing timescales and contexts in the study of affect dynamics. Broadening the scope of literature, we further demonstrated the feasibility of using various inexpensive laboratory paradigms and preexisting social media text in capturing affect dynamics. This is significant in light of the high demand for training and outreach infrastructure of the prevailing clinical high-risk approach to risk detection. Due to its validity and cost-effectiveness, affect dynamics are poised to be an efficient way to answer the multimillion-dollar question of early risk detection and possibly subsequent prediction and prevention.

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CONCLUSION

Recent years have witnessed a push towards clarifying the risk markers for psychosis, particularly to formulate risk in terms of dysfunctions in the general biopsychosocial domains (National Institute of Mental Health, n.d.; National Institutes of Health, 2020). In an attempt to answer this call, the current dissertation provided a comprehensive investigation of affective experiences as they relate to schizophrenia-spectrum risk. Guided by the principles of the dynamic systems theory, this dissertation focused on the temporal aspect of affect by examining trait and state affective experience abnormalities (Chapter 1) and multi-timescale affect dynamics (Chapter 2) associated with schizophrenia-spectrum risk. Findings paint a complex picture of affective experience dysfunctions in schizophrenia-spectrum risk: at-risk individuals self-report severe trait-level abnormalities. On the other hand, at-risk individuals' state-level experiences are less characterized by disturbances in the mean-level affect, but exhibit drastic alterations in the temporal structure consistent with several risk signatures posited by the dynamic systems theory. Overall, this dissertation delineated a number of affective vulnerability markers that can be used to identify, and perhaps predict, risk for psychosis.

In order to elucidate the predictive utility of these affective vulnerability markers, longitudinal investigations that follow at-risk individuals as they progress through the illness course are needed. Affective experiences should be characterized at both short and long timescales as experiences at different temporal courses do not always converge in their association with risk. Particularly, long-term daily life affect monitoring could be implemented to identify whether windows of altered affective fluctuations (e.g., rise in variability and instability) predict subsequent exacerbation of symptoms or whether affect dynamics track treatment response. While essential, longitudinal research is prohibitively resource-intensive that

is difficult to carry out within a single lab. This dissertation has offered several cost-effective alternatives (e.g., social media) useful for piloting ideas on risk prediction, but ultimately large-scale collaborations would be necessary. Fortunately, such work is already underway, as exemplified by the Psychosis-Risk Outcomes Network (ProNET), an international collaboration of 26 sites. The current work has demonstrated the potential of leveraging affective experiences into identifying psychosis risk; it is perceivable that further understanding into the realm of prediction and prevention could be achieved in the foreseeable future.

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Appendix A

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist Item	Reported on Page #
TITLE			
Title	1	Identify the report as a systematic review.	6
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist (Table S2).	7
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	9-18
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	18-19
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	19-20
Information sources	6	Specify all databases, registers, website, organizations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	20-21
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	140-142
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	22-23
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	23-24, 27-28
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g., for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	24-25

	10b	List and define all other variables for which data were sought (e.g., participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	25-27
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	26
Effect measures	12	Specify for each outcome the effect measure(s) (e.g., risk ratio, mean difference) used in the synthesis or presentation of results.	27
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis.	24-25
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	26, 27
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	28
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	28-30
	13e	Describe any methods used to explore possible causes of heterogeneity among study results.	29
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	29
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	29
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	30
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	22
	16b	Cite studies that met many but not all inclusion criteria ('near-misses') and explain why they were excluded.	23, 143-145
Study characteristics	17	Cite each included study and present its characteristics.	146-159, OSF

Risk of bias in studies	18	Present assessments of risk of bias for each included study.	34, OSF
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g., confidence/credible interval), ideally using structured tables or plots.	160-185
Results of syntheses	20a	For each synthesis, briefly summarize the characteristics and risk of bias among contributing studies.	186-199
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	30-33
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	35-40, 41-56
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	30-31
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	34
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	33
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	57-60
	23b	Discuss any limitations of the evidence included in the review.	63-64
	23c	Discuss any limitations of the review processes used.	63
	23d	Discuss implications of the results for practice, policy, and future research.	60-63
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	NA
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	NA
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA

Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	NA
Competing interests	26	Declare any competing interests of review authors.	NA
Availability of data, code, and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	19

PRISMA 2020 for Abstracts Checklist

Section and Topic	Item #	Checklist Item	Reported on Page #
TITLE			
Title	1	Identify the report as a systematic review.	6
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	7
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	7
Information sources	4	Specify the information sources (e.g., databases, registers) used to identify studies and the date when each was last searched.	NA
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	NA
Synthesis of results	6	Specify the methods used to present and synthesize results.	7
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarize relevant characteristics of studies.	7
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e., which group is favored).	7
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g., study risk of bias, inconsistency and imprecision).	7
Interpretation	10	Provide a general interpretation of the results and important implications.	7
OTHER			
Funding	11	Specify the primary source of funding for the review.	NA
Registration	12	Provide the register name and registration number.	NA

Appendix B

Search String Used in ProQuest

Databases: APA PsycINFO and ProQuest Dissertations & Theses A&I

Conducted on July 3, 2018

AB(psychosis or psychotic or schizo[*20]) AND

AB(risk or FHR or FDR or (psychosis NEAR/2 prone*) or PLE or WSS or Chapman or anhedon* or “perceptual aberration” or “magical ideation” or SPQ or “O-LIFE” or CHR or UHR or ARMS or prodrom*) AND

AB(“emotion* experience” or “affect* experience” or mood or “emotion* induct*” or “affect* induct*” or “mood induct*” or “emotion* trait” or “affect* trait” or temperament or emotionality or neuroticism or extraversion or "harm avoidance" or "novelty seeking" or PANAS or GTS or MPQ or EPQ or NEO or "big five" or TPQ or TCI)

Conducted on July 1, 2020

AB(psychosis or psychotic or schizo[*20]) AND

AB(risk or FHR or FDR or (psychosis NEAR/2 prone*) or PLE or WSS or Chapman or anhedon* or “perceptual aberration” or “magical ideation” or SPQ or “O-LIFE” or CHR or UHR or ARMS or prodrom*) AND

AB(((emotion* or mood or affect*) NEAR/2 (positive or negative or experienc* or induct* or trait or temperament or personality or deficit or reactiv* or abnormal* or disturb* or difficult*)) OR (emotionality or neuroticism or extraversion or “harm avoidance” or “novelty seeking” or anhedon* or pleasure or PANAS or TEPS or ACIPS or GTS or MPQ or EPQ or NEO or “big five” or TPQ or TCI))

Search String Used in Ovid

Conducted on July 3, 2018

Database: Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present

1. (psychosis or psychotic or schizo*).ab.
2. (risk or FHR or FDR or (psychosis adj2 prone*) or PLE or WSS or Chapman or anhedon* or "perceptual aberration" or "magical ideation" or SPQ or "O-LIFE" or CHR or UHR or ARMS or prodrom*).ab.
3. ("emotion* experience" or "affect* experience" or mood or "emotion* induct" or "affect* induct" or "mood induct*" or "emotion* trait" or "affect* trait" or temperament or emotionality or neuroticism or extraversion or "harm avoidance" or "novelty seeking" or PANAS or GTS or MPQ or EPQ or NEO or "big five" or TPQ or TCI).ab.
4. 1 and 2 and 3

Conducted on July 1, 2020

Database: Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations and Daily 1946 to June 30, 2020

1. (psychosis or psychotic or schizo*).ab.
2. (risk or FHR or FDR or (psychosis adj2 prone*) or PLE or WSS or Chapman or anhedon* or "perceptual aberration" or "magical ideation" or SPQ or "O-LIFE" or CHR or UHR or ARMS or prodrom*).ab.
3. ((emotion* or mood or affect*) adj2 (positive or negative or experienc* or induct* or trait or temperament or personality or deficit or reactiv* or abnormal* or disturb* or difficult*)).ab.

4. (emotionality or neuroticism or extraversion or "harm avoidance" or "novelty seeking" or anhedon* or pleasure or PANAS or TEPS or ACIPS or GTS or MPQ or EPQ or NEO or "big five" or TPQ or TCI).ab.
5. 3 or 4
6. 1 and 2 and 5

Appendix C

Studies Excluded Due to Insufficient Information

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Appendix D

Included Studies

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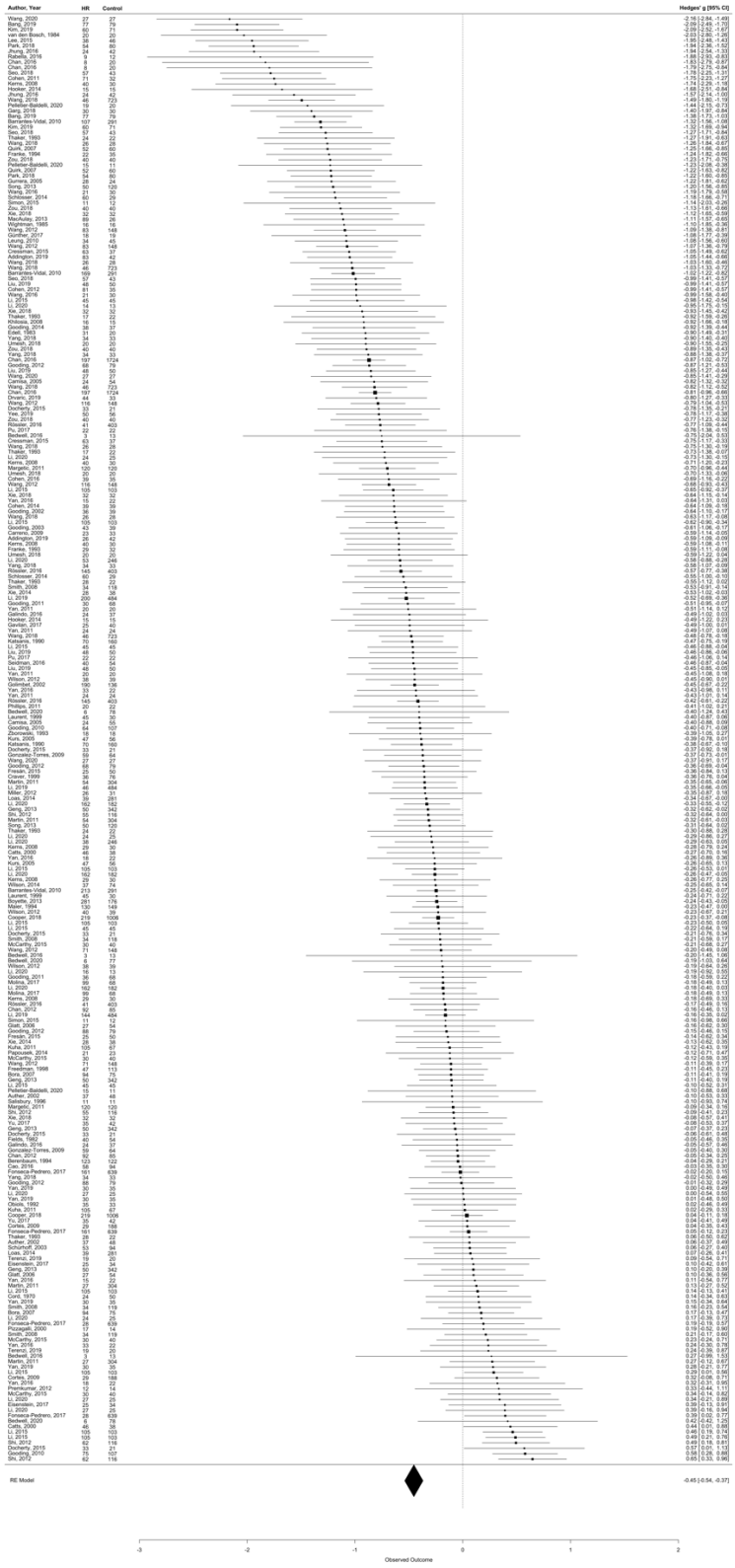
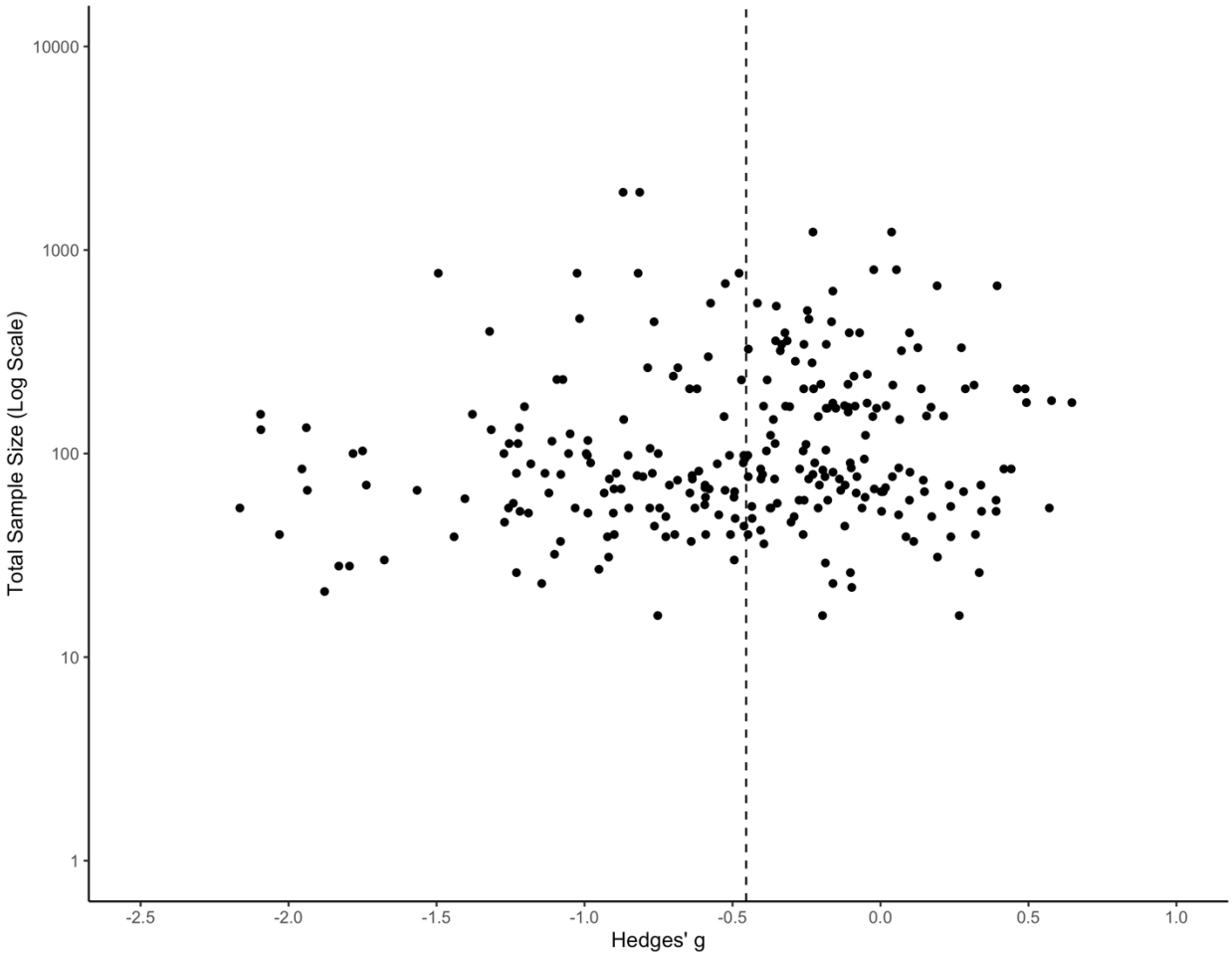
Appendix E

Trait PA Forest Plot



Trait PA Funnel Plot



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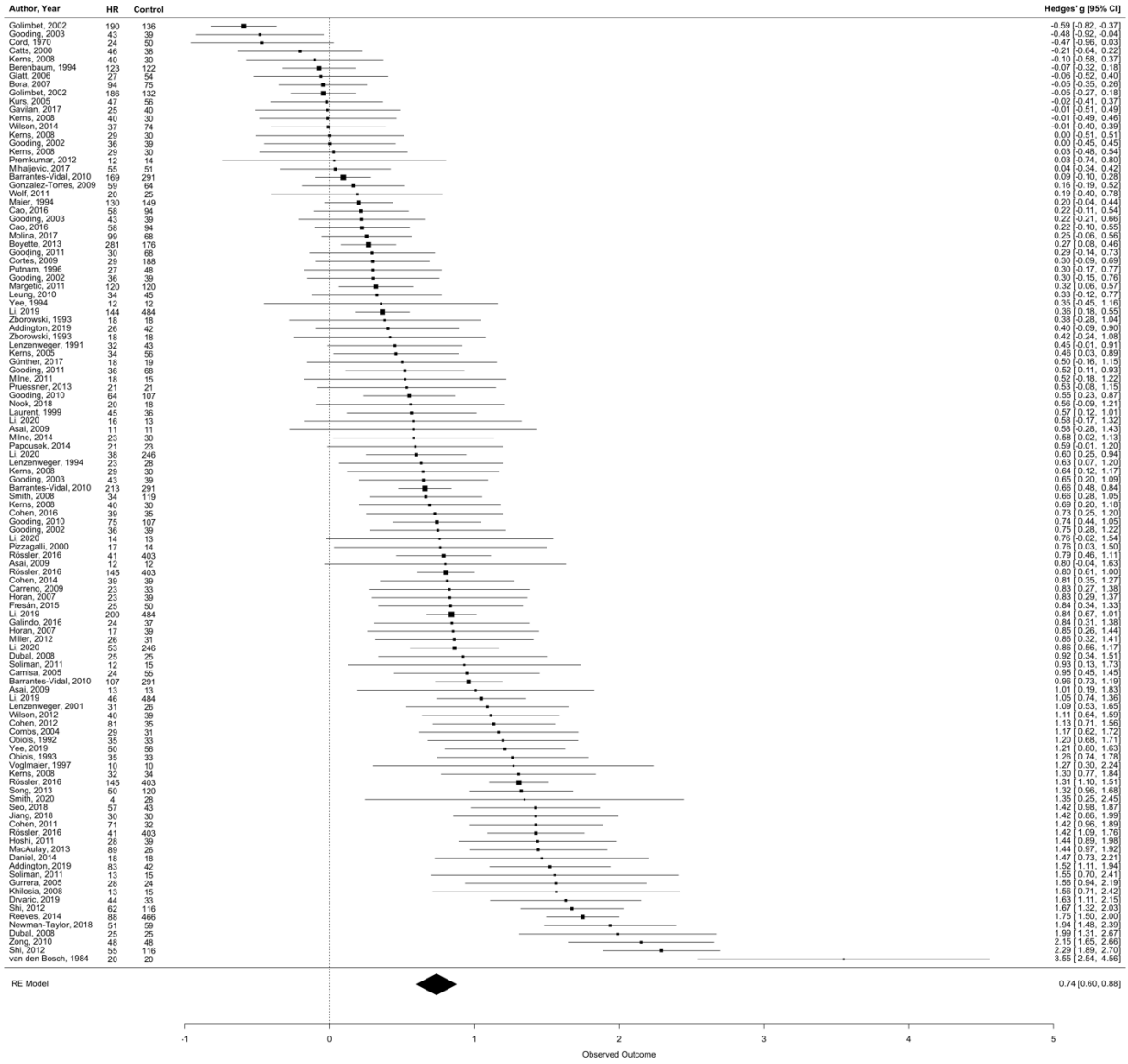

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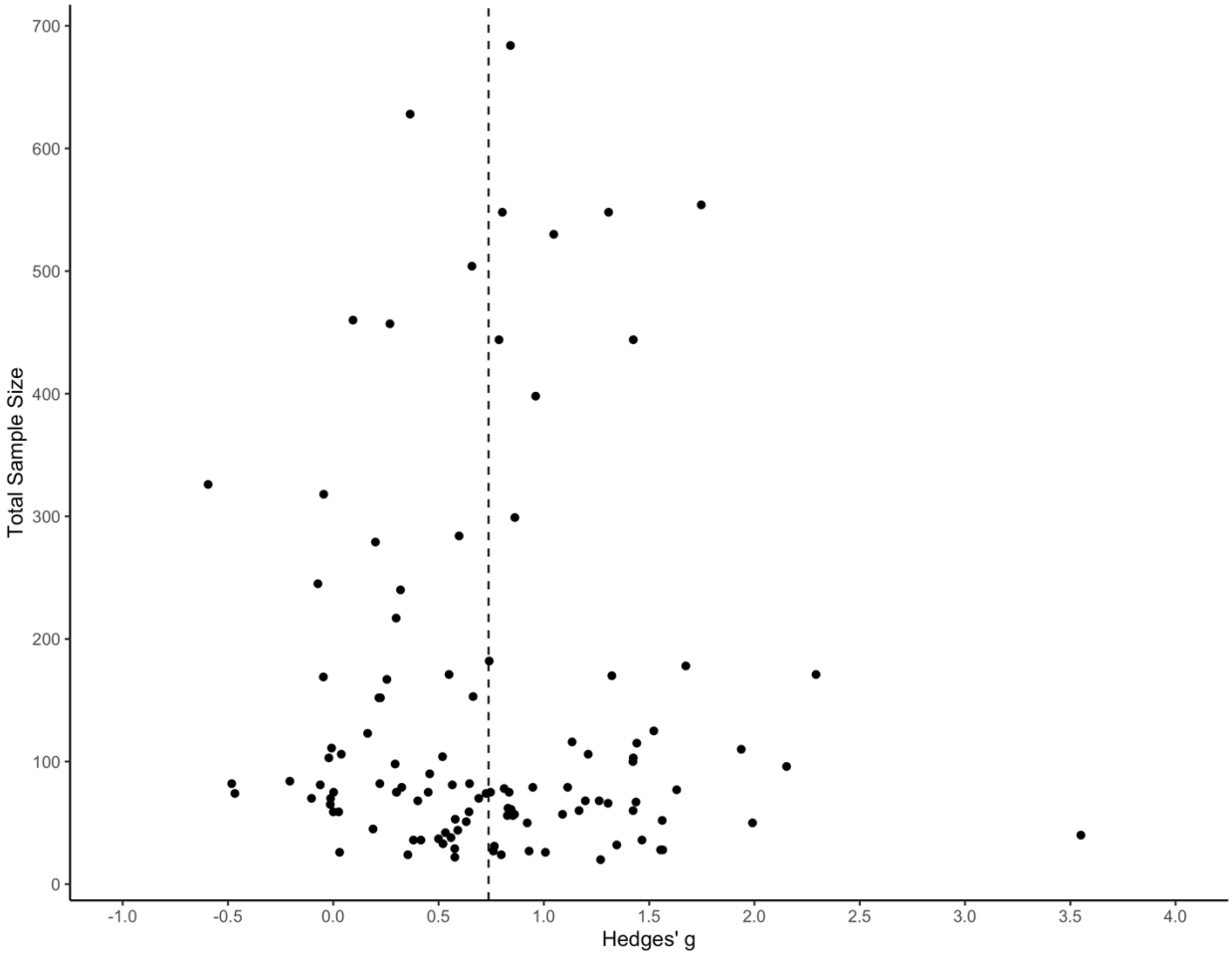
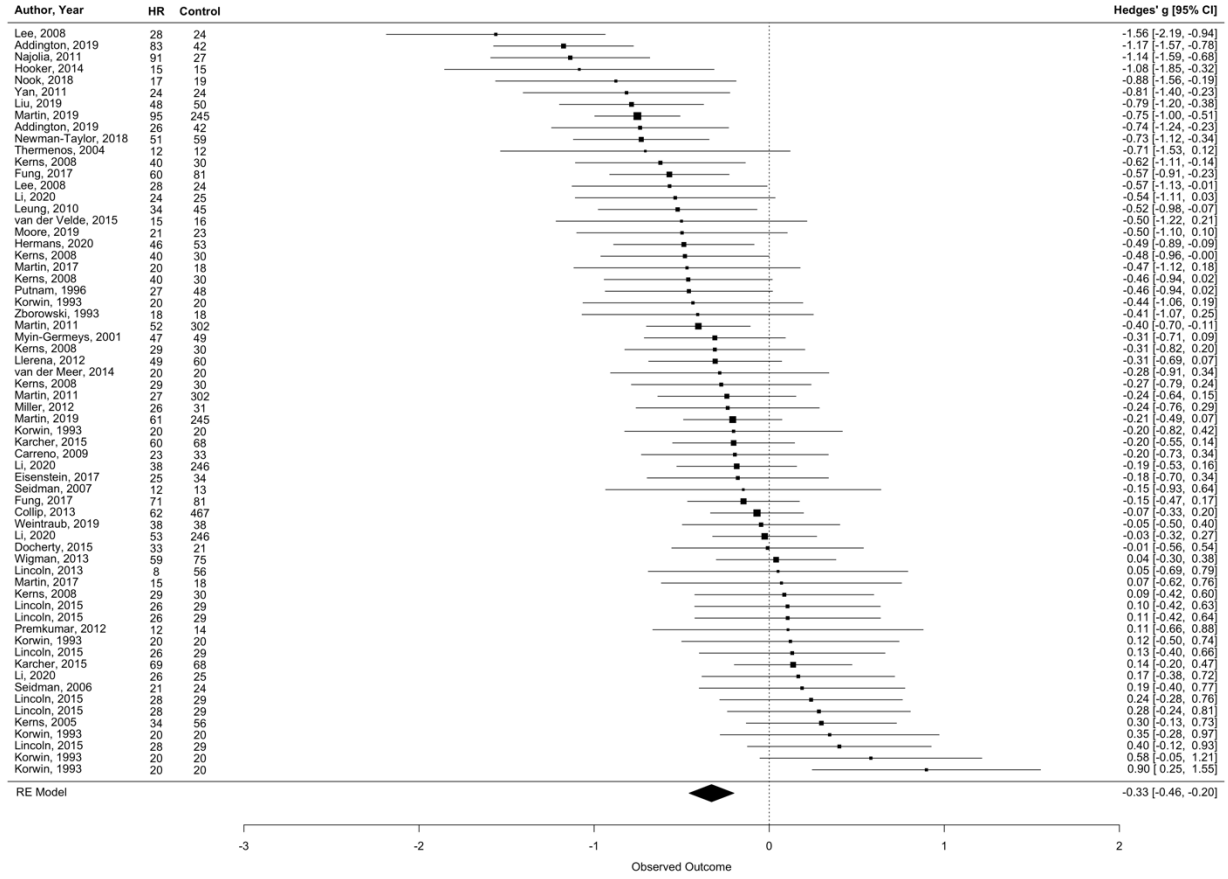


State PA Baseline Forest Plot



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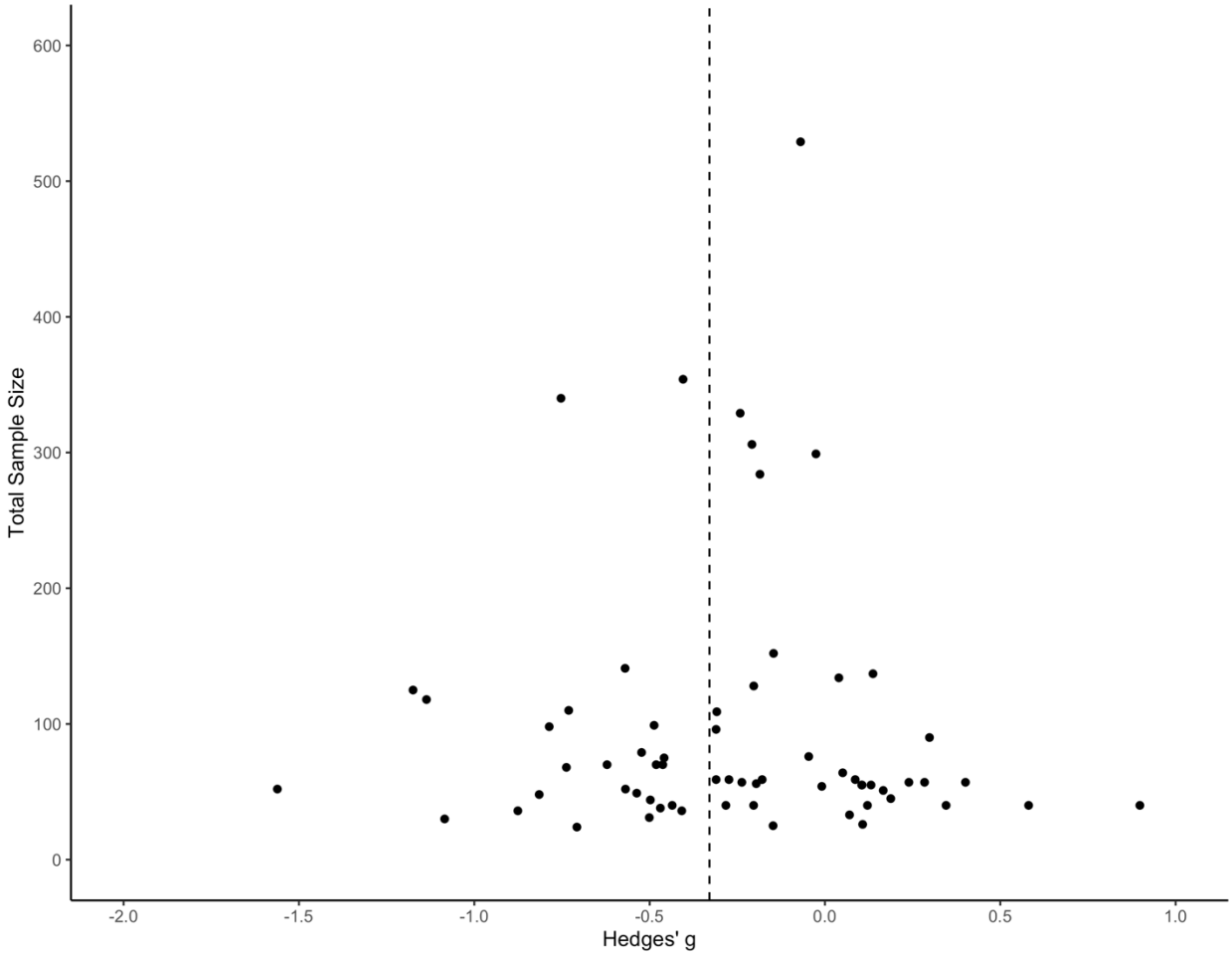

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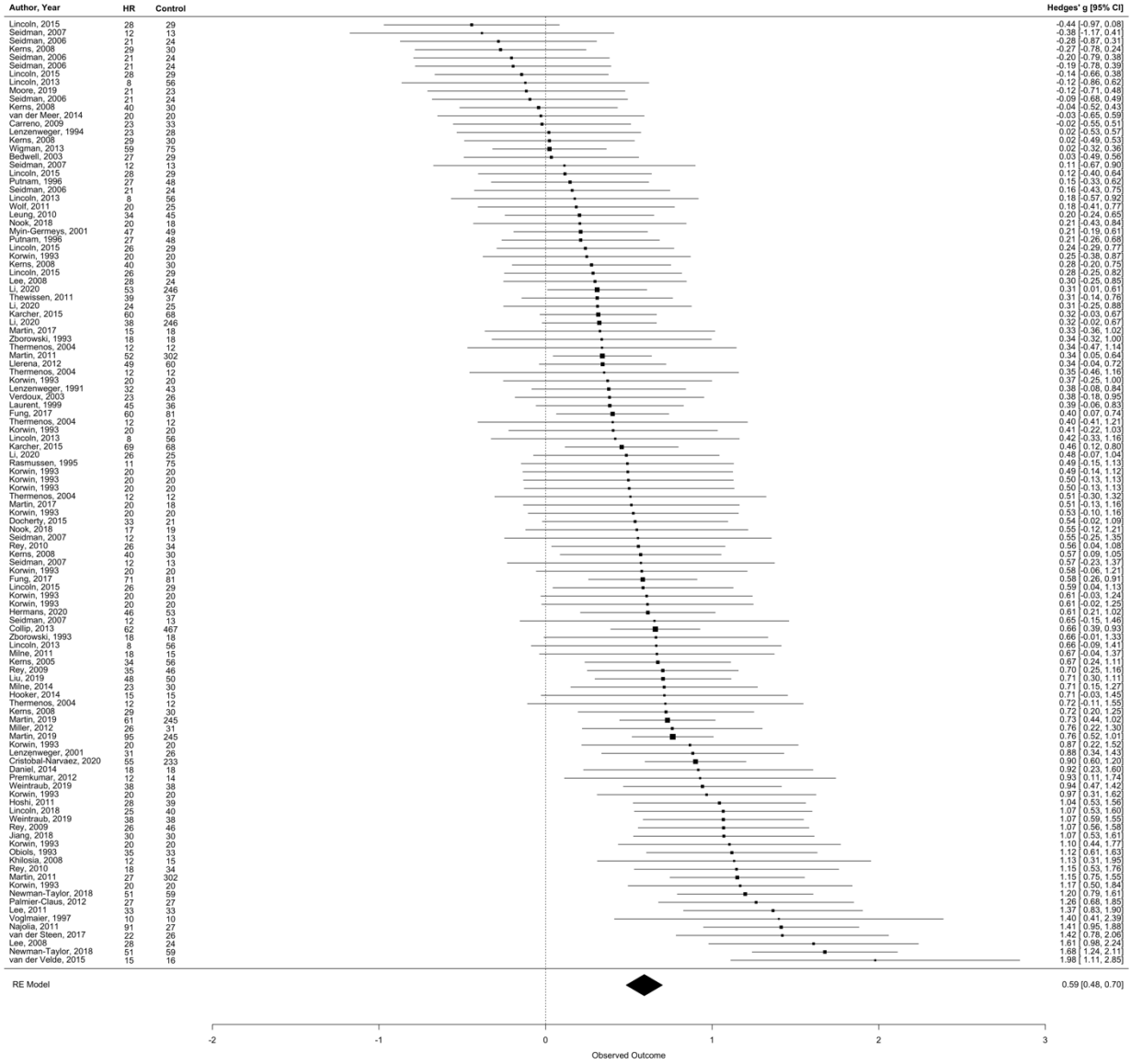

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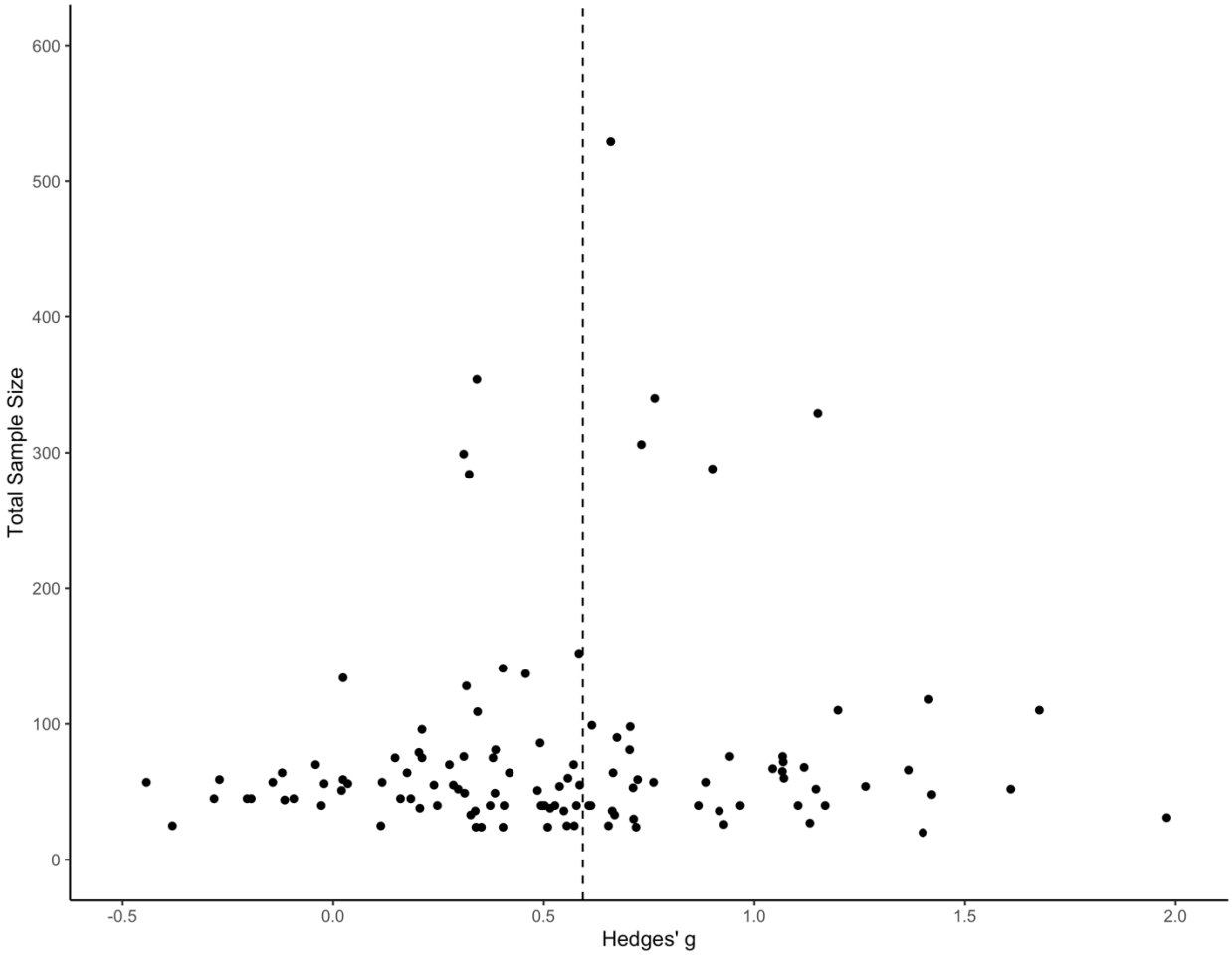
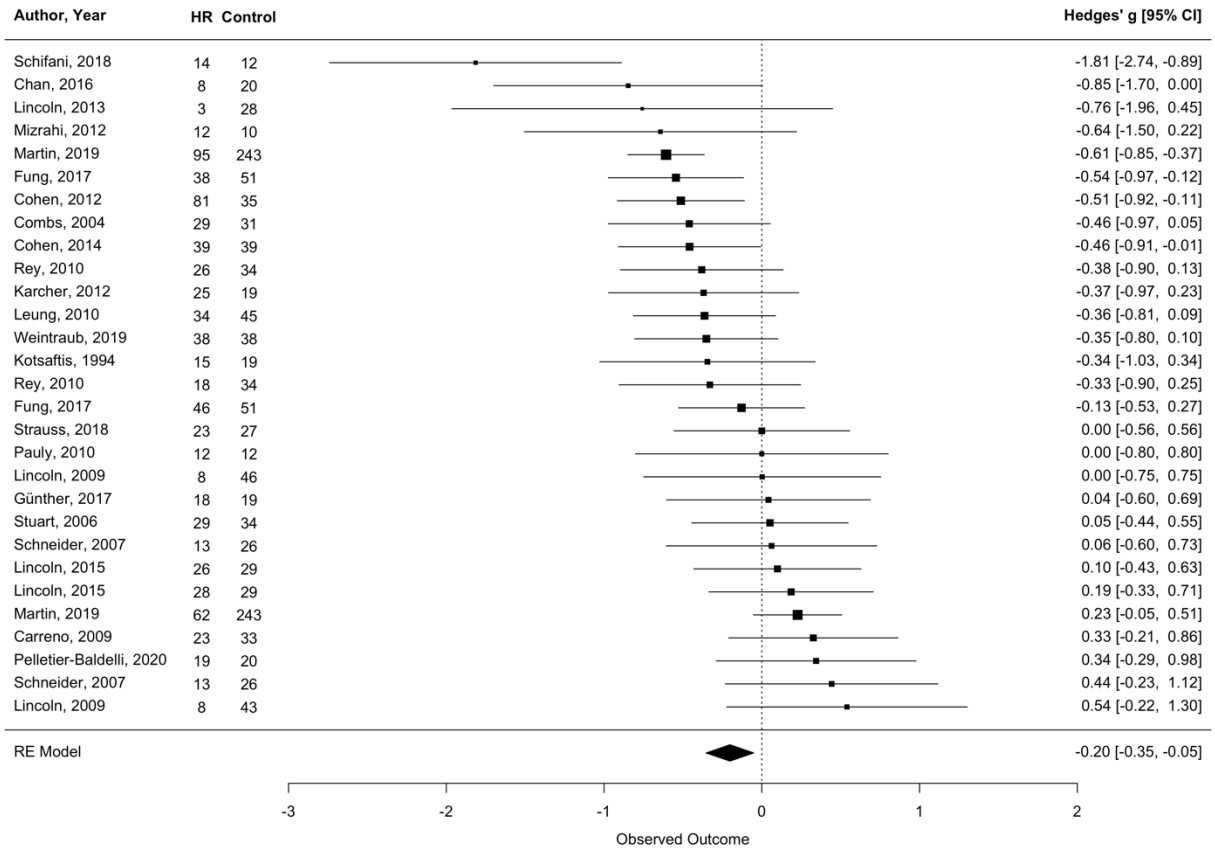


State PA Neutral Induction Forest Plot



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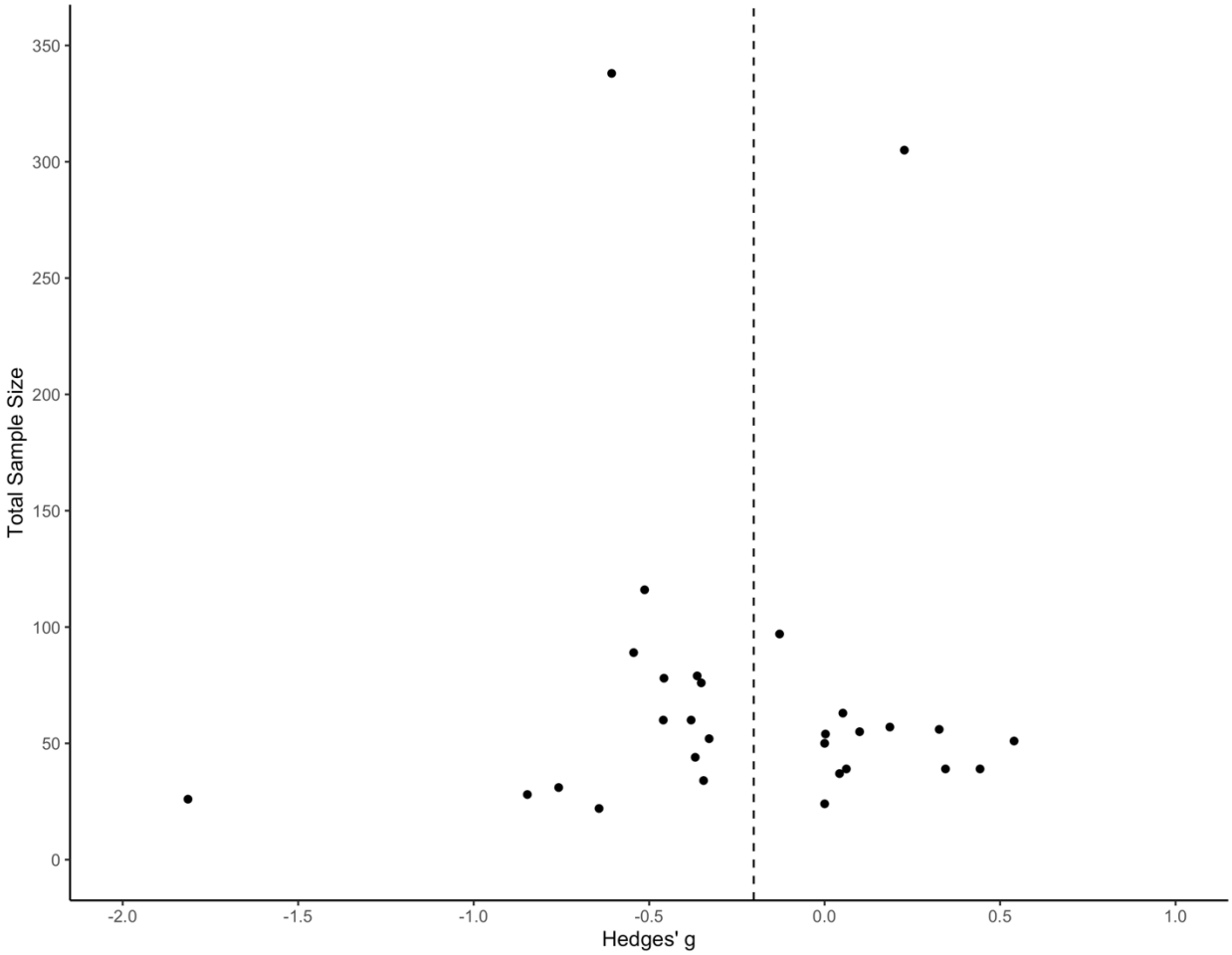

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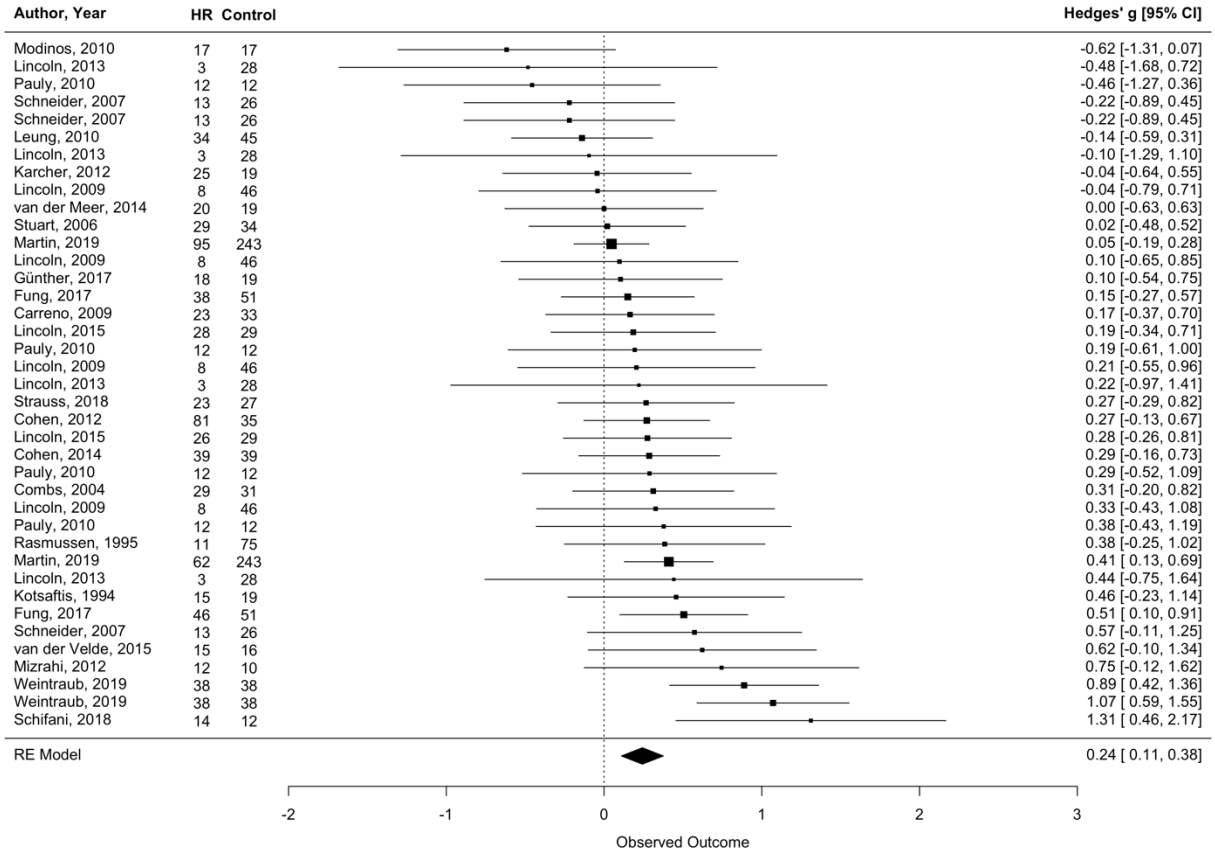

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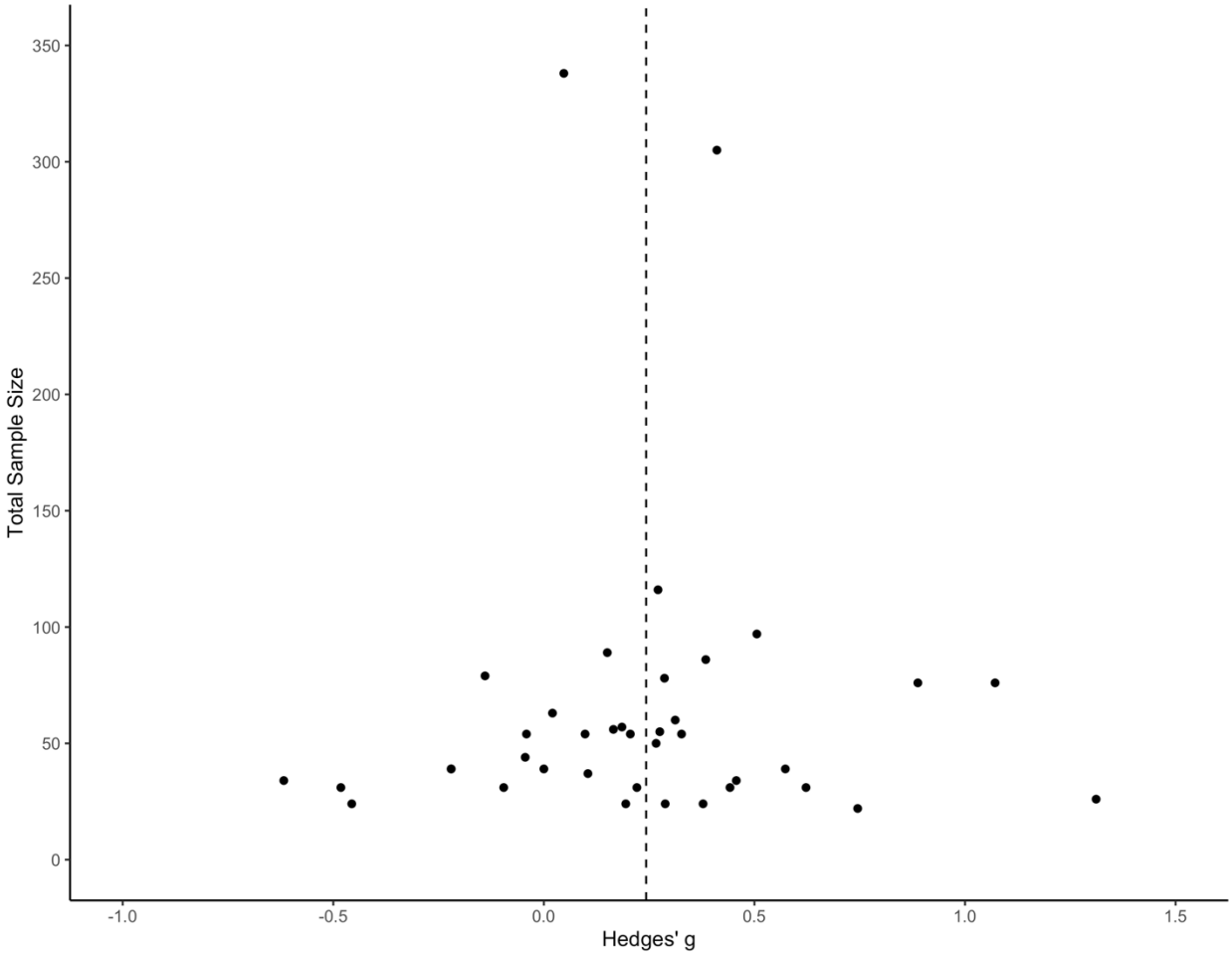
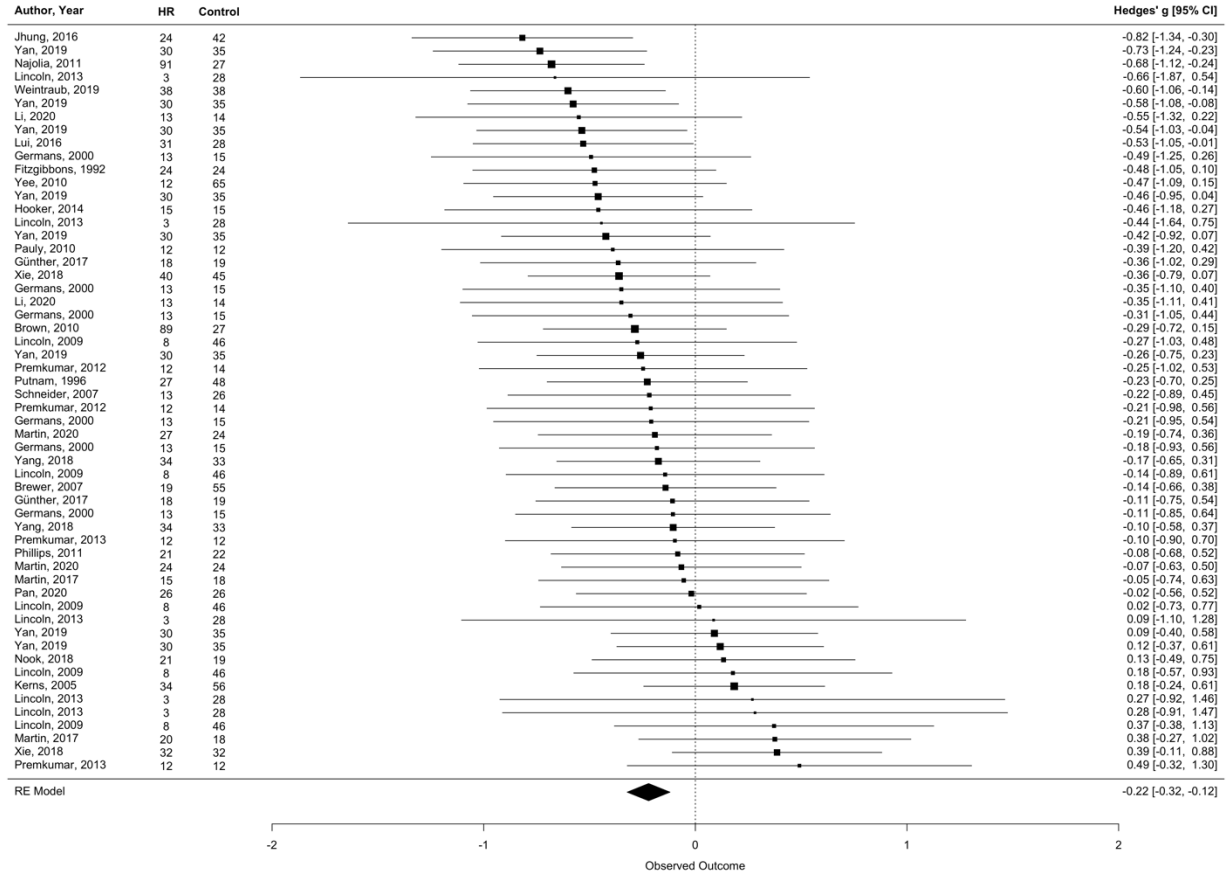


State Bipolar Neutral Induction Forest Plot



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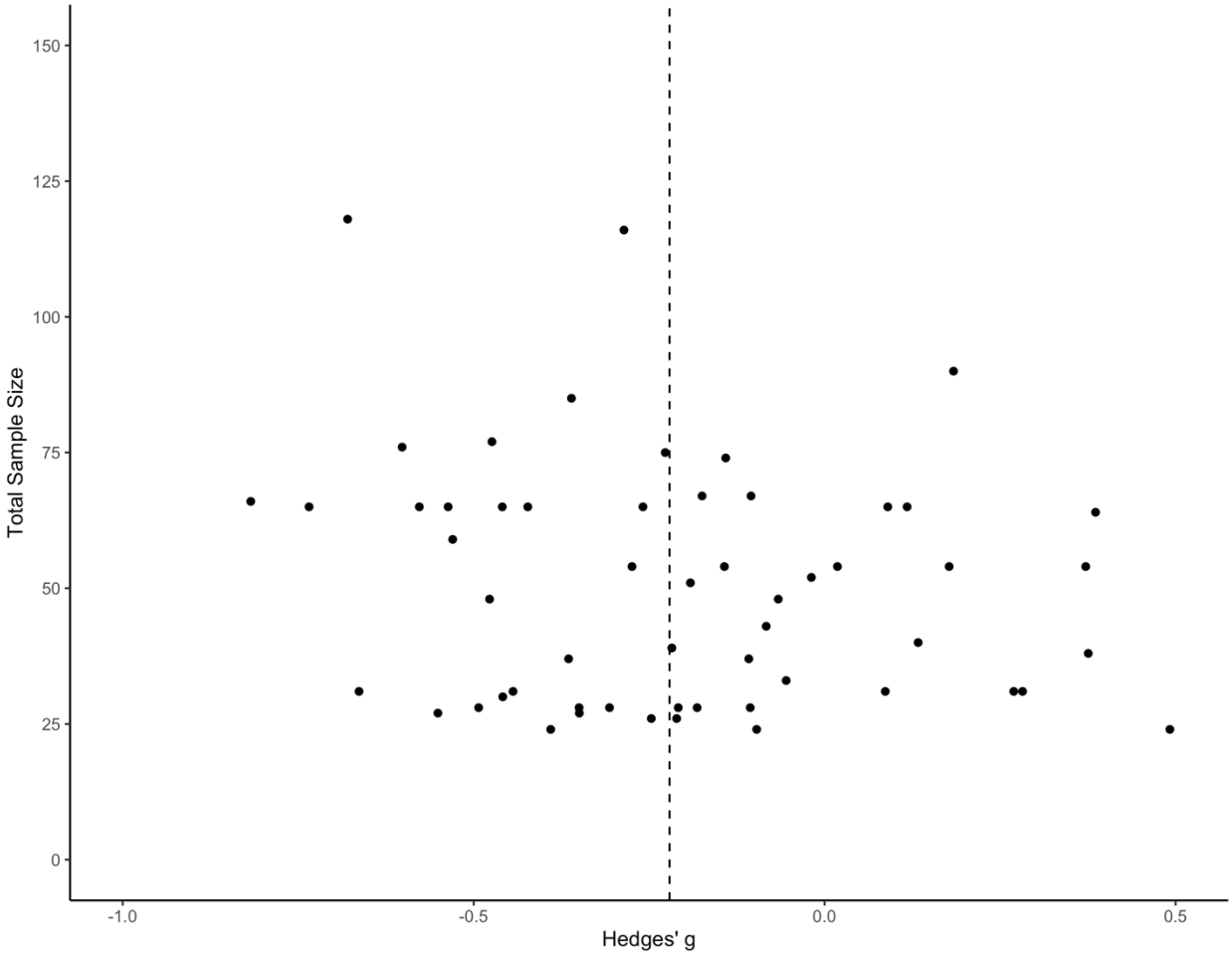
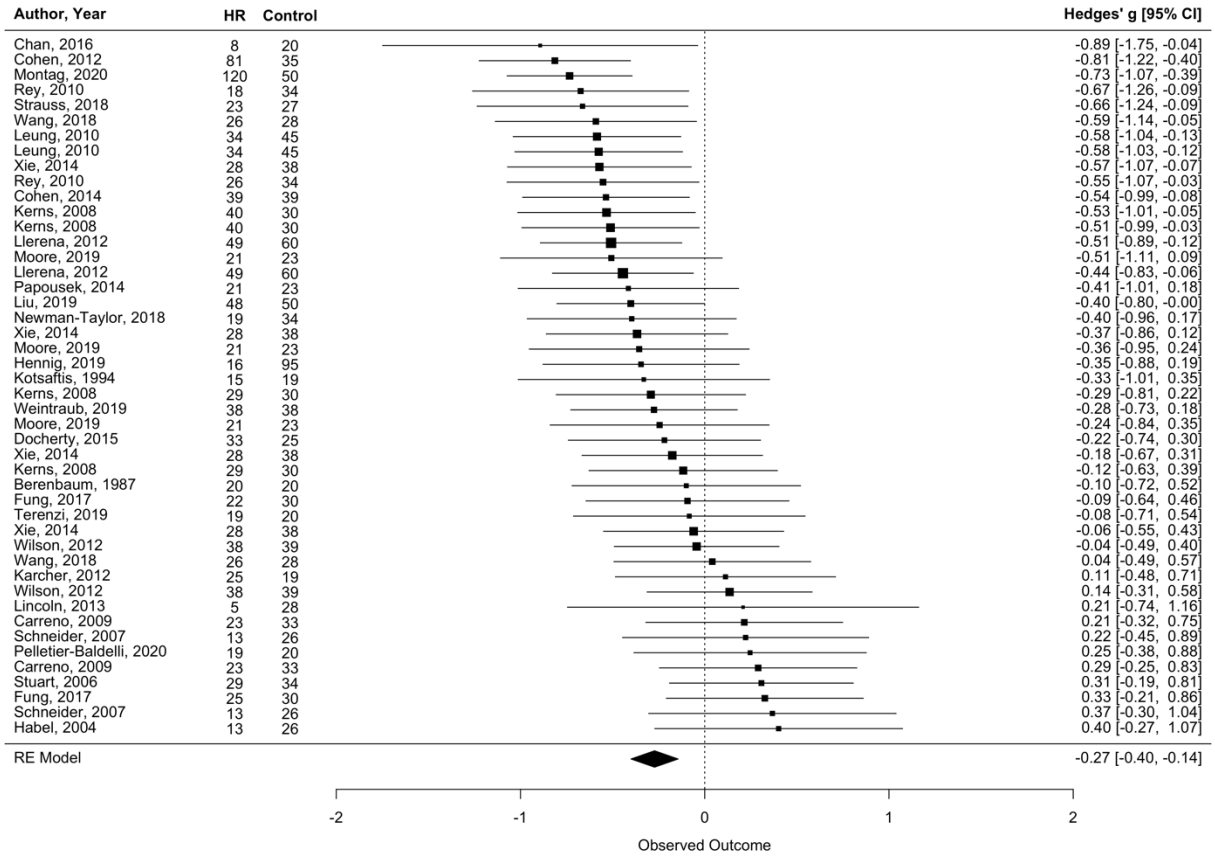


State PA Pleasant Induction Forest Plot



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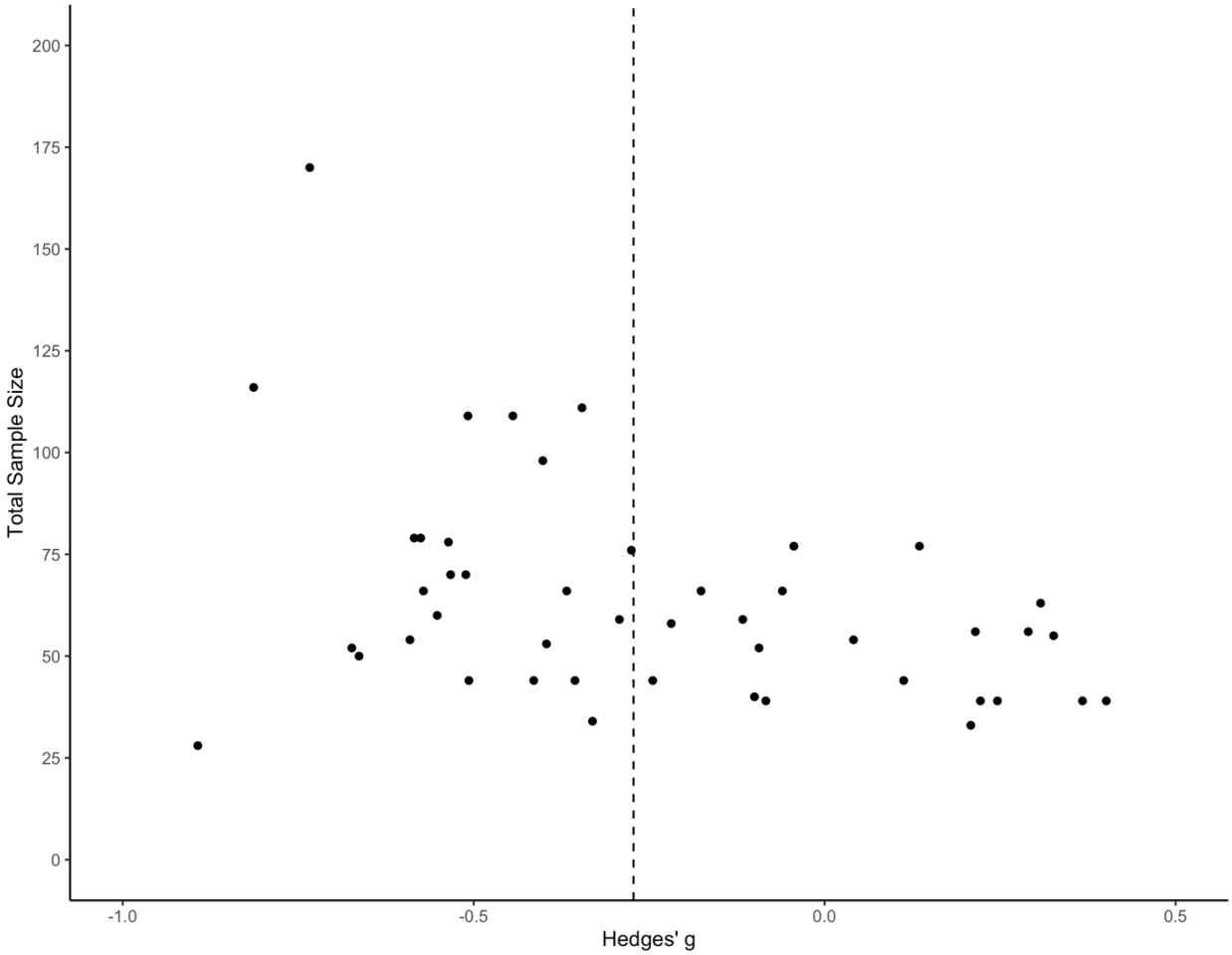

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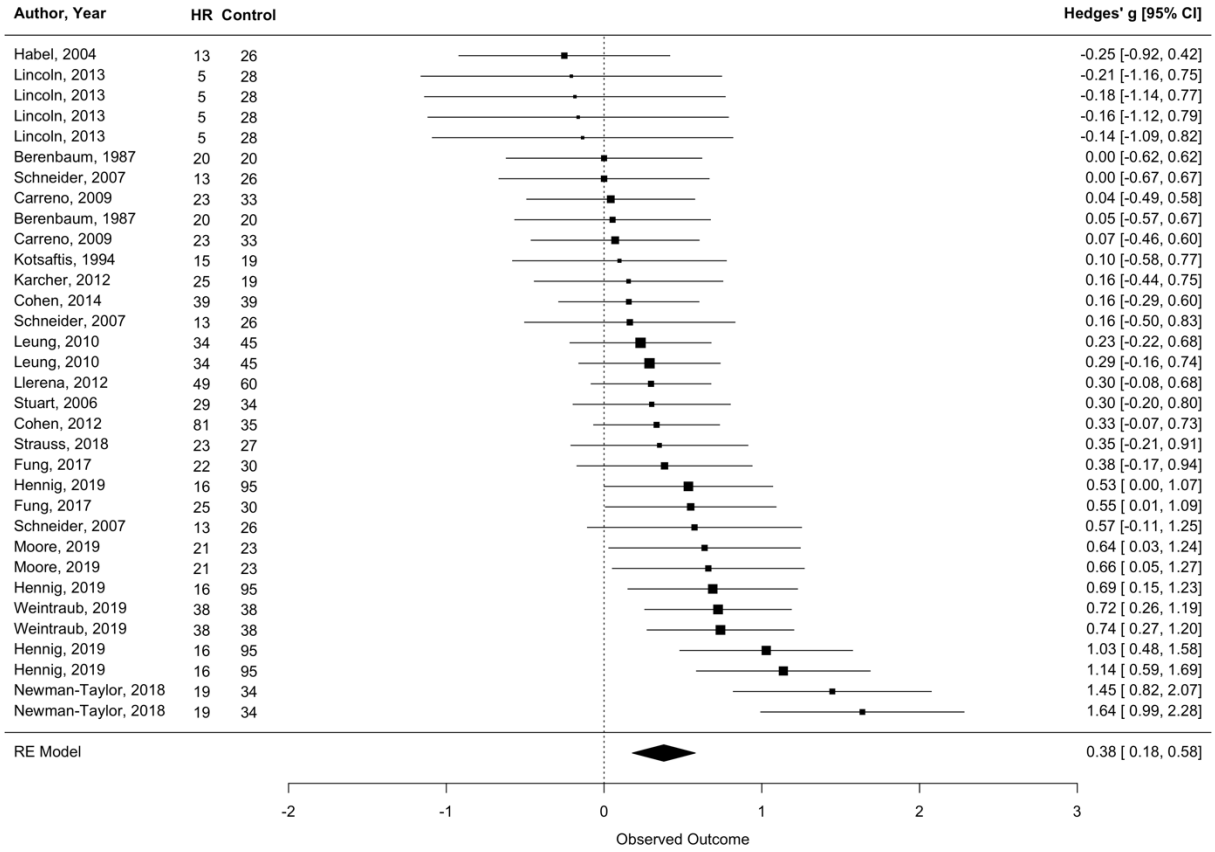

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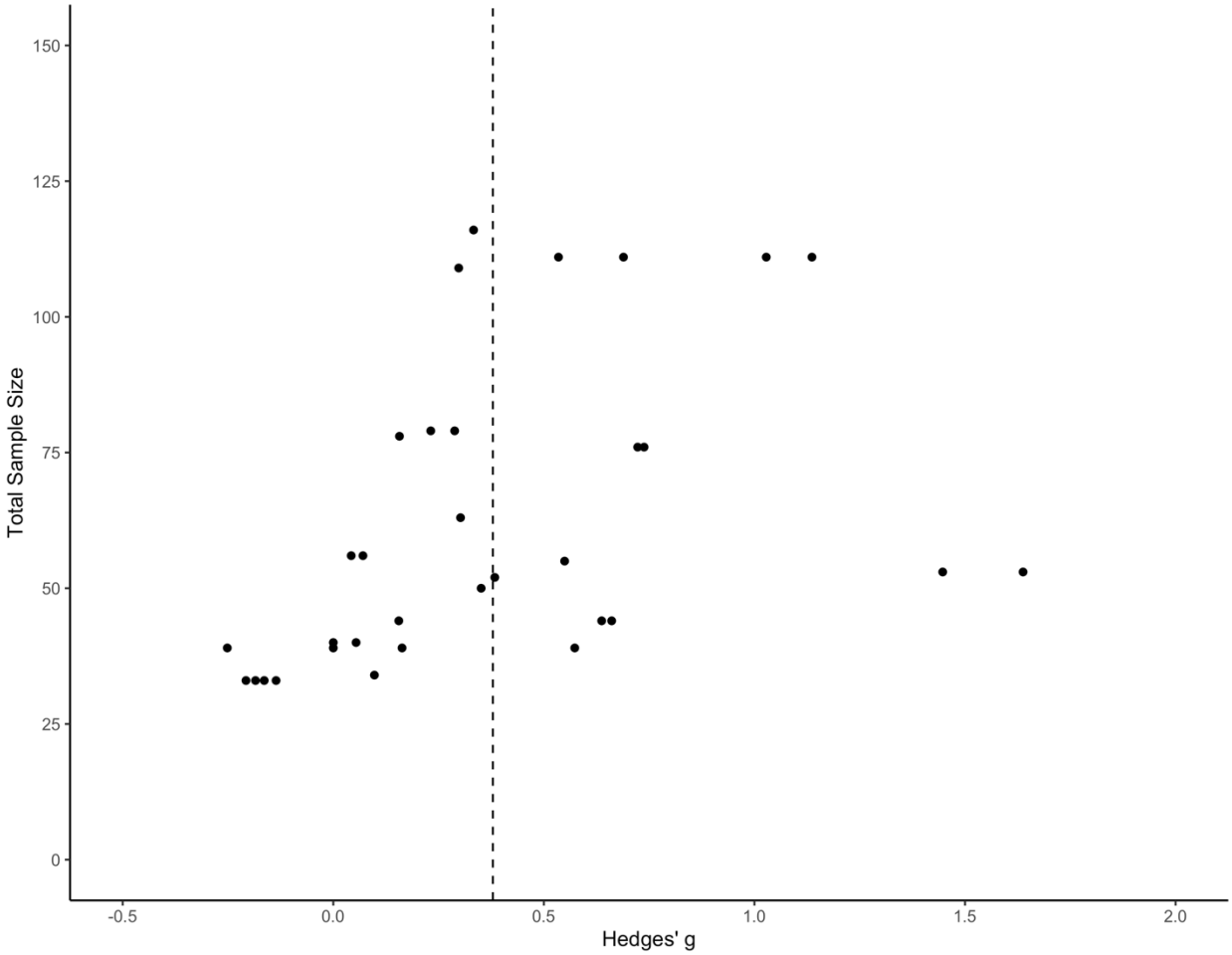

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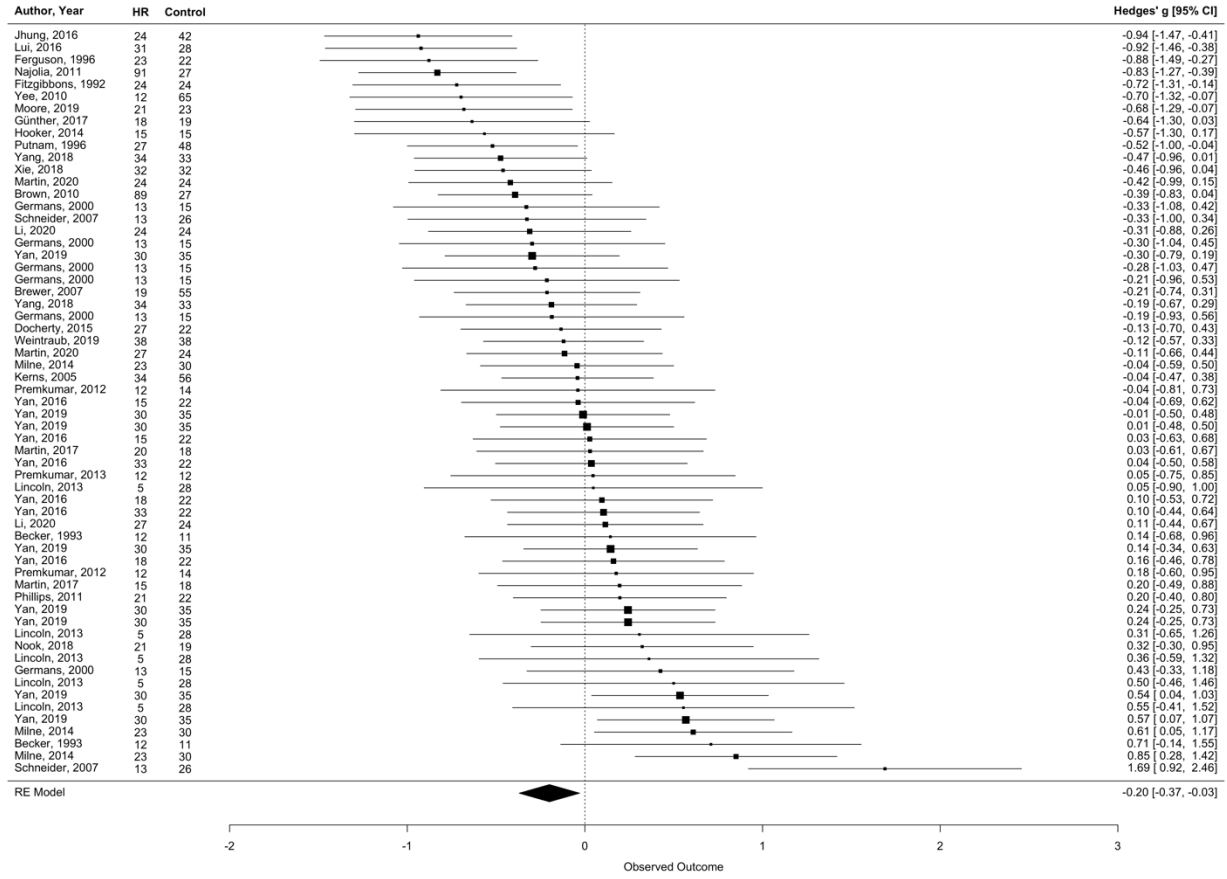

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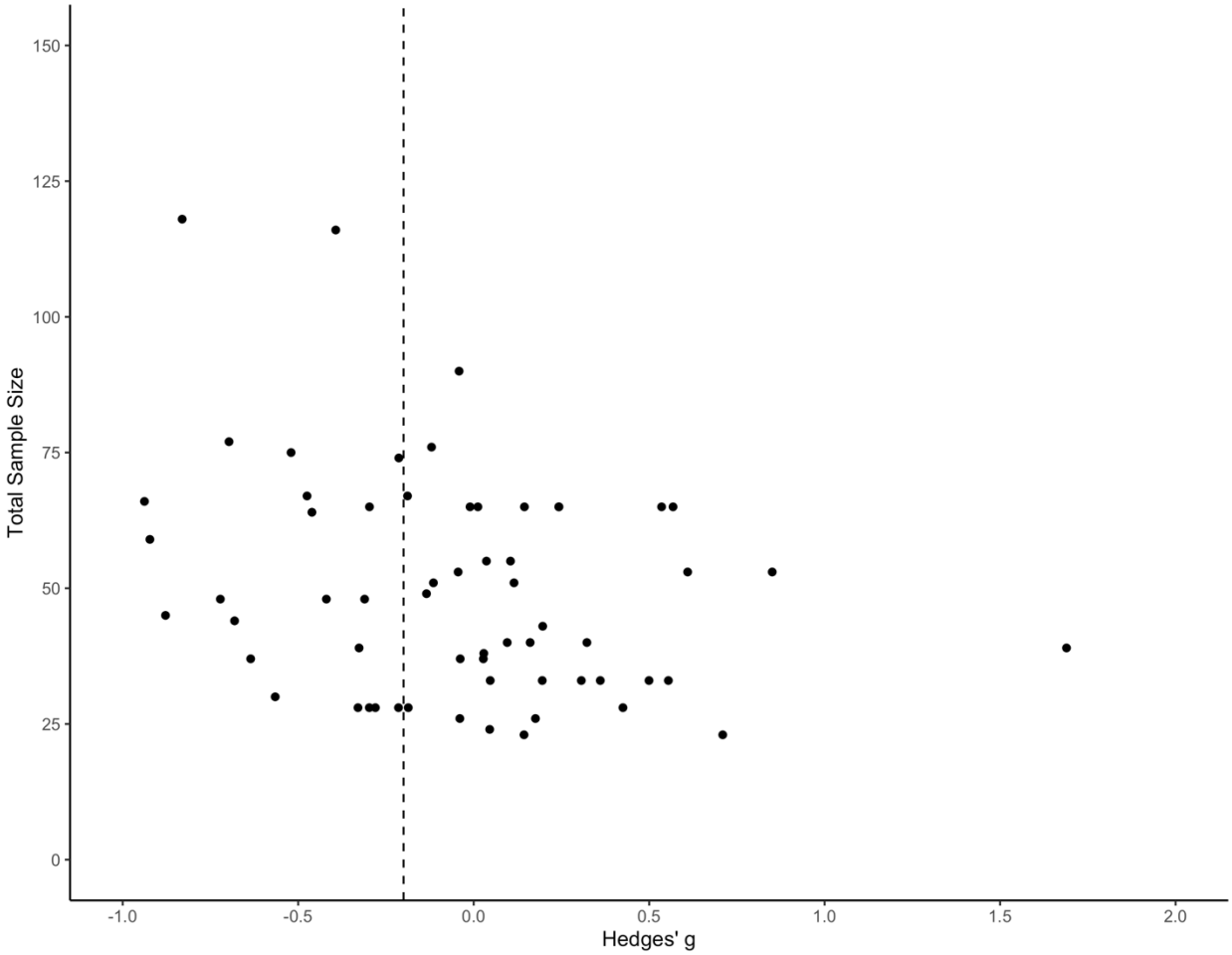

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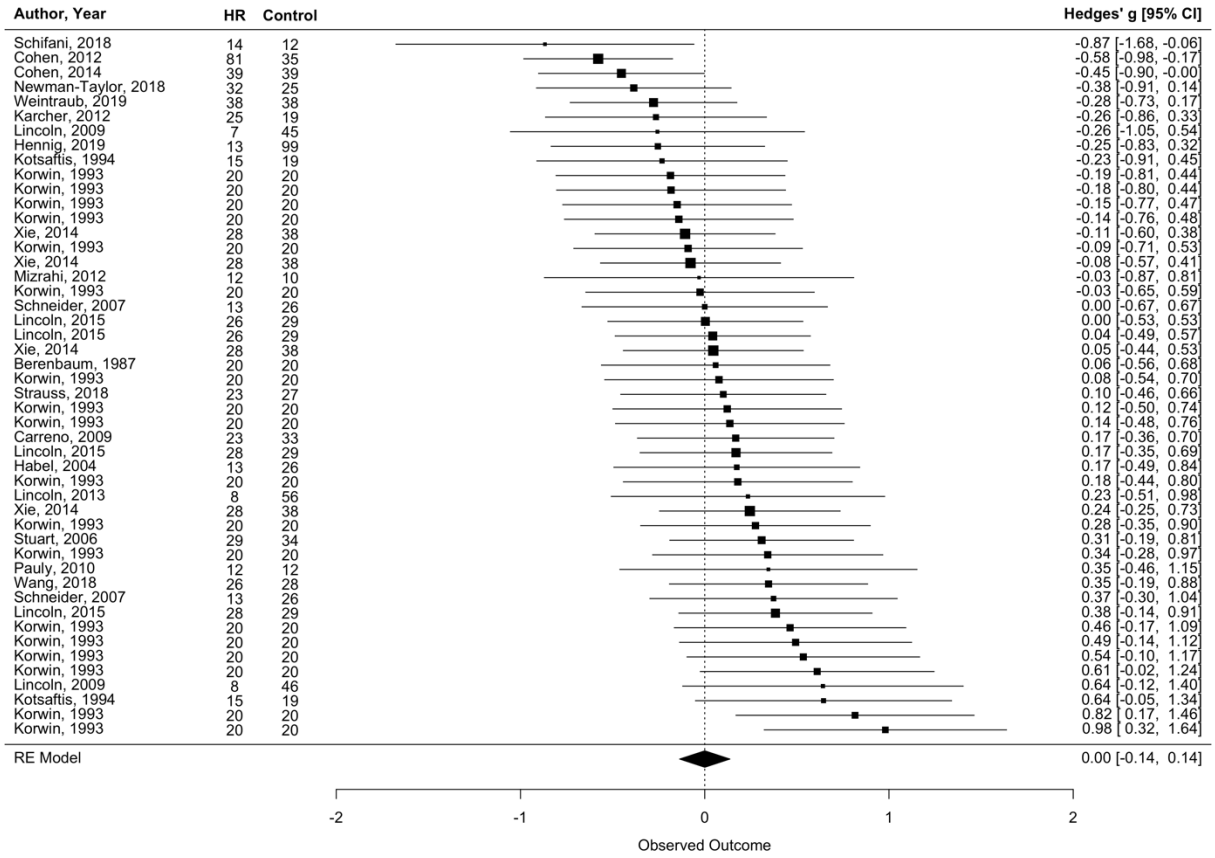

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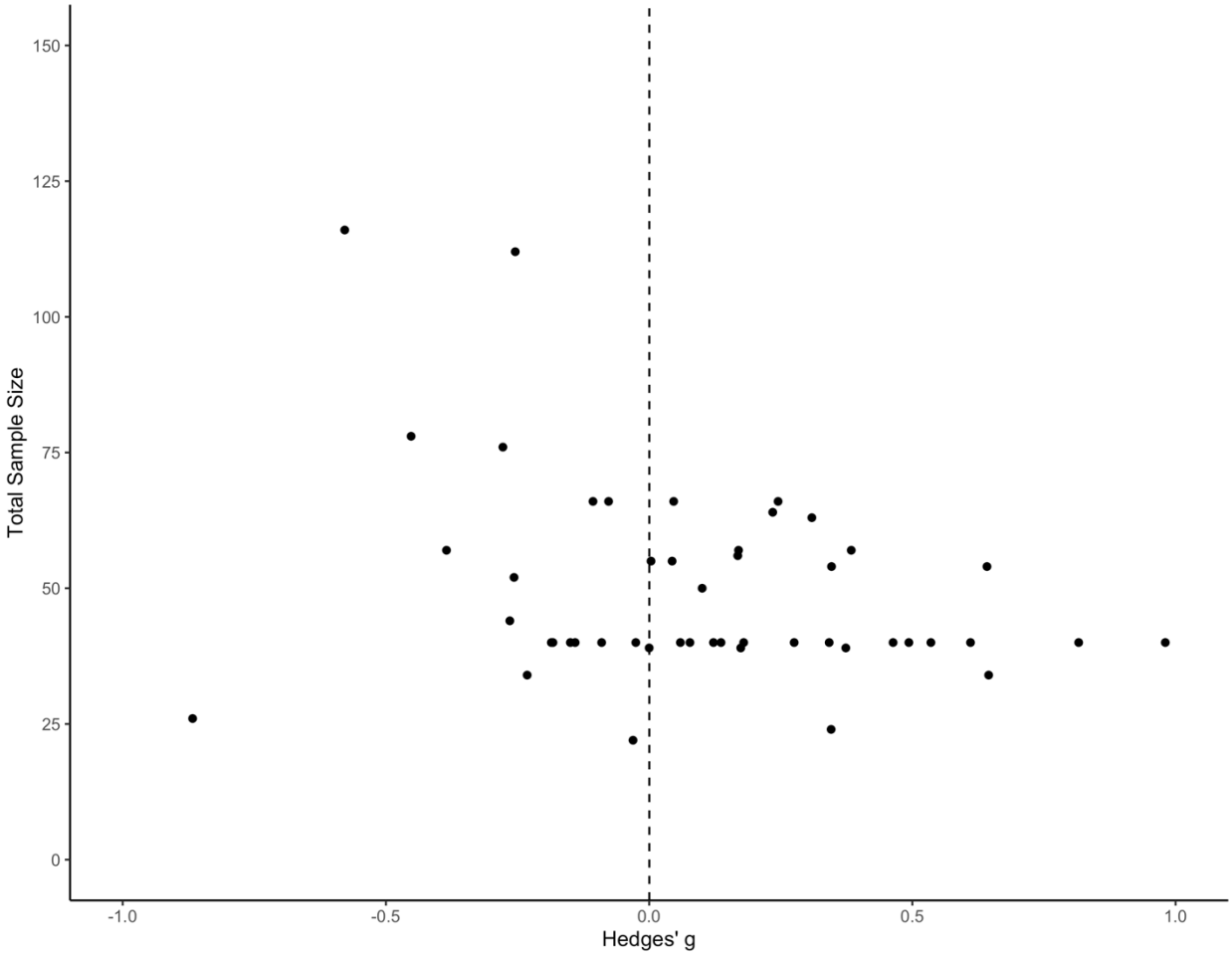

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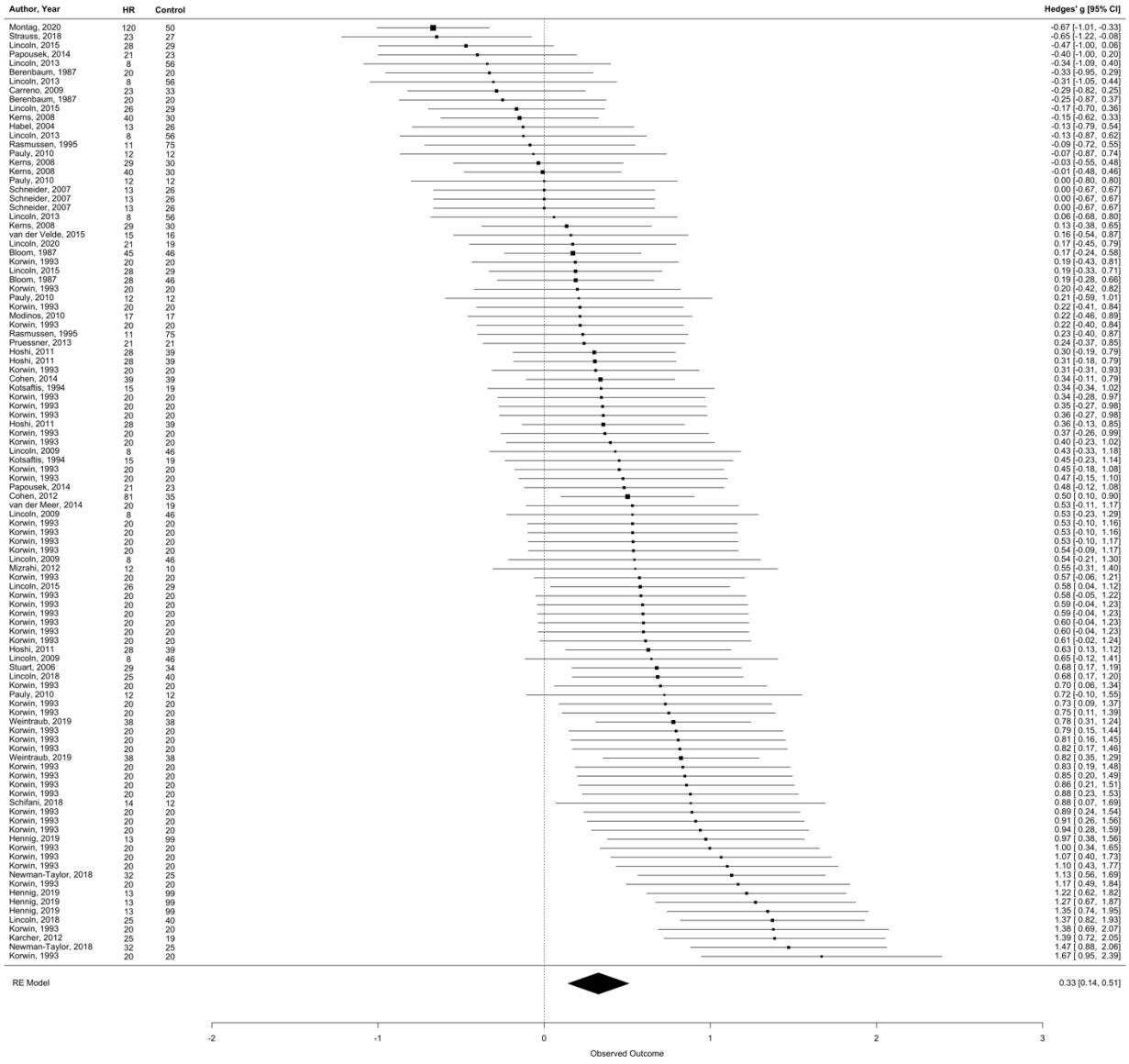

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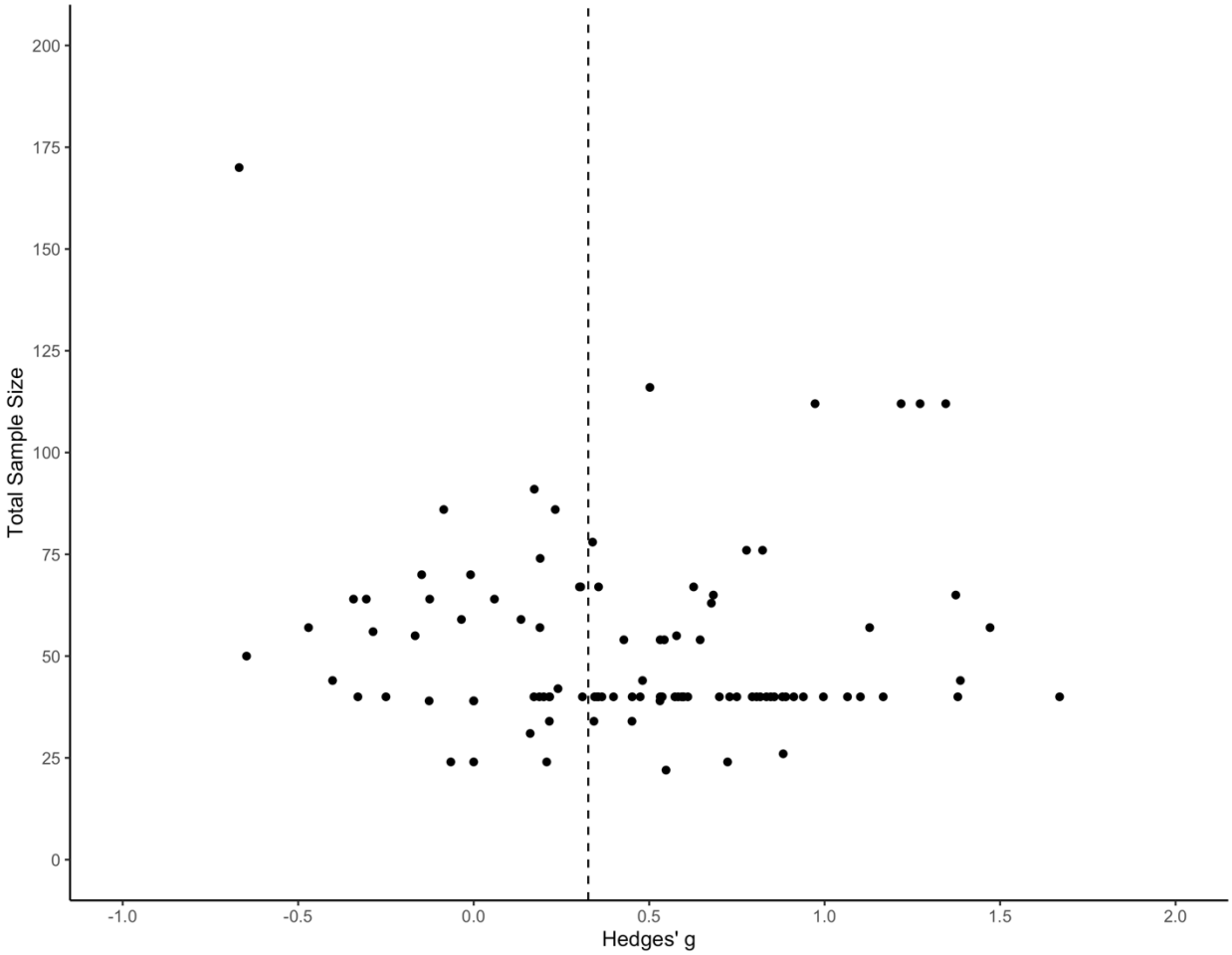

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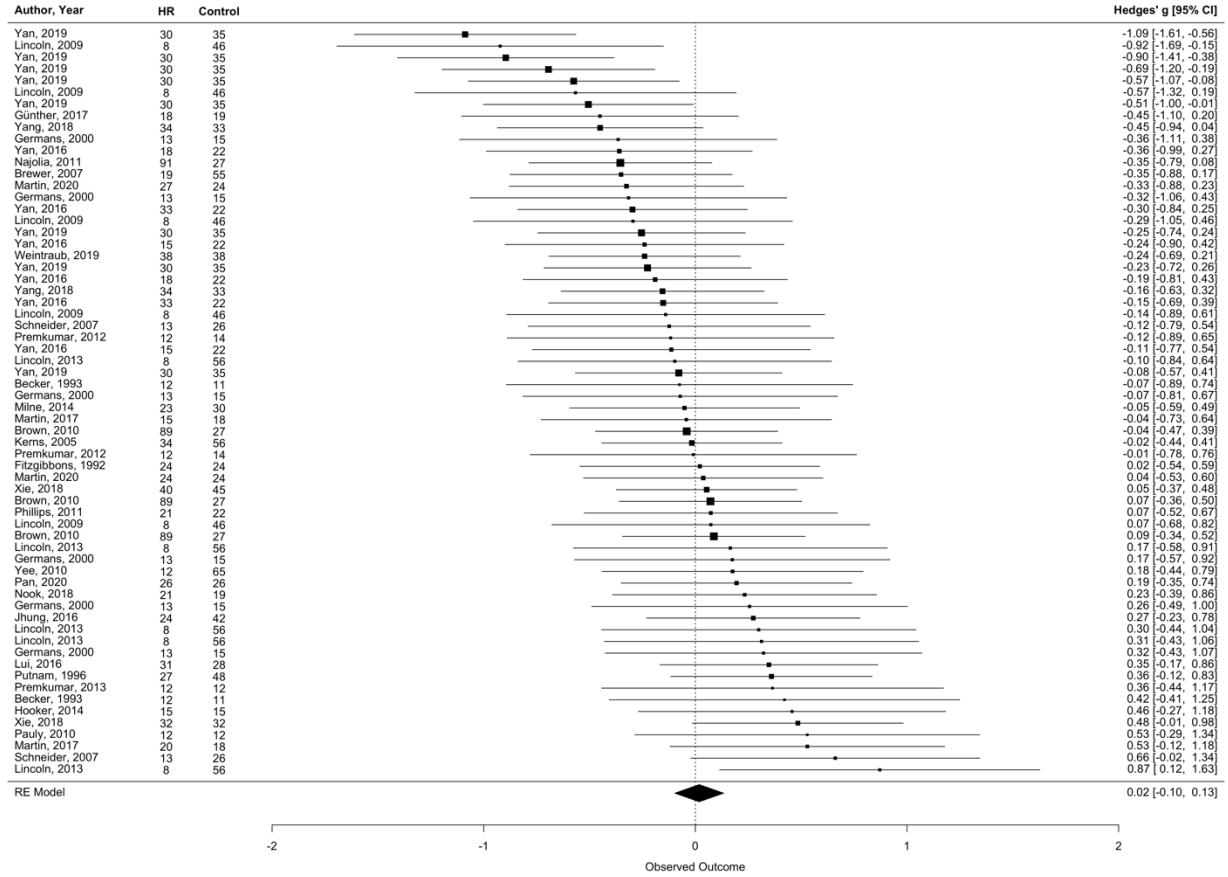

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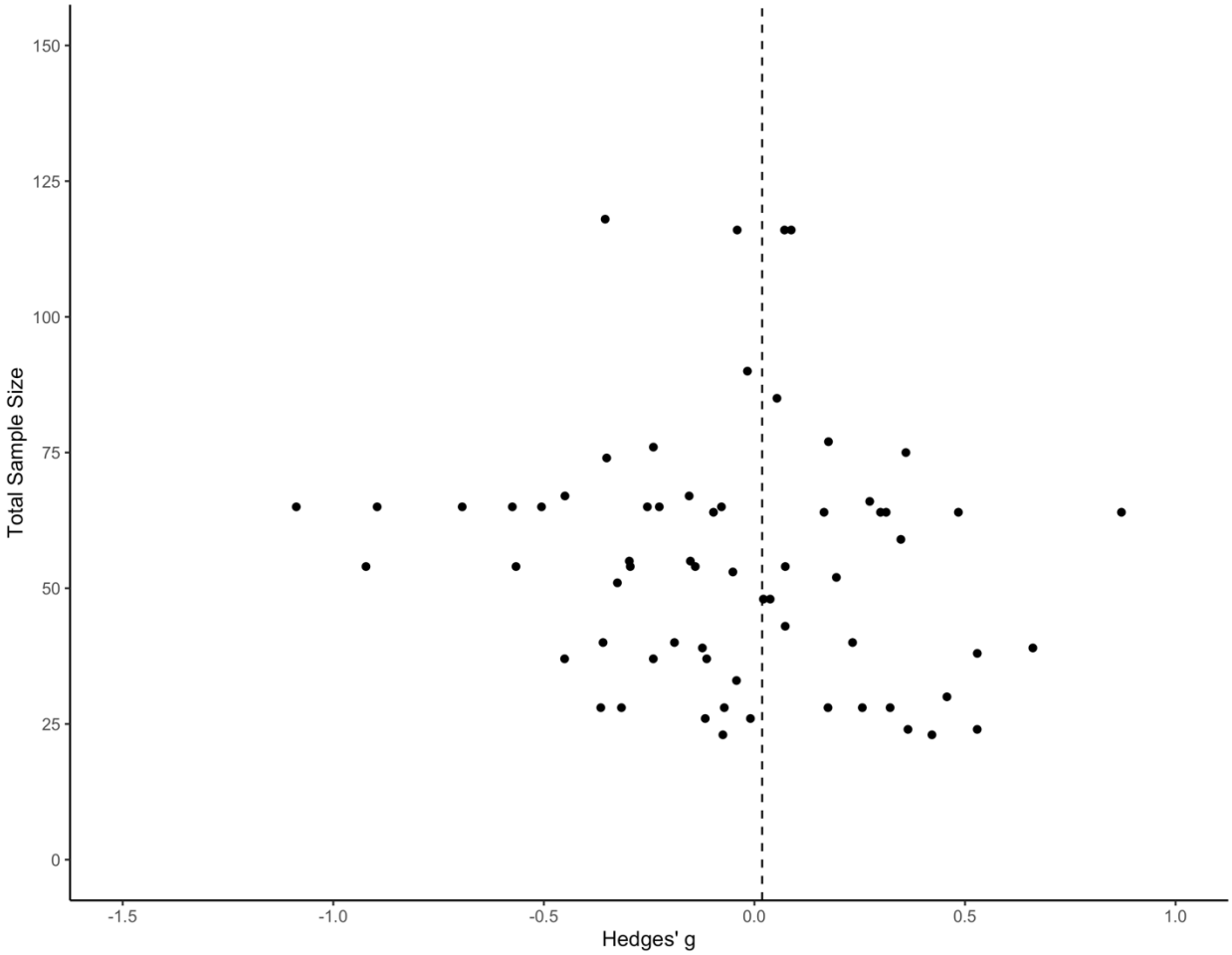


Appendix F

Descriptive Statistics for Continuous Moderators

Affective	Sample size			Year appeared			% Male			*M* age			% White		
experience	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Trait affect															
PA	158.56	244.58	16-1921	2009.78	9.95	1970-2020	47.22	20.43	0-100	28.03	11.14	16.75-61.72	47.20	39.99	0-100
NA	115.99	123.41	20-614	2008.46	9.12	1970-2020	42.74	20.15	0-100	26.64	10.92	16.73-55.60	65.04	32.83	0-100
State baseline															
PA	97.57	103.93	24-529	2011.72	7.18	1993-2020	38.82	17.89	0-100	24.39	7.36	16.75-50.40	61.82	32.75	0-100
NA	86.42	89.96	20-529	2009.65	8.10	1991-2020	43.29	20.68	0-100	25.24	8.92	16.73-50.40	59.60	34.14	0-100
State induction															
Neutral stimuli															
PA	64.39	60.84	22-321.50	2012.22	6.00	1994-2020	46.23	26.48	0-100	22.42	4.88	18.24-38.11	58.70	29.44	0-100
NA	64.56	59.89	22-321.50	2011.21	6.59	1994-2019	43.88	23.08	0-100	22.93	5.20	18.10-38.11	63.95	26.35	10.50-100
Bipolar	55.38	23.30	24-117	2012.04	7.42	1992-2020	46.71	24.67	0-100	23.53	8.42	17.20-58.98	35.52	39.20	0-100
Pleasant stimuli															
PA	64.55	31.37	28-170	2012.76	7.52	1987-2020	43.77	21.85	0-100	22.15	6.42	15.72-50.40	50.52	35.56	0-100
NA	63.44	27.22	33-116	2010.90	8.87	1987-2019	40.76	22.72	0-100	21.15	4.18	15.72-33.80	55.70	29.87	0-93.10
Bipolar	53.46	21.90	23-117	2010.80	8.52	1992-2020	46.67	24.87	0-100	22.88	7.10	17.20-50.40	37.75	36.98	0-94.12
Unpleasant stimuli															
PA	55.71	24.89	22-116	2010.28	8.95	1987-2019	47.96	21.16	0-100	22.48	5.19	15.72-38.11	51.67	35.94	0-100
NA	58.58	31.06	22-170	2009.98	9.33	1987-2020	47.01	18.87	0-100	23.00	5.32	15.72-38.11	65.02	28.08	10.50-100
Bipolar	55.39	22.50	23-116.50	2011.37	7.97	1992-2020	46.22	24.06	0-100	23.39	8.28	17.20-58.98	36.49	38.29	0-100

Note. Results were calculated at the study level. PA = positive affect, NA = negative affect.

Appendix G

Trait PA Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	108	267	0.00012 (0.00016)	.46	-0.00020, 0.00044	0.53 (1, 265)
Published						0.0070 (1, 265)
Yes	98	254	-0.46 (0.045)	<.001	-0.54, -0.37	
No	10	13	-0.44 (0.16)	.0070	-0.76, -0.12	
Measure validated						0.025 (1, 265)
Yes	105	261	-0.45 (0.044)	<.001	-0.54, -0.37	
No	4	6	-0.49 (0.22)	.030	-0.93, -0.047	
Reliability reported						0.92 (1, 265)
Yes	27	83	-0.52 (0.078)	<.001	-0.67, -0.36	
No	83	184	-0.43 (0.050)	<.001	-0.53, -0.33	
Effect size reported						1.15 (1, 265)
Yes	24	51	-0.53 (0.081)	<.001	-0.69, -0.37	
No	93	216	-0.44 (0.046)	<.001	-0.53, -0.35	
Study characteristics						
Year appeared	108	267	-0.0054 (0.0047)	.25	-0.015, 0.0039	1.32 (1, 265)
Country						0.081 (1, 265)
US	48	110	-0.44 (0.066)	<.001	-0.57, -0.31	
Non-US	60	157	-0.46 (0.058)	<.001	-0.58, -0.35	
English speaking						0.11 (1, 265)
Yes	54	119	-0.44 (0.063)	<.001	-0.56, -0.32	
No	54	148	-0.47 (0.060)	<.001	-0.59, -0.35	
Sample characteristics						
Sample type						0.0022 (1, 265)
College	47	141	-0.45 (0.063)	<.001	-0.58, -0.33	
Non-college	61	126	-0.46 (0.060)	<.001	-0.57, -0.34	
% Male	107	266	-0.0042 (0.0022)	.052	-0.0084, 0.000038	3.81 (1, 264)†
M age	108	267	0.0084 (0.0038)	.026	0.00099, 0.016	4.98 (1, 265)*
% White	66	190	0.0024 (0.0014)	.094	-0.00041, 0.0052	2.84 (1, 188)†
Education						0.47 (1, 227)
High school (or less)	17	35	-0.36 (0.11)	<.001	-0.58, -0.15	
College (or more)	70	194	-0.45 (0.054)	<.001	-0.55, -0.34	
Matched demographics						0.70 (1, 253)
Yes	75	180	-0.44 (0.052)	<.001	-0.54, -0.34	
No	36	75	-0.50 (0.069)	<.001	-0.64, -0.37	
Clinical diagnosis						0.78 (1, 265)
Yes	21	42	-0.53 (0.096)	<.001	-0.72, -0.34	
No	89	225	-0.44 (0.046)	<.001	-0.53, -0.35	
Psychotropic medication						7.03 (1, 265)**
Yes	13	34	-0.78 (0.13)	<.001	-1.04, -0.52	
No	95	233	-0.42 (0.044)	<.001	-0.50, -0.33	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to unique covariates entered in the analyses of substantive moderators.

† $p < .10$. * $p < .05$. ** $p < .01$.

Trait NA Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	79	112	-0.00034 (0.00051)	.50	-0.0013, 0.00066	0.46 (1, 110)
Published						0.19 (1, 110)
Yes	70	103	0.75 (0.074)	<.001	0.60, 0.89	
No	9	9	0.65 (0.22)	.0036	0.22, 1.08	
Measure validated						--
Yes	77	110	--	--	--	
No	2	2	--	--	--	
Reliability reported						0.30 (1, 110)
Yes	22	36	0.79 (0.12)	<.001	0.54, 1.04	
No	58	76	0.71 (0.082)	<.001	0.55, 0.88	
Effect size reported						1.12 (1, 110)
Yes	14	16	0.88 (0.15)	<.001	0.58, 1.19	
No	69	96	0.71 (0.073)	<.001	0.57, 0.86	
Study characteristics						
Year appeared	79	112	0.014 (0.0076)	.079	-0.0016, 0.029	3.14 (1, 110)†
Country						1.12 (1, 110)
US	39	61	0.66 (0.098)	<.001	0.47, 0.86	
Non-US	40	51	0.81 (0.099)	<.001	0.62, 1.01	
English speaking						0.025 (1, 110)
Yes	50	74	0.74 (0.088)	<.001	0.57, 0.92	
No	29	38	0.72 (0.12)	<.001	0.49, 0.95	
Sample characteristics						
Sample type						2.97 (1, 110)†
College	41	66	0.85 (0.094)	<.001	0.66, 1.03	
Non-college	38	46	0.61 (0.10)	<.001	0.41, 0.81	
% Male	78	111	0.00044 (0.0034)	.90	-0.0063, 0.0072	0.017 (1, 109)
M age	79	112	-0.025 (0.0056)	<.001	-0.036, -0.014	19.66 (1, 110)***
% White	40	65	-0.0089 (0.0024)	<.001	-0.014, -0.0041	13.88 (1, 63)***
Education						2.90 (1, 95)†
High school (or less)	12	16	0.46 (0.16)	.0049	0.14, 0.78	
College (or more)	54	81	0.77 (0.077)	<.001	0.62, 0.92	
Matched demographics						2.40 (1, 110)
Yes	57	77	0.80 (0.081)	<.001	0.64, 0.96	
No	25	35	0.60 (0.11)	<.001	0.38, 0.82	
Clinical diagnosis						4.13 (1, 110)*
Yes	10	13	1.10 (0.19)	<.001	0.72, 1.48	
No	70	99	0.69 (0.072)	<.001	0.55, 0.83	
Psychotropic medication						4.65 (1, 110)*
Yes	9	10	1.17 (0.21)	<.001	0.75, 1.59	
No	70	102	0.69 (0.072)	<.001	0.54, 0.83	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to unique covariates entered in the analyses of substantive moderators.

† $p < .10$. * $p < .05$. *** $p < .001$.

State PA Baseline Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	38	64	0.000077 (0.00056)	.89	-0.0010, 0.0012	0.019 (1, 62)
Published						--
Yes	35	56	--	--	--	
No	3	8	--	--	--	
Measure validated						0.26 (1, 62)
Yes	25	41	-0.31 (0.079)	<.001	-0.46, -0.15	
No	14	23	-0.37 (0.10)	<.001	-0.58, -0.16	
Reliability reported						0.0044 (1, 62)
Yes	19	25	-0.32 (0.088)	<.001	-0.50, -0.15	
No	20	39	-0.33 (0.089)	<.001	-0.51, -0.16	
Effect size reported						0.80 (1, 62)
Yes	10	12	-0.42 (0.12)	.0012	-0.68, -0.18	
No	29	52	-0.30 (0.072)	<.001	-0.44, -0.16	
Study characteristics						
Year appeared	38	64	-0.011 (0.0087)	.19	-0.029, 0.0059	1.73 (1, 62)
Country						0.74 (1, 62)
US	24	43	-0.29 (0.080)	<.001	-0.45, -0.13	
Non-US	14	21	-0.40 (0.11)	<.001	-0.62, -0.19	
English speaking						0.022 (1, 62)
Yes	28	48	-0.34 (0.075)	<.001	-0.49, -0.18	
No	10	16	-0.31 (0.13)	.017	-0.57, -0.059	
Sample characteristics						
Sample type						0.020 (1, 62)
College	20	39	-0.34 (0.086)	<.001	-0.51, -0.17	
Non-college	18	25	-0.32 (0.099)	.0021	-0.52, -0.12	
% Male	38	64	0.0024 (0.0035)	.49	-0.0045, 0.0093	0.48 (1, 62)
M age	38	64	0.0096 (0.0086)	.27	-0.0076, 0.027	1.24 (1, 62)
% White	29	44	0.0015 (0.0020)	.46	-0.0026, 0.0056	0.55 (1, 42)
Education						0.54 (1, 61)
High school (or less)	6	7	-0.45 (0.17)	.0097	-0.79, -0.11	
College (or more)	31	56	-0.32 (0.070)	<.001	-0.46, -0.18	
Matched demographics						3.30 (1, 62)†
Yes	27	49	-0.25 (0.071)	<.001	-0.40, -0.11	
No	12	15	-0.48 (0.11)	<.001	-0.70, -0.27	
Clinical diagnosis						0.48 (1, 62)
Yes	9	14	-0.24 (0.14)	.085	-0.52, 0.034	
No	29	50	-0.35 (0.072)	<.001	-0.50, -0.21	
Psychotropic medication						0.45 (1, 62)
Yes	7	12	-0.23 (0.15)	.13	-0.54, 0.074	
No	31	52	-0.35 (0.070)	<.001	-0.49, -0.21	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators.
† $p < .10$.

State NA Baseline Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	59	114	0.00017 (0.00055)	.76	-0.00092, 0.0013	0.096 (1, 112)
Published						0.34 (1, 112)
Yes	52	93	0.60 (0.059)	<.001	0.49, 0.72	
No	7	21	0.50 (0.17)	.0034	0.17, 0.83	
Measure validated						0.69 (1, 112)
Yes	43	86	0.62 (0.063)	<.001	0.49, 0.74	
No	19	28	0.53 (0.093)	<.001	0.34, 0.71	
Reliability reported						0.19 (1, 112)
Yes	22	30	0.62 (0.085)	<.001	0.45, 0.79	
No	39	84	0.57 (0.068)	<.001	0.44, 0.71	
Effect size reported						0.090 (1, 112)
Yes	11	13	0.63 (0.12)	<.001	0.38, 0.87	
No	49	101	0.59 (0.060)	<.001	0.47, 0.70	
Study characteristics						
Year appeared	59	114	0.0099 (0.0067)	.14	-0.0034, 0.023	2.16 (1, 112)
Country						7.84 (1, 112)**
US	32	75	0.46 (0.070)	<.001	0.32, 0.60	
Non-US	27	39	0.76 (0.079)	<.001	0.60, 0.91	
English speaking						1.05 (1, 112)
Yes	39	83	0.55 (0.068)	<.001	0.42, 0.69	
No	20	31	0.67 (0.095)	<.001	0.48, 0.86	
Sample characteristics						
Sample type						0.47 (1, 112)
College	29	64	0.56 (0.077)	<.001	0.40, 0.71	
Non-college	30	50	0.63 (0.081)	<.001	0.47, 0.79	
% Male	58	113	0.0045 (0.0026)	.092	-0.00075, 0.0097	2.89 (1, 111)†
M age	59	114	-0.0082 (0.0062)	.18	-0.020, 0.0040	1.78 (1, 112)
% White	32	62	-0.00055 (0.0023)	.81	-0.0052, 0.0040	0.058 (1, 60)
Education						0.083 (1, 105)
High school (or less)	9	13	0.53 (0.14)	<.001	0.24, 0.81	
College (or more)	43	94	0.57 (0.063)	<.001	0.45, 0.70	
Matched demographics						0.18 (1, 112)
Yes	46	87	0.60 (0.063)	<.001	0.48, 0.73	
No	15	27	0.56 (0.10)	<.001	0.36, 0.76	
Clinical diagnosis						1.02 (1, 112)
Yes	16	31	0.50 (0.11)	<.001	0.29, 0.71	
No	43	83	0.62 (0.064)	<.001	0.50, 0.75	
Psychotropic medication						0.033 (1, 112)
Yes	12	21	0.57 (0.13)	<.001	0.32, 0.82	
No	47	93	0.60 (0.062)	<.001	0.48, 0.72	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

† $p < .10$. ** $p < .01$.

State PA Neutral Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	23	29	-0.00022 (0.00087)	.80	-0.0020, 0.0016	0.068 (1, 27)
Published						--
Yes	20	26	--	--	--	
No	3	3	--	--	--	
Measure validated						0.83 (1, 27)
Yes	12	15	-0.14 (0.10)	.18	-0.35, 0.071	
No	12	14	-0.28 (0.11)	.018	-0.50, -0.050	
Reliability reported						0.00016 (1, 27)
Yes	7	9	-0.20 (0.12)	.10	-0.45, 0.045	
No	16	20	-0.20 (0.097)	.046	-0.40, -0.0042	
Stimulus validated						0.0031 (1, 27)
Yes	15	18	-0.20 (0.094)	.044	-0.39, -0.0058	
No	8	11	-0.21 (0.12)	.11	-0.46, 0.048	
Effect size reported						--
Yes	3	4	--	--	--	
No	20	25	--	--	--	
Study characteristics						
Year appeared	23	29	-0.0070 (0.013)	.61	-0.035, 0.021	0.26 (1, 27)
Country						0.21 (1, 27)
US	13	15	-0.23 (0.094)	.022	-0.42, -0.036	
Non-US	10	14	-0.16 (0.12)	.20	-0.40, 0.090	
English speaking						2.63 (1, 27)
Yes	15	17	-0.28 (0.088)	.0032	-0.46, -0.10	
No	8	12	-0.038 (0.12)	.76	-0.29, 0.22	
Sample characteristics						
Sample type						0.25 (1, 27)
College	13	17	-0.23 (0.092)	.019	-0.42, -0.041	
Non-college	10	12	-0.15 (0.12)	.24	-0.41, 0.10	
% Male	23	29	0.0017 (0.0030)	.58	-0.0045, 0.0078	0.32 (1, 27)
M age	23	29	0.024 (0.012)	.056	-0.00066, 0.049	3.99 (1, 27)†
% White	16	18	0.0027 (0.0034)	.44	-0.0046, 0.010	0.62 (1, 16)
Education						--
High school (or less)	1	1	--	--	--	
College (or more)	19	24	--	--	--	
Matched demographics						--
Yes	20	25	--	--	--	
No	3	4	--	--	--	
Clinical diagnosis						5.54 (1, 27)*
Yes	5	6	0.12 (0.15)	.45	-0.19, 0.43	
No	18	23	-0.28 (0.076)	<.001	-0.44, -0.13	
Psychotropic medication						1.40 (1, 27)
Yes	7	8	-0.050 (0.15)	.73	-0.35, 0.25	
No	16	21	-0.25 (0.081)	.0050	-0.42, -0.082	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

† $p < .10$. * $p < .05$.

State NA Neutral Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	24	39	-0.000077 (0.00087)	.93	-0.0018, 0.0017	0.0077 (1, 37)
Published						0.0075 (1, 37)
Yes	20	35	0.24 (0.071)	.0015	0.10, 0.39	
No	4	4	0.23 (0.18)	.22	-0.14, 0.60	
Measure validated						0.048 (1, 37)
Yes	11	25	0.23 (0.090)	.015	0.048, 0.41	
No	13	14	0.26 (0.10)	.015	0.054, 0.46	
Reliability reported						0.76 (1, 37)
Yes	7	10	0.32 (0.11)	.0052	0.10, 0.53	
No	17	29	0.20 (0.082)	.020	0.034, 0.36	
Stimulus validated						1.02 (1, 37)
Yes	16	24	0.29 (0.080)	<.001	0.13, 0.45	
No	8	15	0.15 (0.11)	.19	-0.078, 0.38	
Effect size reported						--
Yes	3	4	--	--	--	
No	21	35	--	--	--	
Study characteristics						
Year appeared	24	39	0.014 (0.010)	.20	-0.0075, 0.035	1.71 (1, 37)
Country						0.85 (1, 37)
US	13	16	0.29 (0.083)	.0012	0.12, 0.46	
Non-US	11	23	0.17 (0.10)	.10	-0.034, 0.38	
English speaking						3.53 (1, 37)†
Yes	15	18	0.33 (0.078)	<.001	0.17, 0.49	
No	9	21	0.090 (0.10)	.39	-0.12, 0.30	
Sample characteristics						
Sample type						4.12 (1, 37)*
College	14	22	0.14 (0.080)	.081	-0.019, 0.30	
Non-college	10	17	0.41 (0.10)	<.001	0.20, 0.62	
% Male	24	39	0.0015 (0.0027)	.60	-0.0041, 0.0070	0.28 (1, 37)
M age	24	39	-0.00054 (0.012)	.96	-0.025, 0.024	0.0020 (1, 37)
% White	15	21	-0.0071 (0.0025)	.010	-0.012, -0.0019	8.13 (1, 19)*
Education						--
High school (or less)	2	2	--	--	--	
College (or more)	20	33	--	--	--	
Matched demographics						--
Yes	22	36	--	--	--	
No	2	3	--	--	--	
Clinical diagnosis						0.22 (1, 37)
Yes	5	6	0.31 (0.16)	.058	-0.011, 0.63	
No	19	33	0.23 (0.074)	.0038	0.078, 0.38	
Psychotropic medication						0.98 (1, 37)
Yes	7	11	0.36 (0.14)	.012	0.082, 0.64	
No	17	28	0.20 (0.078)	.013	0.045, 0.36	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

† $p < .10$. * $p < .05$.

State Bipolar Neutral Induction Moderator Analyses of Bias Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	26	56	-0.0026 (0.0020)	.19	-0.0066, 0.0014	1.74 (1, 54)
Published						--
Yes	24	54	--	--	--	
No	2	2	--	--	--	
Measure validated						0.57 (1, 54)
Yes	13	25	-0.26 (0.079)	.0015	-0.42, -0.10	
No	13	31	-0.18 (0.069)	.010	-0.32, -0.046	
Reliability reported						--
Yes	1	1	--	--	--	
No	25	55	--	--	--	
Stimulus validated						2.39 (1, 54)
Yes	23	36	-0.27 (0.050)	<.001	-0.37, -0.17	
No	5	20	-0.10 (0.095)	.29	-0.29, 0.088	
Effect size reported						--
Yes	3	6	--	--	--	
No	23	50	--	--	--	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators.

State PA Pleasant Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	29	46	-0.0054 (0.0017)	.0029	-0.0088, -0.0019	9.95 (1, 44)**
Published						8.10 (1, 44)**
Yes	25	40	-0.34 (0.059)	<.001	-0.46, -0.22	
No	4	6	0.11 (0.15)	.45	-0.18, 0.41	
Measure validated						0.84 (1, 44)
Yes	15	23	-0.21 (0.091)	.023	-0.40, -0.031	
No	14	23	-0.33 (0.091)	<.001	-0.51, -0.15	
Reliability reported						1.48 (1, 44)
Yes	10	17	-0.18 (0.10)	.091	-0.38, 0.029	
No	19	29	-0.33 (0.080)	<.001	-0.49, -0.17	
Stimulus validated						0.16 (1, 44)
Yes	20	31	-0.26 (0.076)	.0016	-0.41, -0.10	
No	11	15	-0.30 (0.10)	.0042	-0.50, -0.10	
Effect size reported						0.75 (1, 44)
Yes	9	16	-0.35 (0.11)	.0025	-0.57, -0.13	
No	21	30	-0.23 (0.077)	.0038	-0.39, -0.080	
Study characteristics						
Year appeared	29	46	-0.011 (0.0094)	.23	-0.030, 0.0076	1.47 (1, 44)
Country						0.56 (1, 44)
US	17	27	-0.23 (0.082)	.0067	-0.40, -0.068	
Non-US	12	19	-0.33 (0.10)	.0023	-0.54, -0.12	
English speaking						0.42 (1, 44)
Yes	18	28	-0.24 (0.080)	.0045	-0.40, -0.079	
No	11	18	-0.33 (0.11)	.0037	-0.54, -0.11	
Sample characteristics						
Sample type						0.049 (1, 44)
College	20	35	-0.26 (0.075)	.0011	-0.42, -0.11	
Non-college	9	11	-0.30 (0.12)	.022	-0.55, -0.045	
% Male	29	46	0.0040 (0.0029)	.18	-0.0020, 0.0099	1.81 (1, 44)
M age	29	46	0.010 (0.010)	.32	-0.010, 0.031	1.03 (1, 44)
% White	22	36	0.00059 (0.0020)	.76	-0.0034, 0.0046	0.090 (1, 34)
Education						--
High school (or less)	2	2	--	--	--	
College (or more)	24	39	--	--	--	
Matched demographics						0.55 (1, 44)
Yes	23	37	-0.25 (0.072)	.0012	-0.39, -0.10	
No	6	9	-0.37 (0.14)	.013	-0.65, -0.080	
Clinical diagnosis						0.00033 (1, 44)
Yes	6	7	-0.27 (0.15)	.072	-0.57, 0.025	
No	23	39	-0.27 (0.072)	<.001	-0.42, -0.13	
Psychotropic medication						0.019 (1, 44)
Yes	4	5	-0.25 (0.18)	.16	-0.60, 0.10	
No	25	41	-0.28 (0.069)	<.001	-0.42, -0.14	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to unique covariates entered in the analyses of substantive moderators.

** $p < .01$.

State NA Pleasant Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	17	33	0.0037 (0.0036)	.31	-0.0036, 0.011	1.06 (1, 31)
Published						--
Yes	14	29	--	--	--	
No	3	4	--	--	--	
Measure validated						1.46 (1, 31)
Yes	9	22	0.48 (0.13)	<.001	0.22, 0.75	
No	8	11	0.25 (0.14)	.083	-0.035, 0.54	
Reliability reported						1.68 (1, 31)
Yes	9	15	0.50 (0.13)	<.001	0.23, 0.76	
No	8	18	0.24 (0.14)	.092	-0.042, 0.53	
Stimulus validated						1.68 (1, 31)
Yes	11	19	0.28 (0.12)	.028	0.033, 0.53	
No	7	14	0.52 (0.15)	.0013	0.22, 0.82	
Effect size reported						0.0014 (1, 31)
Yes	4	6	0.38 (0.21)	.072	-0.036, 0.80	
No	13	27	0.38 (0.12)	.0028	0.14, 0.61	
Study characteristics						
Year appeared	17	33	0.027 (0.0098)	.0095	0.0071, 0.047	7.64 (1, 31)**
Country						1.55 (1, 31)
US	13	19	0.31 (0.11)	.0088	0.084, 0.54	
Non-US	4	14	0.58 (0.19)	.0046	0.20, 0.98	
English speaking						--
Yes	14	21	--	--	--	
No	3	12	--	--	--	
Sample characteristics						
Sample type						0.34 (1, 31)
College	12	21	0.34 (0.12)	.0070	0.10, 0.58	
Non-college	5	12	0.47 (0.18)	.015	0.095, 0.84	
% Male	17	33	-0.0082 (0.0039)	.043	-0.016, -0.00028	4.46 (1, 31)*
M age	17	33	-0.028 (0.023)	.24	-0.075, 0.020	1.42 (1, 31)
% White	13	19	-0.0028 (0.0038)	.47	-0.011, 0.0052	0.54 (1, 17)
Education						--
High school (or less)	1	4	--	--	--	
College (or more)	15	25	--	--	--	
Matched demographics						--
Yes	14	28	--	--	--	
No	3	5	--	--	--	
Clinical diagnosis						0.00014 (1, 31)
Yes	4	8	0.38 (0.21)	.087	-0.058, 0.81	
No	13	25	0.38 (0.11)	.0024	0.14, 0.61	
Psychotropic medication						--
Yes	2	3	--	--	--	
No	15	30	--	--	--	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

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

State Bipolar Pleasant Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	27	61	-0.0052 (0.0032)	.11	-0.012, 0.0012	2.64 (1, 59)
Published						--
Yes	24	56	--	--	--	
No	3	5	--	--	--	
Measure validated						2.93 (1, 59)†
Yes	15	25	-0.34 (0.12)	.0056	-0.58, -0.10	
No	13	36	-0.051 (0.12)	.69	-0.30, 0.20	
Reliability reported						--
Yes	2	2	--	--	--	
No	25	59	--	--	--	
Stimulus validated						2.29 (1, 59)
Yes	24	47	-0.25 (0.089)	.0074	-0.42, -0.069	
No	6	14	-0.0021 (0.15)	.99	-0.31, 0.30	
Effect size reported						1.90 (1, 59)
Yes	6	9	-0.41 (0.18)	.022	-0.76, -0.062	
No	22	52	-0.15 (0.094)	.12	-0.34, 0.038	
Study characteristics						
Year appeared	27	61	0.0040 (0.010)	.70	-0.017, 0.025	0.15 (1, 59)
Country						0.28 (1, 59)
US	17	29	-0.24 (0.11)	.035	-0.46, -0.017	
Non-US	10	32	-0.14 (0.14)	.31	-0.42, 0.14	
English speaking						0.084 (1, 59)
Yes	18	32	-0.22 (0.11)	.045	-0.43, -0.0054	
No	9	29	-0.16 (0.15)	.27	-0.46, 0.13	
Sample characteristics						
Sample type						1.08 (1, 59)
College	17	47	-0.26 (0.10)	.015	-0.47, -0.054	
Non-college	10	14	-0.075 (0.15)	.62	-0.37, 0.22	
% Male	27	61	-0.00035 (0.0034)	.92	-0.0072, 0.0065	0.010 (1, 59)
M age	26	59	0.019 (0.012)	.13	-0.0058, 0.044	2.38 (1, 57)
% White	17	38	0.0037 (0.0028)	.19	-0.0019, 0.0093	1.79 (1, 36)
Education						--
High school (or less)	1	1	--	--	--	
College (or more)	23	55	--	--	--	
Matched demographics						0.14 (1, 59)
Yes	23	55	-0.19 (0.094)	.049	-0.38, -0.00050	
No	4	6	-0.28 (0.23)	.23	-0.74, 0.18	
Clinical diagnosis						--
Yes	2	2	--	--	--	
No	25	59	--	--	--	
Psychotropic medication						--
Yes	3	5	--	--	--	
No	24	56	--	--	--	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators.
† $p < .10$.

State PA Unpleasant Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	21	48	-0.0081 (0.0021)	<.001	-0.012, -0.0039	14.99 (1, 46)***
Published						5.10 (1, 46)*
Yes	17	26	-0.062 (0.069)	.37	-0.20, 0.076	
No	4	22	0.23 (0.11)	.041	0.0096, 0.44	
Measure validated						3.89 (1, 46)†
Yes	11	31	0.13 (0.092)	.17	-0.057, 0.31	
No	11	17	-0.13 (0.092)	.17	-0.31, 0.057	
Reliability reported						0.00023 (1, 46)
Yes	5	6	0.000010 (0.14)	1.00	-0.29, 0.29	
No	16	42	-0.0025 (0.079)	.97	-0.16, 0.16	
Stimulus validated						0.53 (1, 46)
Yes	14	35	0.039 (0.082)	.63	-0.12, 0.20	
No	8	13	-0.054 (0.10)	.61	-0.26, 0.16	
Effect size reported						--
Yes	2	5	--	--	--	
No	19	43	--	--	--	
Study characteristics						
Year appeared	21	48	-0.013 (0.0053)	.018	-0.024, -0.0023	6.02 (1, 46)*
Country						0.28 (1, 46)
US	10	28	-0.040 (0.097)	.68	-0.24, 0.16	
Non-US	11	20	0.034 (0.10)	.74	-0.17, 0.23	
English speaking						2.67 (1, 46)
Yes	13	31	-0.094 (0.088)	.29	-0.27, 0.083	
No	8	17	0.13 (0.11)	.22	-0.083, 0.35	
Sample characteristics						
Sample type						0.0030 (1, 46)
College	12	33	-0.0061 (0.089)	.94	-0.18, 0.17	
Non-college	9	15	0.0017 (0.11)	.99	-0.22, 0.23	
% Male	21	48	0.0037 (0.0034)	.28	-0.0031, 0.010	1.18 (1, 46)
M age	21	48	0.010 (0.011)	.33	-0.011, 0.032	0.96 (1, 46)
% White	13	17	-0.0034 (0.0024)	.17	-0.0086, 0.0017	2.06 (1, 15)
Education						--
High school (or less)	1	1	--	--	--	
College (or more)	18	43	--	--	--	
Matched demographics						--
Yes	18	45	--	--	--	
No	3	3	--	--	--	
Clinical diagnosis						0.66 (1, 46)
Yes	5	9	0.094 (0.14)	.50	-0.18, 0.37	
No	16	39	-0.036 (0.080)	.65	-0.20, 0.12	
Psychotropic medication						0.17 (1, 46)
Yes	6	9	0.048 (0.14)	.74	-0.24, 0.34	
No	15	39	-0.019 (0.079)	.81	-0.18, 0.14	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

† $p < .10$. * $p < .05$. *** $p < .001$.

State NA Unpleasant Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1*, *df2*)
Bias indicators						
Sample size	31	104	-0.0022 (0.0029)	.46	-0.0080, 0.0036	0.54 (1, 102)
Published						0.024 (1, 102)
Yes	25	54	0.33 (0.10)	.0019	0.12, 0.54	
No	6	50	0.30 (0.21)	.16	-0.12, 0.71	
Measure validated						2.10 (1, 102)
Yes	14	77	0.46 (0.13)	<.001	0.20, 0.71	
No	18	27	0.21 (0.12)	.089	-0.033, 0.45	
Reliability reported						5.69 (1, 102)*
Yes	6	9	0.72 (0.19)	<.001	0.35, 1.10	
No	26	95	0.24 (0.095)	.013	0.051, 0.43	
Stimulus validated						1.40 (1, 102)
Yes	21	81	0.25 (0.11)	.028	0.028, 0.47	
No	10	23	0.48 (0.16)	.0032	0.16, 0.80	
Effect size reported						--
Yes	3	5	--	--	--	
No	28	99	--	--	--	
Study characteristics						
Year appeared	31	104	0.0091 (0.0098)	.36	-0.010, 0.028	0.86 (1, 102)
Country						0.19 (1, 102)
US	14	63	0.28 (0.14)	.043	0.0085, 0.56	
Non-US	17	41	0.36 (0.13)	.0050	0.11, 0.62	
English speaking						0.43 (1, 102)
Yes	19	72	0.38 (0.12)	.0022	0.14, 0.61	
No	12	32	0.25 (0.15)	.091	-0.041, 0.54	
Sample characteristics						
Sample type						0.0034 (1, 102)
College	15	70	0.33 (0.13)	.014	0.069, 0.60	
Non-college	16	34	0.32 (0.13)	.017	0.059, 0.58	
% Male	31	104	-0.0094 (0.0044)	.037	-0.018, -0.00057	4.46 (1, 102)*
M age	31	104	0.0032 (0.016)	.84	-0.028, 0.034	0.040 (1, 102)
% White	14	23	-0.0054 (0.0051)	.31	-0.016, 0.0053	1.10 (1, 21)
Education						1.08 (1, 93)
High school (or less)	4	7	0.59 (0.27)	.034	0.044, 1.13	
College (or more)	24	88	0.28 (0.11)	.0088	0.073, 0.50	
Matched demographics						0.031 (1, 102)
Yes	27	99	0.32 (0.10)	.0019	0.12, 0.52	
No	4	5	0.37 (0.26)	.16	-0.15, 0.89	
Clinical diagnosis						0.97 (1, 102)
Yes	8	16	0.17 (0.18)	.34	-0.19, 0.53	
No	23	88	0.38 (0.11)	<.001	0.17, 0.59	
Psychotropic medication						2.42 (1, 102)
Yes	10	17	0.11 (0.16)	.50	-0.21, 0.44	
No	21	87	0.42 (0.11)	<.001	0.20, 0.63	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

* $p < .05$.

State Bipolar Unpleasant Induction Moderator Analyses of Bias, Study, and Sample Characteristics

Moderator	$N_{studies}$	$N_{effects}$	Estimate (*SE*)	*p*	95% CI	*F* (*df1, df2*)
Bias indicators						
Sample size	28	64	-0.0032 (0.0024)	.18	-0.0079, 0.0015	1.83 (1, 62)
Published						--
Yes	25	61	--	--	--	
No	3	3	--	--	--	
Measure validated						0.0016 (1, 62)
Yes	14	26	0.022 (0.085)	.79	-0.15, 0.19	
No	15	38	0.018 (0.079)	.82	-0.14, 0.18	
Reliability reported						--
Yes	1	1	--	--	--	
No	27	63	--	--	--	
Stimulus validated						1.24 (1, 62)
Yes	25	49	0.046 (0.062)	.47	-0.079, 0.17	
No	5	15	-0.11 (0.12)	.40	-0.36, 0.14	
Effect size reported						--
Yes	2	4	--	--	--	
No	26	60	--	--	--	
Study characteristics						
Year appeared	28	64	-0.0082 (0.0074)	.27	-0.023, 0.0067	1.22 (1, 62)
Country						0.0022 (1, 62)
US	14	24	0.023 (0.084)	.79	-0.14, 0.19	
Non-US	14	40	0.017 (0.081)	.83	-0.14, 0.18	
English speaking						0.012 (1, 62)
Yes	15	27	0.026 (0.081)	.75	-0.14, 0.19	
No	13	37	0.013 (0.084)	.88	-0.16, 0.18	
Sample characteristics						
Sample type						2.50 (1, 62)
College	17	49	-0.044 (0.067)	.52	-0.18, 0.090	
Non-college	11	15	0.15 (0.10)	.15	-0.054, 0.35	
% Male	28	64	0.0063 (0.0024)	.011	0.0015, 0.011	6.86 (1, 62)*
M age	27	62	0.0030 (0.0072)	.68	-0.011, 0.017	0.17 (1, 60)
% White	18	37	0.00084 (0.0020)	.68	-0.0033, 0.0050	0.17 (1, 35)
Education						--
High school (or less)	1	1	--	--	--	
College (or more)	25	59	--	--	--	
Matched demographics						--
Yes	25	61	--	--	--	
No	3	3	--	--	--	
Clinical diagnosis						--
Yes	2	2	--	--	--	
No	26	62	--	--	--	
Psychotropic medication						1.09 (1, 62)
Yes	4	4	0.20 (0.18)	.28	-0.16, 0.56	
No	24	60	-0.0023 (0.060)	.97	-0.12, 0.12	

Note. Estimate refers to Hedges' *g* for categorical moderators and meta-regression coefficient *B* for continuous moderators. Highlighted cells refer to the unique covariate entered in the analyses of substantive moderators.

* $p < .05$.

Appendix H

Study 1 Tweet Preprocessing Steps

To improve sentiment analysis accuracy, basic preprocessing steps were applied, including (a) removing URLs and mentions, (b) extracting hashtag contents and, if necessary, separating hashtags into words based on the Twitter word statistics, (c) removing elongated tails (e.g., YAYYYY to YAY), and (d) translating non-English tweets using the Google translate Application Programming Interface (API). Information such as punctuation, capitalization, and emojis/emoticons were preserved for sentiment analysis using the Valence Aware Dictionary and sEntiment Reasoner (VADER; Hutto & Gilbert, 2014). After sentiment analysis, tweets were further cleaned to (a) remove punctuations, numbers, and emojis/emoticons, (b) unpack contractions (e.g., "didn't" to "did not"), (c) correct slangs (e.g., "wanna" to "want to"), (c) apply lowercasing, and (d) segment into individual words. Next, only words that matched those in the VADER sentiment dictionary were retained and they were subsequently lemmatized to the base form (e.g., "worrying" and "worried" to "worry").

Study 2 Text Entry Preprocessing Steps

All text entries were first checked by the first author and a trained research assistant that included (a) proofreading for spelling, (b) translating non-English words, and (c) removing unfinished sentences at the end of the entries. Text entries were then segmented into sentences for sentiment analysis. Subsequent data cleaning steps were identical as Study 1.

Appendix I

Standardized Regression Coefficients for the Association of Positive Symptoms and Social Anhedonia with Twitter Affect Dynamics

Outcome	Positive Symptoms			Social Anhedonia			Mean Sentiment			
	β (*SE*)	*t*	*p*	β (*SE*)	*t*	*p*	β (*SE*)	*t*	*p*	*df*
Mean Sentiment										
Overall	0.014 (0.094)	0.15	.88	0.049 (0.096)	0.51	.61		--		119
Positive	0.039 (0.093)	0.42	.67	-0.024 (0.095)	-0.26	.80		--		119
Negative	0.041 (0.092)	0.44	.66	-0.076 (0.094)	-0.80	.42		--		119
Variability										
Overall	**0.24 (0.087)**	**2.80**	**.006**	***-0.16 (0.089)***	***-1.80***	***.074***	0.090 (0.085)	1.06	.29	117
Positive	-0.038 (0.066)	-0.58	.56	-0.091 (0.068)	-1.34	.18	**0.68 (0.066)**	**10.44**	**<.001**	118
Negative	-0.071 (0.046)	-1.54	.13	-0.0045 (0.047)	-0.096	.92	**0.86 (0.046)**	**18.69**	**<.001**	118
Instability (MSSD)										
Overall	0.11 (0.094)	1.20	.23	0.046 (0.096)	0.48	.63	-0.059 (0.091)	-0.65	.52	118
Positive	0.0043 (0.095)	0.045	.96	0.020 (0.097)	0.21	.83	0.092 (0.094)	0.98	.33	118
Negative	0.095 (0.090)	1.06	.29	0.11 (0.092)	1.19	.24	**0.31 (0.089)**	**3.53**	**<.001**	118
Instability (PAC)										
Overall	0.077 (0.094)	0.81	.42	0.095 (0.097)	0.98	.33	0.068 (0.092)	0.74	0.46	118
Positive	0.055 (0.089)	0.62	.54	0.097 (0.091)	1.06	.29	**0.33 (0.088)**	**3.71**	**<.001**	118
Negative	0.063 (0.083)	0.75	.45	0.086 (0.085)	1.00	.32	**0.49 (0.083)**	**5.88**	**<.001**	118
Inertia										
Overall	-0.053 (0.051)	-1.03	.30	**0.11 (0.052)**	**2.03**	**.045**	**0.84 (0.050)**	**16.88**	**<.001**	118
Positive	0.0032 (0.049)	0.065	.95	**0.12 (0.050)**	**2.52**	**.013**	**0.88 (0.048)**	**18.14**	**<.001**	118
Negative	-0.094 (0.081)	-1.16	.25	0.094 (0.083)	1.13	.26	**-0.53 (0.081)**	**-6.53**	**<.001**	118
Emodiversity										
Overall	0.072 (0.091)	0.79	.43	0.014 (0.094)	0.15	.88	**-0.30 (0.089)**	**-3.43**	**<.001**	118
Positive	0.078 (0.094)	0.83	.41	0.00060 (0.096)	0.0062	1.00	-0.15 (0.093)	-1.64	.10	118
Negative	0.060 (0.090)	0.66	.51	0.028 (0.093)	0.31	.76	**0.35 (0.090)**	**3.89**	**<.001**	118
Density	-0.0022 (0.058)	-0.037	.97	0.090 (0.060)	1.51	.13	**POS: 0.71 (0.060)** **NEG: -0.25 (0.061)**	**11.71** **-4.07**	**<.001** **<.001**	117
Synchrony	-0.026 (0.078)	-0.33	.74	0.026 (0.080)	0.32	.75	**POS: -0.52 (0.081)** **NEG: -0.39 (0.082)**	**-6.44** **-4.81**	**<.001** **<.001**	117

Note. Significant and trend-level significant results are highlighted. MSSD = mean square successive difference, PAC = probability of acute change, POS = positive sentiment, NEG = negative sentiment.

Appendix J

Study 2 Example Responses

Condition	Participant Response
Free Writing	just came back from my support group and it was our last meeting and it made me very happy to have gone today. I got good feedback and it makes me think about how I really do make a difference in people's lives. I also am very excited that i having something very great coming in the mail by Friday. This thing will help me in so many ways. I also am very anxious at the moment and don't know if it is because of all the coffee I drank or because I am just anxious today. I just can't wait for this week to be over so I can finally start studying for finals and get this quarter out of my system. I am done with the year and hopefully the summer brings a different feeling. I am thinking a lot of about my parents and my family which has added some feeling to why I feel anxious. I hope that everything goes well and all of this can go away for a while. From here on out I have a different perspective on things. I am hungry actually. i hope to get some in n out because their burgers are so good. I have a paper due. Ugh, i need to get it done by tonight or else i am for sure staying up. I hate papers, I hate how we have to write on something we don't want to write about. They should make us do personal statements better.
Pleasant	One of the most pleasant events in my life was the first time I went to Disneyland with my boyfriend. This event took place about two years ago, but I still remember the highlights of it, and the feelings throughout. I remember the day started off on the wrong foot because he didn't wake up on time. He had a connection inside the park that was supposed to get us tickets, and I didn't want to be late meeting them. We didn't end up getting to the park until around 11am, and I felt like it was really late and the crowds would have started already. To top that off, it turned out that his connection couldn't get us in, but my boyfriend did the most amazing thing and bought us both tickets. At the time it wasn't such a crazy move because we were still pretty young, and he often made so much more than his bills, he had a TON of spending money. What made the day great was that it so carefree. As someone who has been pretty much on her own since eighteen, I felt like I was actually in another world, one where I didn't have to worry about work or grades or anything else in the real world that actually mattered. We went on so many rides together; we were both truly happy ourselves, and we fed off the happiness of the other. It was just us in a sea In truth, it was a very long day, but I didn't feel that tired after. I just wanted to go back!

Condition	Participant Response
Unpleasant	The most unpleasant experience I have ever had was in this winter quarter. At the beginning of fall quarter, I knew a freshman, she is nice and we soon became very good friends. She lives in MC, but her roommate was so dirty, and she can not bear it, so I let her to live with me. In winter quarter, my friends and I decided to go to New York for a visit, and I took her with me. However, the most terrible thing happened. During the day we were there, this girl quickly became a friend with my best friend! When they are talking or doing something, they will not think about me and just leave me aside. New York is cold, but my heart gets colder. The most regretful thing I have ever done is to take her to this vacation.

Appendix K

Standardized Parameter Estimates of Study 2 Analyses

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Mean Sentiment							
Overall	Intercept	0.18 (0.28)	0.64	444.00	.52	-0.37	0.72
	PerMag	-0.019 (0.059)	-0.32	444.00	.75	-0.13	0.096
	SocAnh	-0.020 (0.058)	-0.35	444.00	.73	-0.13	0.094
	Pleasant (vs. FW) Condition	**0.87 (0.080)**	**10.88**	**444.00**	**< .001**	**0.72**	**1.03**
	Unpleasant (vs. FW) Condition	**-0.85 (0.080)**	**-10.59**	**444.00**	**< .001**	**-1.01**	**-0.69**
	PerMag X Pleasant (vs. FW) Condition	-0.11 (0.082)	-1.36	444.00	.18	-0.27	0.050
	PerMag X Unpleasant (vs. FW) Condition	**0.18 (0.082)**	**2.13**	**444.00**	**.03**	**0.014**	**0.34**
	SocAnh X Pleasant (vs. FW) Condition	-0.040 (0.082)	-0.49	444.00	.62	-0.20	0.12
	SocAnh X Unpleasant (vs. FW) Condition	-0.043 (0.082)	-0.53	444.00	.60	-0.20	0.12
Positive	Intercept	0.30 (0.35)	0.86	149.63	.39	-0.38	0.98
	PerMag	0.0089 (0.069)	0.13	432.82	.90	-0.13	0.14
	SocAnh	-0.023 (0.068)	-0.34	435.79	.73	-0.16	0.11
	Pleasant (vs. FW) Condition	**0.80 (0.091)**	**8.81**	**299.33**	**< .001**	**0.62**	**0.98**
	Unpleasant (vs. FW) Condition	**-0.57 (0.091)**	**-6.34**	**299.33**	**< .001**	**-0.75**	**-0.40**
	PerMag X Pleasant (vs. FW) Condition	-0.10 (0.093)	-1.13	301.15	.26	-0.29	0.077
	PerMag X Unpleasant (vs. FW) Condition	0.098 (0.093)	1.06	301.15	.29	-0.084	0.28
	SocAnh X Pleasant (vs. FW) Condition	-0.020 (0.092)	-0.21	298.19	.83	-0.20	0.16
	SocAnh X Unpleasant (vs. FW) Condition	-0.0032 (0.092)	-0.035	298.19	.97	-0.18	0.18
Negative	Intercept	-0.30 (0.32)	-0.92	151.49	.36	-0.93	0.34
	PerMag	0.068 (0.065)	1.04	435.65	.30	-0.060	0.20
	SocAnh	-0.033 (0.064)	-0.51	438.19	.61	-0.16	0.093
	Pleasant (vs. FW) Condition	**-0.47 (0.086)**	**-5.41**	**300.89**	**< .001**	**-0.64**	**-0.30**
	Unpleasant (vs. FW) Condition	**1.03 (0.086)**	**11.98**	**300.89**	**< .001**	**0.86**	**1.20**
	PerMag X Pleasant (vs. FW) Condition	0.027 (0.088)	0.30	302.68	.76	-0.15	0.20
	PerMag X Unpleasant (vs. FW) Condition	***-0.15 (0.088)***	***-1.66***	***302.68***	***.097***	***-0.32***	***0.026***
	SocAnh X Pleasant (vs. FW) Condition	0.073 (0.088)	0.83	299.75	.40	-0.099	0.24
	SocAnh X Unpleasant (vs. FW) Condition	0.072 (0.088)	0.82	299.75	.41	-0.10	0.24

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Variability							
Overall	Intercept	-0.68 (0.46)	-1.48	147.36	.14	-1.59	0.22
	PerMag	0.091 (0.083)	1.09	393.15	.27	-0.072	0.25
	SocAnh	-0.094 (0.082)	-1.15	399.44	.25	-0.26	0.066
	Pleasant (vs. FW) Condition	-0.0023 (0.11)	-0.020	322.26	.98	-0.23	0.22
	Unpleasant (vs. FW) Condition	**0.31 (0.11)**	**2.72**	**324.00**	**.0068**	**0.087**	**0.54**
	PerMag X Pleasant (vs. FW) Condition	0.062 (0.10)	0.60	299.43	.55	-0.14	0.26
	PerMag X Unpleasant (vs. FW) Condition	-0.027 (0.10)	-0.26	300.54	.80	-0.23	0.18
	SocAnh X Pleasant (vs. FW) Condition	0.088 (0.10)	0.86	296.50	.39	-0.11	0.29
	SocAnh X Unpleasant (vs. FW) Condition	0.080 (0.10)	0.78	296.50	.44	-0.12	0.28
	Mean Overall Sentiment	-0.033 (0.064)	-0.51	405.21	.61	-0.16	0.092
Positive	Intercept	-0.22 (0.35)	-0.64	141.45	.52	-0.90	0.46
	PerMag	0.056 (0.063)	0.89	399.63	.37	-0.068	0.18
	SocAnh	0.053 (0.063)	0.84	405.74	.40	-0.070	0.18
	Pleasant (vs. FW) Condition	**-0.28 (0.086)**	**-3.27**	**319.22**	**.0012**	**-0.45**	**-0.11**
	Unpleasant (vs. FW) Condition	**-0.34 (0.082)**	**-4.17**	**306.30**	**< .001**	**-0.50**	**-0.18**
	PerMag X Pleasant (vs. FW) Condition	0.024 (0.080)	0.29	293.24	.77	-0.13	0.18
	PerMag X Unpleasant (vs. FW) Condition	0.014 (0.080)	0.18	293.40	.86	-0.14	0.17
	SocAnh X Pleasant (vs. FW) Condition	0.012 (0.080)	0.15	290.25	.88	-0.14	0.17
	SocAnh X Unpleasant (vs. FW) Condition	***-0.15 (0.080)***	***-1.83***	***290.20***	***.068***	***-0.30***	***0.010***
	Mean Positive Sentiment	**0.60 (0.043)**	**14.08**	**436.39**	**< .001**	**0.52**	**0.69**
Negative	Intercept	***-0.53 (0.28)***	***-1.84***	***148.45***	***.067***	***-1.08***	***0.033***
	PerMag	0.054 (0.054)	0.99	417.14	.32	-0.052	0.16
	SocAnh	-0.057 (0.054)	-1.06	421.77	.29	-0.16	0.048
	Pleasant (vs. FW) Condition	**-0.18 (0.071)**	**-2.47**	**307.78**	**.014**	**-0.31**	**-0.036**
	Unpleasant (vs. FW) Condition	-0.028 (0.080)	-0.35	347.58	.73	-0.18	0.13
	PerMag X Pleasant (vs. FW) Condition	0.089 (0.070)	1.26	299.30	.21	-0.049	0.23
	PerMag X Unpleasant (vs. FW) Condition	0.11 (0.071)	1.55	300.54	.12	-0.029	0.25
	SocAnh X Pleasant (vs. FW) Condition	0.059 (0.070)	0.84	296.80	.40	-0.078	0.20
	SocAnh X Unpleasant (vs. FW) Condition	0.029 (0.070)	0.42	296.80	.68	-0.11	0.17
	Mean Negative Sentiment	**0.72 (0.039)**	**18.36**	**440.09**	**< .001**	**0.64**	**0.80**

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Instability (MSSD)							
Overall	Intercept	-0.44 (0.44)	-1.00	149.49	.32	-1.30	0.42
	PerMag	0.034 (0.084)	0.41	418.26	.68	-0.13	0.20
	SocAnh	***-0.15 (0.083)***	***-1.87***	***422.86***	***.062***	***-0.32***	***0.0074***
	Pleasant (vs. FW) Condition	-0.052 (0.12)	-0.43	327.18	.66	-0.29	0.18
	Unpleasant (vs. FW) Condition	**0.32 (0.12)**	**2.61**	**328.86**	**.0094**	**0.079**	**0.55**
	PerMag X Pleasant (vs. FW) Condition	0.014 (0.11)	0.13	300.68	.89	-0.20	0.23
	PerMag X Unpleasant (vs. FW) Condition	0.022 (0.11)	0.20	301.92	.84	-0.19	0.24
	SocAnh X Pleasant (vs. FW) Condition	***0.20 (0.11)***	***1.84***	***297.79***	***.067***	***-0.013***	***0.41***
	SocAnh X Unpleasant (vs. FW) Condition	0.17 (0.11)	1.54	297.80	.12	-0.045	0.38
	Mean Overall Sentiment	0.021 (0.066)	0.32	420.25	.75	-0.11	0.15
Positive	Intercept	-0.064 (0.35)	-0.18	145.97	.86	-0.75	0.62
	PerMag	-0.0081 (0.064)	-0.12	403.46	.90	-0.13	0.12
	SocAnh	0.063 (0.064)	1.00	409.21	.32	-0.061	0.19
	Pleasant (vs. FW) Condition	**-0.33 (0.087)**	**-3.80**	**323.50**	**< .001**	**-0.50**	**-0.16**
	Unpleasant (vs. FW) Condition	**-0.28 (0.083)**	**-3.34**	**310.71**	**< .001**	**-0.44**	**-0.11**
	PerMag X Pleasant (vs. FW) Condition	0.019 (0.082)	0.23	297.75	.82	-0.14	0.18
	PerMag X Unpleasant (vs. FW) Condition	0.063 (0.082)	0.77	297.90	.44	-0.098	0.22
	SocAnh X Pleasant (vs. FW) Condition	0.050 (0.081)	0.62	294.81	.54	-0.11	0.21
	SocAnh X Unpleasant (vs. FW) Condition	***-0.14 (0.081)***	***-1.74***	***294.75***	***.082***	***-0.30***	***0.018***
	Mean Positive Sentiment	**0.63 (0.044)**	**14.37**	**437.31**	**< .001**	**0.54**	**0.71**
Negative	Intercept	**-0.73 (0.30)**	**-2.45**	**148.12**	**.015**	**-1.32**	**-0.15**
	PerMag	0.015 (0.058)	0.26	422.74	.79	-0.098	0.13
	SocAnh	-0.057 (0.057)	-1.00	426.86	.32	-0.17	0.055
	Pleasant (vs. FW) Condition	-0.12 (0.076)	-1.61	307.50	.11	-0.27	0.026
	Unpleasant (vs. FW) Condition	-0.010 (0.086)	-0.12	348.54	.90	-0.18	0.16
	PerMag X Pleasant (vs. FW) Condition	0.12 (0.076)	1.52	298.68	.13	-0.034	0.26
	PerMag X Unpleasant (vs. FW) Condition	***0.13 (0.076)***	***1.67***	***299.95***	***.095***	***-0.022***	***0.28***
	SocAnh X Pleasant (vs. FW) Condition	0.063 (0.076)	0.84	296.22	.40	-0.085	0.21
	SocAnh X Unpleasant (vs. FW) Condition	0.053 (0.076)	0.70	296.21	.48	-0.095	0.20
	Mean Negative Sentiment	**0.69 (0.042)**	**16.51**	**441.33**	**< .001**	**0.61**	**0.78**

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Instability (PAC)							
Overall	Intercept	-0.37 (0.41)	-0.92	150.52	.36	-1.17	0.42
	PerMag	0.020 (0.084)	0.24	438.48	.81	-0.14	0.18
	SocAnh	-0.085 (0.084)	-1.02	440.11	.31	-0.25	0.079
	Pleasant (vs. FW) Condition	-0.12 (0.13)	-0.95	332.06	.34	-0.37	0.13
	Unpleasant (vs. FW) Condition	-0.0075 (0.13)	-0.059	333.55	.95	-0.26	0.24
	PerMag X Pleasant (vs. FW) Condition	-0.069 (0.12)	-0.59	300.06	.56	-0.30	0.16
	PerMag X Unpleasant (vs. FW) Condition	-0.012 (0.12)	-0.099	301.48	.92	-0.24	0.22
	SocAnh X Pleasant (vs. FW) Condition	0.15 (0.12)	1.30	297.31	.19	-0.076	0.38
	SocAnh X Unpleasant (vs. FW) Condition	0.11 (0.12)	0.92	297.32	.36	-0.12	0.33
	Mean Overall Sentiment	0.045 (0.068)	0.66	436.25	.51	-0.088	0.18
Positive	Intercept	-0.54 (0.39)	-1.38	146.04	.17	-1.30	0.22
	PerMag	0.0075 (0.074)	0.10	417.48	.92	-0.14	0.15
	SocAnh	0.11 (0.073)	1.55	422.19	.12	-0.030	0.26
	Pleasant (vs. FW) Condition	**-0.45 (0.10)**	**-4.42**	**324.83**	**< .001**	**-0.65**	**-0.25**
	Unpleasant (vs. FW) Condition	**0.43 (0.098)**	**4.40**	**311.15**	**< .001**	**0.24**	**0.62**
	PerMag X Pleasant (vs. FW) Condition	0.057 (0.096)	0.59	297.29	.56	-0.13	0.25
	PerMag X Unpleasant (vs. FW) Condition	0.14 (0.096)	1.44	297.45	.15	-0.050	0.33
	SocAnh X Pleasant (vs. FW) Condition	-0.044 (0.096)	-0.46	294.38	.64	-0.23	0.14
	SocAnh X Unpleasant (vs. FW) Condition	-0.14 (0.096)	-1.48	294.32	.14	-0.33	0.046
	Mean Positive Sentiment	**0.55 (0.050)**	**10.91**	**440.96**	**< .001**	**0.45**	**0.65**
Negative	Intercept	-0.29 (0.40)	-0.72	148.46	.47	-1.08	0.49
	PerMag	0.015 (0.072)	0.21	396.10	.83	-0.13	0.16
	SocAnh	-0.073 (0.072)	-1.02	402.02	.31	-0.21	0.068
	Pleasant (vs. FW) Condition	**0.27 (0.091)**	**3.00**	**307.55**	**.0029**	**0.095**	**0.45**
	Unpleasant (vs. FW) Condition	**-0.68 (0.10)**	**-6.52**	**343.64**	**< .001**	**-0.88**	**-0.47**
	PerMag X Pleasant (vs. FW) Condition	0.15 (0.090)	1.64	300.10	.10	-0.029	0.33
	PerMag X Unpleasant (vs. FW) Condition	0.018 (0.091)	0.20	301.24	.84	-0.16	0.20
	SocAnh X Pleasant (vs. FW) Condition	0.15 (0.090)	1.65	297.52	.10	-0.028	0.32
	SocAnh X Unpleasant (vs. FW) Condition	***0.16 (0.090)***	***1.81***	***297.52***	***.071***	***-0.013***	***0.34***
	Mean Negative Sentiment	**0.61 (0.052)**	**11.71**	**432.97**	**< .001**	**0.50**	**0.71**

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Inertia							
Overall	Intercept	-0.025 (0.36)	-0.070	442.00	.94	-0.72	0.67
	PerMag	0.032 (0.076)	0.43	442.00	.67	-0.12	0.18
	SocAnh	0.027 (0.075)	0.36	442.00	.72	-0.12	0.17
	Pleasant (vs. FW) Condition	**0.33 (0.12)**	**2.88**	**442.00**	**.0042**	**0.11**	**0.56**
	Unpleasant (vs. FW) Condition	**-0.85 (0.12)**	**-7.31**	**442.00**	**< .001**	**-1.07**	**-0.62**
	PerMag X Pleasant (vs. FW) Condition	-0.013 (0.11)	-0.12	442.00	.90	-0.22	0.20
	PerMag X Unpleasant (vs. FW) Condition	-0.074 (0.11)	-0.70	442.00	.49	-0.28	0.13
	SocAnh X Pleasant (vs. FW) Condition	-0.16 (0.10)	-1.53	442.00	.13	-0.37	0.046
	SocAnh X Unpleasant (vs. FW) Condition	0.035 (0.10)	0.33	442.00	.74	-0.17	0.24
	Mean Overall Sentiment	**-0.58 (0.061)**	**-9.57**	**442.00**	**< .001**	**-0.70**	**-0.46**
Positive	Intercept	0.20 (0.33)	0.61	151.41	.54	-0.44	0.84
	PerMag	0.070 (0.069)	1.02	440.37	.31	-0.064	0.20
	SocAnh	0.0043 (0.068)	0.064	441.38	.95	-0.13	0.14
	Pleasant (vs. FW) Condition	**0.56 (0.10)**	**5.51**	**331.92**	**< .001**	**0.36**	**0.76**
	Unpleasant (vs. FW) Condition	**-0.86 (0.098)**	**-8.78**	**316.31**	**< .001**	**-1.05**	**-0.67**
	PerMag X Pleasant (vs. FW) Condition	-0.025 (0.097)	-0.26	300.54	.80	-0.21	0.16
	PerMag X Unpleasant (vs. FW) Condition	-0.076 (0.097)	-0.79	300.71	.43	-0.27	0.11
	SocAnh X Pleasant (vs. FW) Condition	-0.091 (0.096)	-0.95	297.88	.34	-0.28	0.097
	SocAnh X Unpleasant (vs. FW) Condition	-0.051 (0.096)	-0.53	297.82	.59	-0.24	0.14
	Mean Positive Sentiment	**-0.62 (0.048)**	**-13.03**	**436.17**	**< .001**	**-0.72**	**-0.53**
Negative	Intercept	**0.91 (0.18)**	**5.05**	**151.54**	**< .001**	**0.56**	**1.26**
	PerMag	**0.082 (0.037)**	**2.18**	**439.30**	**.030**	**0.0083**	**0.16**
	SocAnh	0.00076 (0.037)	0.020	440.70	.98	-0.072	0.074
	Pleasant (vs. FW) Condition	**-1.84 (0.052)**	**-35.25**	**310.50**	**< .001**	**-1.95**	**-1.74**
	Unpleasant (vs. FW) Condition	**-0.48 (0.058)**	**-8.20**	**355.59**	**< .001**	**-0.59**	**-0.36**
	PerMag X Pleasant (vs. FW) Condition	-0.025 (0.052)	-0.47	300.40	.64	-0.13	0.077
	PerMag X Unpleasant (vs. FW) Condition	-0.036 (0.052)	-0.70	301.74	.48	-0.14	0.066
	SocAnh X Pleasant (vs. FW) Condition	0.045 (0.052)	0.88	298.16	.38	-0.056	0.15
	SocAnh X Unpleasant (vs. FW) Condition	-0.0050 (0.052)	-0.096	298.15	.92	-0.11	0.097
	Mean Negative Sentiment	**0.24 (0.028)**	**8.63**	**438.70**	**< .001**	**0.18**	**0.29**

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Emodiversity							
Overall	Intercept	-0.36 (0.53)	-0.68	145.45	.50	-1.40	0.68
	PerMag	0.089 (0.084)	1.06	304.99	.29	-0.076	0.25
	SocAnh	0.026 (0.082)	0.32	310.87	.75	-0.14	0.19
	Pleasant (vs. FW) Condition	-0.021 (0.098)	-0.21	312.97	.83	-0.21	0.17
	Unpleasant (vs. FW) Condition	**0.27 (0.098)**	**2.80**	**315.19**	**.0054**	**0.082**	**0.47**
	PerMag X Pleasant (vs. FW) Condition	-0.12 (0.088)	-1.42	299.83	.16	-0.30	0.047
	PerMag X Unpleasant (vs. FW) Condition	-0.066 (0.088)	-0.74	300.51	.46	-0.24	0.11
	SocAnh X Pleasant (vs. FW) Condition	0.0029 (0.087)	0.033	296.81	.97	-0.17	0.17
	SocAnh X Unpleasant (vs. FW) Condition	0.068 (0.087)	0.78	296.82	.44	-0.10	0.24
	Mean Overall Sentiment	**0.12 (0.056)**	**2.18**	**365.10**	**.030**	**0.012**	**0.23**
Positive	Intercept	-0.12 (0.39)	-0.32	144.09	.75	-0.89	0.64
	PerMag	-0.017 (0.065)	-0.26	336.78	.80	-0.14	0.11
	SocAnh	0.066 (0.064)	1.03	343.22	.30	-0.059	0.19
	Pleasant (vs. FW) Condition	-0.086 (0.078)	-1.11	314.35	.27	-0.24	0.066
	Unpleasant (vs. FW) Condition	**-0.32 (0.075)**	**-4.30**	**308.18**	**< .001**	**-0.47**	**-0.17**
	PerMag X Pleasant (vs. FW) Condition	-0.016 (0.073)	-0.22	298.22	.82	-0.16	0.13
	PerMag X Unpleasant (vs. FW) Condition	0.086 (0.073)	1.18	298.24	.24	-0.057	0.23
	SocAnh X Pleasant (vs. FW) Condition	-0.050 (0.072)	-0.69	294.91	.49	-0.19	0.091
	SocAnh X Unpleasant (vs. FW) Condition	-0.0085 (0.072)	-0.12	294.91	.90	-0.15	0.13
	Mean Positive Sentiment	**0.55 (0.041)**	**13.43**	**406.10**	**< .001**	**0.47**	**0.63**
Negative	Intercept	-0.21 (0.35)	-0.59	148.49	.56	-0.90	0.48
	PerMag	**0.14 (0.060)**	**2.41**	**363.02**	**.016**	**0.027**	**0.26**
	SocAnh	0.0079 (0.059)	0.13	369.02	.89	-0.11	0.12
	Pleasant (vs. FW) Condition	**-0.18 (0.071)**	**-2.53**	**308.21**	**.012**	**-0.32**	**-0.040**
	Unpleasant (vs. FW) Condition	**0.28 (0.081)**	**3.52**	**334.38**	**< .001**	**0.13**	**0.44**
	PerMag X Pleasant (vs. FW) Condition	***-0.14 (0.071)***	***-1.91***	***301.82***	***.056***	***-0.27***	***0.0032***
	PerMag X Unpleasant (vs. FW) Condition	-0.12 (0.071)	-1.62	302.85	.10	-0.25	0.024
	SocAnh X Pleasant (vs. FW) Condition	0.027 (0.070)	0.39	299.02	.70	-0.11	0.16
	SocAnh X Unpleasant (vs. FW) Condition	0.043 (0.070)	0.61	299.02	.54	-0.095	0.18
	Mean Negative Sentiment	**0.56 (0.041)**	**13.75**	**414.71**	**< .001**	**0.48**	**0.64**

Outcome	Predictor	β (*SE*)	*t*	*df*	*p*	95% CI	
						Lower	Upper
Density							
	Intercept	**-0.68 (0.24)**	**-2.76**	**152.32**	**.0065**	**-1.16**	**-0.20**
	PerMag	0.047 (0.050)	0.93	435.93	.35	-0.052	0.14
	SocAnh	-0.0016 (0.050)	-0.031	437.93	.98	-0.099	0.096
	Pleasant (vs. FW) Condition	**1.19 (0.074)**	**16.11**	**331.62**	**< .001**	**1.05**	**1.34**
	Unpleasant (vs. FW) Condition	0.096 (0.079)	1.21	353.63	.22	-0.059	0.25
	PerMag X Pleasant (vs. FW) Condition	**-0.21 (0.069)**	**-3.04**	**301.49**	**.0026**	**-0.34**	**-0.075**
	PerMag X Unpleasant (vs. FW) Condition	-0.016 (0.069)	-0.24	302.60	.81	-0.15	0.12
	SocAnh X Pleasant (vs. FW) Condition	0.023 (0.069)	0.33	298.83	.74	-0.11	0.16
	SocAnh X Unpleasant (vs. FW) Condition	-0.0091 (0.069)	-0.13	298.80	.89	-0.14	0.12
	Mean Positive Sentiment	**0.36 (0.035)**	**10.20**	**436.43**	**< .001**	**0.29**	**0.42**
	Mean Negative Sentiment	-0.024 (0.037)	-0.63	437.41	.53	-0.096	0.049
Synchrony							
	Intercept	0.14 (0.39)	0.34	152.63	.73	-0.64	0.91
	PerMag	***-0.13 (0.079)***	***-1.67***	***431.98***	***.096***	***-0.28***	***0.023***
	SocAnh	0.032 (0.078)	0.41	434.72	.68	-0.12	0.18
	Pleasant (vs. FW) Condition	0.11 (0.11)	0.99	331.13	.32	-0.11	0.34
	Unpleasant (vs. FW) Condition	0.13 (0.12)	1.05	352.36	.29	-0.11	0.37
	PerMag X Pleasant (vs. FW) Condition	0.11 (0.11)	1.03	302.21	.30	-0.10	0.32
	PerMag X Unpleasant (vs. FW) Condition	0.072 (0.11)	0.68	303.29	.50	-0.14	0.28
	SocAnh X Pleasant (vs. FW) Condition	-0.078 (0.11)	-0.74	299.51	.46	-0.29	0.13
	SocAnh X Unpleasant (vs. FW) Condition	0.0090 (0.11)	0.085	299.47	.93	-0.20	0.22
	Mean Positive Sentiment	**-0.35 (0.055)**	**-6.35**	**439.01**	**< .001**	**-0.46**	**-0.24**
	Mean Negative Sentiment	**-0.32 (0.058)**	**-5.58**	**439.66**	**< .001**	**-0.44**	**-0.21**

Note. Significant and trend-level significant results are highlighted. PerMag = perceptual aberration and magical ideation (positive symptoms), SocAnh = social anhedonia, FW = free writing, MSSD = mean square successive difference, PAC = probability of acute change.

Appendix L

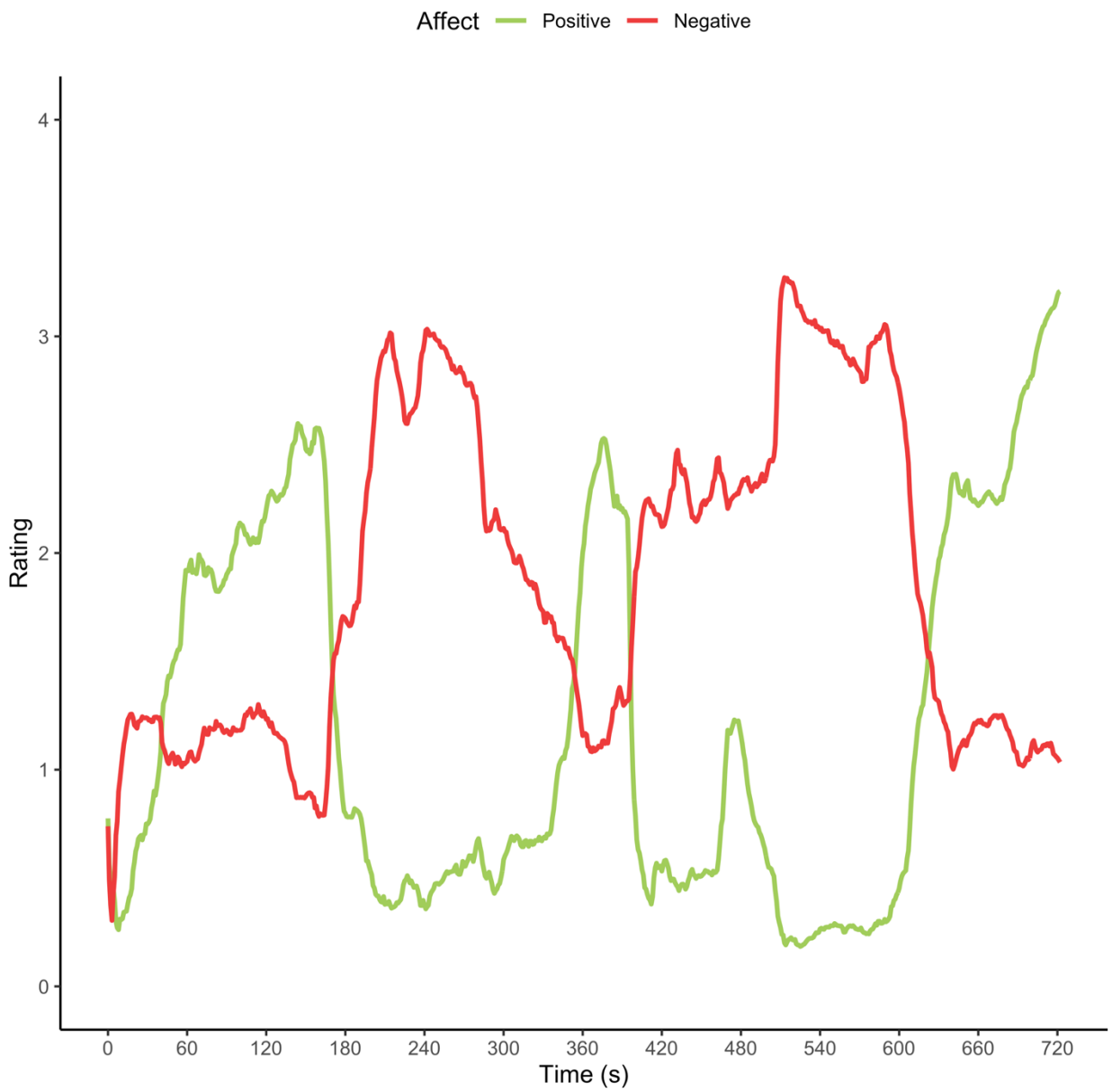
Standardized Simple Slope Estimates for the Association of Positive Symptoms and Social Anhedonia with Affect Dynamics Under Free Writing, Pleasant, and Unpleasant Conditions

Outcome	Free Writing		Pleasant		Unpleasant	
	Positive Symptoms	Social Anhedonia	Positive Symptoms	Social Anhedonia	Positive Symptoms	Social Anhedonia
Mean Sentiment						
Overall	-0.019 (0.059)	-0.020 (0.058)	**-0.13 (0.059)***	-0.061 (0.058)	**0.16 (0.059)****	-0.064 (0.058)
Positive	0.0089 (0.069)	-0.023 (0.068)	-0.096 (0.070)	-0.043 (0.068)	0.11 (0.070)	-0.027 (0.068)
Negative	0.068 (0.065)	-0.033 (0.064)	0.095 (0.066)	0.040 (0.064)	-0.080 (0.066)	0.039 (0.064)
Variability						
Overall	0.091 (0.083)	-0.094 (0.082)	***0.15 (0.084)†***	-0.0058 (0.082)	0.064 (0.084)	-0.015 (0.082)
Positive	0.056 (0.063)	0.053 (0.063)	0.080 (0.064)	0.065 (0.063)	0.071 (0.064)	-0.094 (0.063)
Negative	0.054 (0.054)	-0.057 (0.054)	**0.14 (0.055)****	0.0024 (0.053)	**0.16 (0.055)****	-0.027 (0.053)
Instability (MSSD)						
Overall	0.034 (0.084)	***-0.15 (0.083)†***	0.049 (0.085)	0.045 (0.083)	0.056 (0.085)	0.013 (0.083)
Positive	-0.0081 (0.064)	0.063 (0.064)	0.011 (0.065)	***0.11 (0.063)†***	0.055 (0.065)	-0.078 (0.063)
Negative	0.015 (0.058)	-0.057 (0.057)	**0.13 (0.058)***	0.0067 (0.057)	**0.14 (0.058)***	-0.0040 (0.057)
Instability (PAC)						
Overall	0.020 (0.084)	-0.085 (0.084)	-0.048 (0.086)	0.066 (0.083)	0.0088 (0.086)	0.022 (0.083)
Positive	0.0074 (0.074)	0.11 (0.073)	0.064 (0.074)	0.068 (0.073)	***0.15 (0.074)†***	-0.029 (0.073)
Negative	0.015 (0.072)	-0.073 (0.072)	**0.16 (0.073)***	0.075 (0.071)	0.033 (0.073)	0.090 (0.071)
Inertia						
Overall	0.032 (0.076)	0.027 (0.075)	0.019 (0.077)	***-0.13 (0.075)†***	-0.042 (0.077)	0.062 (0.075)
Positive	0.070 (0.069)	0.0043 (0.068)	0.046 (0.070)	-0.087 (0.068)	-0.0060 (0.070)	-0.047 (0.068)
Negative	**0.082 (0.037)***	0.00076 (0.037)	0.057 (0.038)	0.046 (0.037)	0.045 (0.038)	-0.0042 (0.037)
Emodiversity						
Overall	0.089 (0.084)	0.026 (0.082)	-0.037 (0.085)	0.029 (0.082)	0.023 (0.085)	0.094 (0.082)
Positive	-0.017 (0.065)	0.066 (0.064)	-0.033 (0.065)	0.016 (0.064)	0.069 (0.065)	0.057 (0.064)
Negative	**0.14 (0.060)***	0.0079 (0.059)	0.010 (0.061)	0.035 (0.059)	0.030 (0.061)	0.050 (0.059)
Density	0.047 (0.050)	-0.0016 (0.050)	**-0.16 (0.051)***	0.021 (0.050)	0.030 (0.051)	-0.011 (0.050)
Synchrony	***-0.13 (0.079)†***	0.032 (0.078)	-0.021 (0.080)	-0.046 (0.078)	-0.059 (0.080)	0.041 (0.078)

Note. Significant and trend-level significant results are highlighted. MSSD = mean square successive difference, PAC = probability of acute change.
** $p < .01$. * $p < .05$. † $p < .10$.

Appendix M

Average affect ratings of the film clip data



Appendix N

Standardized Regression Coefficients for the Association of Positive Symptoms and Social Anhedonia with Film Clip Affect Dynamics

Outcome	Positive Symptoms			Social Anhedonia			Mean Sentiment			
	β (*SE*)	*t*	*p*	β (*SE*)	*t*	*p*	β (*SE*)	*t*	*p*	*df*
Mean Sentiment										
Positive	**0.29 (0.077)**	**3.74**	**< .001**	**-0.17 (0.076)**	**-2.26**	**.025**	--			145
Negative	0.10 (0.081)	1.25	.21	-0.026 (0.080)	-0.33	.74	--			145
Variability										
Positive	0.11 (0.076)	1.50	.14	-0.079 (0.073)	-1.09	.28	**0.41 (0.078)**	**5.31**	**< .001**	144
Negative	0.12 (0.081)	1.47	.14	-0.11 (0.080)	-1.36	.18	**0.27 (0.083)**	**3.23**	**.0015**	144
Instability (MSSD)										
Positive	**0.18 (0.081)**	**2.15**	**.033**	-0.099 (0.078)	-1.26	.21	**0.27 (0.084)**	**3.22**	**.0016**	144
Negative	**0.25 (0.080)**	**3.14**	**.0021**	-0.13 (0.079)	-1.64	.10	0.078 (0.082)	0.96	.34	144
Instability (PAC)										
Positive	**0.22 (0.085)**	**2.56**	**.011**	-0.086 (0.082)	-1.05	.29	0.11 (0.088)	1.24	.22	144
Negative	**0.23 (0.083)**	**2.80**	**.0059**	-0.069 (0.082)	-0.85	.40	0.045 (0.085)	0.54	.59	144
Inertia										
Positive	-0.074 (0.084)	-0.88	.38	0.034 (0.080)	0.43	.67	**-0.28 (0.086)**	**-3.30**	**.0012**	143
Negative	-0.11 (0.084)	-1.29	.20	0.080 (0.083)	0.96	.34	0.014 (0.086)	0.16	.87	143
Emodiversity										
Overall	0.14 (0.085)	1.61	.11	***-0.14 (0.081)***	***-1.74***	***.084***	***PA: 0.15 (0.088)***	***1.69***	***.094***	143
							NA: 0.098 (0.084)	1.18	.24	
Positive	0.047 (0.087)	0.54	.59	-0.12 (0.084)	-1.45	.15	***0.16 (0.089)***	***1.74***	***.084***	144
Negative	**0.22 (0.081)**	**2.68**	**.0081**	-0.066 (0.080)	-0.82	.41	0.12 (0.082)	1.49	.14	144
Density	-0.067 (0.085)	-0.78	.43	0.070 (0.082)	0.85	.39	**PA: -0.25 (0.088)**	**-2.83**	**.0054**	142
							NA: 0.067 (0.083)	0.81	.42	
Synchrony	-0.026 (0.086)	-0.30	.76	0.059 (0.082)	0.72	.47	***PA: -0.16 (0.088)***	***-1.82***	***.071***	143
							NA: -0.30 (0.084)	**-3.52**	**< .001**	

Note. Significant and trend-level significant results are highlighted. MSSD = mean square successive difference, PAC = probability of acute change, PA = positive affect, NA = negative affect.