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ORIGINAL ARTICLE

Looming Cognitive Style and Its Associations with Anxiety and Depression: A Meta-analysis

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Abstract

Background The looming cognitive style (LCS) is a cognitive bias to interpret and generate mental scenarios (i.e., mentally simulate) of threats as rapidly developing and approaching. A rapidly growing and approaching threat is likely to evoke a greater experience of urgency and anxiety in individuals compared to a threat that is interpreted to be static. Individuals who possess the LCS tend to perceive mentally simulated threats as rapidly intensifying and approaching, and this future-oriented prospection (or future-oriented thinking) is assumed to put them at risk of anxiety and depression.

Methods The current meta-analytic review examined the strength of the relations between the LCS and different subtypes of anxiety (i.e., nonspecific anxiety, social anxiety, obsessions-compulsions, fears, and worry) and depression. Articles were retrieved from online databases and unpublished data sets. A total of 141 effect sizes were obtained from 61 articles with 69 independent samples after selection criteria were met.

Results Random- and mixed-effects models indicated significant mean effect sizes of moderate magnitude. The relations between LCS and the anxiety subtypes were generally significantly stronger than that of depression, in particular for nonspecific anxiety, social anxiety, and worry. Additionally, sample type and study quality emerged as significant moderators for the effect sizes for certain symptoms.

Conclusions These results support the idea that LCS is a transdiagnostic vulnerability factor for various anxiety subtypes and that it is more specific to anxiety than to depression. Clinical implications and future directions are discussed.

Keywords Looming cognitive style · Meta-analysis · Anxiety · Depression · Transdiagnostic

Introduction

Cognitive models of anxiety posit that the way people appraise threat information is critical to the development and maintenance of anxiety (Beck et al. 1985; Clark and Beck 2010; Riskind and Alloy 2006). One such cognitive model—the looming vulnerability model (Riskind et al. 2000)—emphasizes an evolutionary based parameter related to the perception of rapidly intensifying and approaching threat. This model assumes that the detection and overestimation of the growing intensity and approach of a "looming" threat—such as spiders, snakes, or dangerous human agents—may help individuals to avoid being caught flat-footed by approaching dangers and thus be evolutionarily adaptive (Neuhoff 2001; Schiff et al. 1962). However, when individuals have excessive or chronic perceptions of threats as rapidly approaching and gaining in magnitude, proximity, or probability, these perceptions may then contribute to anxiety symptoms and disorders, cognitive vulnerability to anxiety, as well as under some circumstances, depression (Riskind et al. 2000).

The looming vulnerability model draws its conceptual foundations from several scientific sources. For example, many lines of research illustrate that potential threats that are rapidly approaching serve as warning signals. Numerous

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experimental cognitive and cognitive neuroscience studies demonstrate that looming objects have been shown in humans to have strong priority in producing attentional capture (e.g., Franconeri and Simons 2003; Judd et al. 2004; Parker and Alais 2007) and memory (Pilz et al. 2011) as compared to static or receding objects or those on near-miss trajectories. Furthermore, approaching objects trigger greater anxiety/fear responses than static or receding objects, and they elicit distinct patterns of brain activation than objects that are equally or more distant in proximity (Mobbs et al. 2010; Van Wassenhove et al. 2011). Likewise, when objects start out as close in proximity or high in probability, they evoke less negative affect reactions than when they start out lower but rapidly increase in their proximity or probability (Hsee et al. 2014; Mobbs et al. 2010). A wide variety of animal species, including fruit flies and barnacles (Card and Dickenson 2008; Dill 1990; Gwilliam 1963; Westby et al. 1990) as well as human infants (Ball and Tronick 1971), react vigilantly and defensively to approaching threats.

The looming model also draws on other theories such as (a) the concept of "prospection" (Seligman et al. 2013) as a ubiquitous action of looking forward mentally and representing possible futures in human thought, and (b) the concept of mental simulation (Taylor et al. 1998) as a way of providing a window into the future that allows individuals to anticipate possibilities and develop response plans (for more, see Riskind and Calvete 2019; Riskind and Rector 2018).

The Looming Cognitive Style

The looming vulnerability model stipulates that some individuals, more than others, are put at a greater risk for anxiety because they develop a "looming cognitive style" (LCS; Riskind et al. 2000). The LCS refers to a cognitive bias towards prospection and perception of future-oriented mental simulations of threats as rapidly gaining in proximity and magnitude, and rising in urgency per unit time. The LCS is a putative but well-validated cognitive style for anxiety that reflects relatively trait-like individual differences in the extent to which people tend to simulate and interpret threat scenarios (either physical or social) as rapidly intensifying and approaching, and thereby rising in their risk, significance, and urgency. When individuals are cognitively biased in this relatively trait-like manner to overestimate the extent to which threats are rapidly approaching or growing in risk (e.g., not just as close or probable but increasing in intensity), they are especially prone to experiencing elevated anxiety. Thus, it is not just the perception of threat alone but the prospection and simulation of rapid escalation in threat levels that is critical. Conversely, when individuals tend to perceive potential threats as constant in magnitude (i.e., not gaining in proximity or probability) and unchanging per unit time (i.e., regardless of whether the fixed level of threat is low, medium or high) or even as receding as a function of time, it is theoretically expected that their sense of urgency and relevance of the threat and hence anxiety may tend to eventually decline (Riskind and Rector 2018). In brief, anxiety arises because individuals mentally simulate and imagine, and have dynamic prospections and expectations of, future threats as rapidly intensifying and advancing toward them (Riskind and Calvete 2019).

The LCS is related to a variety of theoretically expected cognitive and behavioral correlates. We briefly describe a few examples here and readers are referred to Riskind and Rector (2018) for a comprehensive review. Consistent with the looming vulnerability model, individuals high on LCS tend to possess interpretative and memory biases for threat cues (Riskind et al. 2000) and show freezing responses to images of threatening animals (Riskind et al. 2016). LCS is found to be elevated in DSM-IV diagnosed anxiety disorder patients (Riskind et al. 2011) and recent findings show that LCS scores in generalized anxiety disorder patients appear to decrease over the course of standard cognitive-behavioral therapy (Katz et al. 2017).

LCS independently predicts anxiety even when related constructs such as interpretative biases to overestimate threat probabilities, anxiety sensitivity, intolerance of certainty, negative affectivity (a proxy for neuroticism), and behavioral inhibition/activation scores are controlled for (Elwood et al. 2011; Reardon and Williams 2007; Riskind et al. 2007, 2017a, b). More important, LCS prospectively predicts residualized increases in various anxiety symptoms over time, including social anxiety, worry, obsessions-compulsions (OC), and spontaneous threat cognitions (Adler and Strunk 2010; González-Díez et al. 2015; Riskind et al. 2000, 2007, 2017a, b; Sica et al. 2012). In addition, LCS interacts with other cognitive vulnerability variables (e.g., anxiety sensitivity, negative cognitive style) to predict anxiety-related outcomes, such as the generation of stress (see Kleiman and Riskind 2012, 2014; Riskind et al. 2010, 2013b). Overall, these findings suggest that LCS provides unique and non-redundant perspectives to the understanding on the etiology of anxiety symptoms.

Given that ample evidence has amassed that the LCS assesses a facet of cognitive vulnerability not well captured or coded by other constructs, it warrants separate attention. More specifically, since the LCS's formal introduction nearly two decades ago (Riskind et al. 2000), a sizable number of studies have been done to evaluate the theoretical status of the LCS as a cognitive vulnerability factor to anxiety (Riskind and Rector 2018). However, little work has been done to examine the comparative robustness of effects across different variants and subtypes of anxiety in the literature. This article sought to consolidate this literature via a meta-analytic review, specifically examining the empirical associations between LCS and various anxiety subtypes

and depression. Depression is included because of its strong comorbidity with anxiety (Mineka et al. 1998). Although LCS might be associated with depression, this relation is expected to be weaker than the relation to anxiety, as depression has been widely regarded as an affective response to "losses" or events that have already taken place (or that are inescapable and certain to occur) rather than in the process of occurring (Beck et al. 1985; Johnson-Laird and Oatley 1989).

Relations to Syndromes

Research has repeatedly supported the expectation that the perception of rapidly advancing threat has bearing in understanding aspects of anxiety across the anxiety disorder spectrum. Looming vulnerable individuals who are predisposed to social anxiety or generalized anxiety show not just exaggerated perceptions of threat or estimates of the probability of rejection, but also mental simulations of rapidly rising gains in the probabilities of rejection and intensifying threat in social threat situations (Brown and Stopa 2008; González-Díez et al. 2014, 2015, 2016; Reardon and Williams 2007; Riskind et al. 2013b; Williams et al. 2005).

In the context of OC, looming vulnerable individuals generate more mental simulations of the rising danger pertaining to rapidly spreading contamination or intrusive thoughts (e.g., about harming others), which then cause them to react with greater anxiety and label such intrusive thoughts as "over-important" (Riskind et al. 2002). LCS appears to be implicated in OC symptoms in both clinical (Riskind and Rector 2007; Riskind et al. 2011; Tolin et al. 2004) and nonclinical samples (Dorfan and Woody 2006; Elwood et al. 2011; Riskind et al. 1997a, 2007; Riskind and Richards 2018; Sica et al. 2012). Furthermore, interventions have been designed to address the escalation of perceived threat (see Dorfan and Woody 2006; Riskind and Rector 2018; Riskind et al. 1997b).

Similarly, several studies have supported the expected role of LCS in specific fears/phobias (e.g., fear of spiders). Individuals with spider phobia tend to exaggerate the degree to which spiders are moving rapidly forward towards them (Riskind et al. 1992, 1995; Riskind and Maddux 1993). Also, in support of the core premise of the LCS, specific signatures of changes in brain activity as well as heightened reports of fear are observed when videos of approaching spiders are shown (compared to static or retreating spiders), after controlling for proximity (Mobbs et al. 2010).

Generalized anxiety disorder (GAD) and its defining feature of excessive worry are linked to LCS. Individuals high on LCS tend to generate catastrophic images of mundane everyday events that rapidly increase in threat level, which may lead to unnecessary worrying (Borkovec et al. 1998). Substantive links between LCS and worry/GAD are found cross-sectionally in both college students and clinical patients (Clemente et al. 2013; Hughes et al. 2008; Riskind et al. 2000, 2011; Voon and Phillips 2015; Williams et al. 2005). The same associations are also found in nonclinical prospective studies (Riskind et al. 2000; Williams 2002). LCS also independently accounts for unique variance in worry after taking into consideration the effects of anxiety and depression (Clemente et al. 2013; Riskind and Williams 2005), and other cognitive vulnerabilities such as intolerance of uncertainty (Riskind et al. 2007).

While the LCS may be related to depression (which also encompasses negative future expectancies; Beck 1974; Roepke and Seligman 2016), it is nonetheless expected to be more closely related to anxiety and anxiety-subtypes. Some studies statistically controlling for the overlap between anxiety and depression found that LCS's link to depression was reduced to nonsignificant levels (e.g., Riskind et al. 2000; Williams 2002; González-Díez et al. 2014), whereas other studies showed that LCS's association to depression remained significant (Hong et al. 2017; Riskind et al. 2013a, b). Moreover, in a time series study, LCS predicted hopelessness and depression over a period of six months among three individuals with comorbid anxiety and depressive symptoms (Tzur-Bitan et al. 2012), and the relationship between LCS and depression was comparable to anxiety in sample of cancer patients (Levin et al. 2007). A previous meta-analysis (Hong et al. 2017) involving data from ten countries demonstrated LCS's similar magnitude of associations with depression and anxiety.

One plausible account for the association between LCS and depression is that the perception of rapidly growing and approaching threats may bring about depression when individuals feel hopeless or unable to evade the threats (Riskind et al. 2013b). For instance, the LCS predicted higher levels of depression, but only when individuals had depressive cognitive styles (Abramson et al. 1989) that would create hopelessness (Kleiman and Riskind 2012, 2014). Another possible explanation is that the strong overlap between depression and anxiety (Mineka et al. 1998) could result from a common etiology, such as the perception of uncontrollability in internal and external environments (Barlow 2000). Depression could emerge from such perceptions of uncontrollability regarding threat intensification over time. A third possibility is that the relationship between the LCS and depression may simply reflect the secondary impact of experiencing anxiety symptoms on depression rather than a direct causal link from the LCS. Thus, in addition to examining the strength of the associations between the LCS and subtypes on the anxiety symptom spectrum, the current study sought to better quantify the strength of the association between the LCS and depression.

Study Objectives

To date, no systematic synthesis of the literature on the looming vulnerability model has been conducted to clarify the robustness and generality of evidence regarding the following central tenets: (a) the LCS as an overarching and transdiagnostic vulnerability factor to anxiety subtypes, and (b) its links to anxiety subtypes are stronger compared to its association with depression. The objective of this research aims to address these gaps by conducting a comprehensive meta-analysis to examine the abovementioned issues empirically.

Based on theoretical expectations from the model, we hypothesized that LCS is a transdiagnostic risk construct to anxiety that would exhibit significant and moderately strong associations with nonspecific anxiety and the following anxiety subtypes: (a) social anxiety, (b) OC, (c) fears/phobias, and (d) worry/GAD. By nonspecific anxiety, we meant general anxiety symptoms not specifically tied to any subtype and are measured by instruments such as the Beck Anxiety Inventory (Beck et al. 1988), State-Trait Anxiety Inventory (Spielberger 1989), and the Symptom Checklist-90-R anxiety subscale (Derogatis 1983). While one clinical study has shown a strong relationship of LCS to DSM-IV diagnosed panic disorder (Riskind et al. 2011) and two studies with non-clinical samples have suggested links to posttraumatic stress symptoms (Reardon and Williams 2007; Williams et al. 2005), these effect sizes were not included due to the small number of studies. As noted, we further examined the association between LCS and depression although we expected this relationship would be weaker in magnitude, compared to those associated with the anxiety syndromes.[1]

The primary measure of LCS is the Looming Maladaptive Style Questionnaire (LMSQ; Riskind et al. 2000; see Appendix A in the Online Supplementary Materials; OSM). This easy-to-administer self-report measure presents individuals with ambiguous threat scenarios and captures individuals' bias to interpret or frame ambiguous social (e.g., potential rejection) and physical threats (e.g., injury or death) as rapidly approaching dynamically in their magnitude.[2] We focused only on the overall looming index and not its subscales (i.e., social and physical looming) because the majority of studies reported only the former. In a few cases (see Table 1), however, we used syndrome-specific variants of the LCS such as "looming contamination" scales when examining OC or "looming spider" scales when examining spider phobias.

We considered several possible moderating variables. They included (a) type of sample (clinical versus non-clinical), (b) proportion of female in the sample, (c) study design (correlational versus experimental), (d) interval (cross-sectional versus longitudinal studies), (e) author (studies conducted by Riskind versus other authors), and (f) study quality. We did not have specific a priori hypotheses regarding these moderators, except that we expected stronger effect sizes for clinical (versus non-clinical) samples and for samples with higher (versus lower) proportions of females. Past meta-analyses done with cognitive risk factors such as anxiety sensitivity (Olatunji and Wolitzky-Taylor 2009) and self-focused attention (Mor and Winquist 2002) had shown stronger associations between risk and symptoms in clinical and female-dominated samples. Moreover, with higher prevalence of depression (Cyronowski et al. 2000) and anxiety (McLean et al. 2011) among women compared to men, it was reasonable to predict stronger effect sizes among samples with higher proportion of females. As the majority of LCS studies have been conducted by the third author (Riskind), who is also the leading proponent of the looming vulnerability model, we were interested to examine if there would be differences in effect sizes for studies conducted by this author versus other authors. As study quality might potentially affect the magnitude of effect sizes, we included this moderator variable in our analysis.

Multivariate meta-analysis was employed in the current research. Many studies included in the meta-analysis had provided more than one effect size (e.g., correlation coefficients between LCS and social anxiety and between LCS and OC). In this case, conducting separate univariate meta-analyses would not be viable because the relationships between effect sizes are not taken into account. In contrast, multivariate meta-analysis considers the relations among the effect sizes in the estimation procedure (Becker 2000; Jackson et al. 2012, 2010; Kalaian and Raudenbush 1996). As such, the estimated mean effect sizes have generally smaller standard errors and are more precise in multivariate meta-analysis as compared to the results obtained from executing several univariate meta-analyses (Demidenko 2013; Riley 2009). Therefore, multivariate meta-analysis is typically

[1] Although OCD and PTSD are no longer classified under "Anxiety Disorders" in the DSM-5 (a move not accepted by all experts; e.g., Abramowitz 2018), we included studies associated with obsessions-compulsions (OC) for two reasons. First, anxiety remains a significant experience of individuals with OC and DSM-5 recognizes the close links between anxiety and OC-related syndromes. Second, quite a number of studies (see p. 7) had documented the robust relation between LCS and OC and they were done prior to the publication of DSM-5.

[2] Although the LMSQ contains an item that pertains to anxiety/worry, this item should not be including in the computation of the scale score, according to the scoring instruction. Our review of the included studies showed that most of the studies that used the LMSQ had explicitly stated the non-inclusion of this item in scoring the LMSQ. A small number of studies were not explicit on this point, but we assumed that the standard scoring procedure had been adhered to.

Table 1 Studies included in the meta-analysis and their associated characteristics

Study	Year	Sample	*N*	Prop. female	Design	Interval	Publication	Measures	Study Quality	Effect size (*r*)
Ayers	2005	0	169	0.67	Corr	0	D	AMAS, LMS-OA	1.25	Anx = .34
Balaban	2004	0	290	0.62	Corr	0	D	BAI, PSWQ, LMSQ	1.42	Anx = .43 Worry = .47
Bashiri	2017	0	242	0.76	Corr	0	NP	BAI, BDI, LMSQ	–	Dep = .38 Anx = .41
Berger	2013	0	320	0.85	Corr	0	D	TAI-worry, LMSQ	1.33	Worry = -.07
Black	2004	0	224	0.62	Corr	0	D	BAI, BDI, CIDI-social phobia, specific phobias and GAD subscale, LMSQ	1.67	Dep = .30 Anx = .37 SocAnx = .27 Fears = .03 Worry = -.14
Brown and Stopa	2008	0	152	1	Corr	0	J	BDI, BAI, SPS, LMSQ	1.25	Dep = .27 Anx = .29 SocAnx = .38
Calvete et al.	2016	0	640	0.53	Corr	1	J	SAQ-A30, SCL-90-R, LMSQ	1.00	Dep = .30 SocAnx = .46
Chiechi	2005	0	57	0.83	Corr	0	D	TAI-Worry, STAI-T, LMSQ	1.33	Anx = .32 Worry = .37
Clemente et al. (SA1)	2013	1	25	0.68	Corr	0	J	PSWQ, CES-D, IPIP-trait anxiety, LMSQ	1.33	Dep = .69 Anx = .62 Worry = .78
Clemente et al. (SA2)	2013	1	24	0.33	Corr	0	J	PSWQ, CES-D, IPIP-trait anxiety, LMSQ	1.33	Dep = .49 Anx = .73 Worry = .64
Conrad	2009	0	108	0.84	Corr	0	D	TAI-worry, LMSQ	1.42	Worry = .19
Consolla	2006	0	124	0.63	Corr	0	D	AnTI- Type 1 worry subscale, LMSQ	1.25	Worry = .36
Dorfan	2008	0	103	0.6	Corr	0	D	OCI-R, BAT scale-anxiety, WAQ	1.33	Anx = .23 OC = .26
Dorfan and Woody	2006	0	60		Expt	0	J	Self-reported OC distress rating, Looming experimentally induced	1.20	OC = .20
Elwood et al	2011	0	194	0.71	Corr	0	J	PI-WSUR, LMSQ	1.08	OC = .31
González-Díez et al	2015	0	471	0.51	Corr	1	J	SAQ-A30, LMSQ	1.50	SocAnx = .42
González-Díez et al	2014	0	1128	0.56	Corr	0	J	SAQ-A30, SCL-90-R-Depression and Generalised anxiety subscales, LMSQ	1.33	Dep = .26 Anx = .23 SocAnx = .40
González-Díez et al	2016	0	550	0.56	Corr	1	J	SAQ-A30, LMSQ	1.33	SocAnx = .43
Gravel	2009	0	93	0.71	Corr	1	D	TAS, LMSQ	1.17	Anx = .32
Haikal and Hong	2010	0	52	0.92	Expt	0	J	BAI, Looming experimentally induced	1.25	Anx = .53
Hong (SA1)	2013	0	140	0.6	Corr	0	J	BDI, IDAS-depression, social anxiety subscales, BAI, PWSQ, LMSQ	1.42	Dep = .29 Anx = .17 SocAnx = .31 Worry = .31
Hong (SA2)	2013	0	195	0.87	Corr	1	J	BDI, IDAS-depression, social anxiety and subscales, BAI, PWSQ, LMSQ	1.42	Dep = .39 Anx = .31 SocAnx = .33 Worry = .40

Table 1 (continued)

Study	Year	Sample	*N*	Prop. female	Design	Interval	Publication	Measures	Study Quality	Effect size (*r*)
Hughes et al	2008	0	364	0.72	Corr	0	J	BDI, STAI-T, PSWQ, LMSQ	1.17	Dep = .20 Anx = .29 Worry = .41
Kiken and Shook	2012	0	181	0.41	Corr	0	J	BAI, BDI, LMSQ	1.08	Dep = .27 Anx = .20
Kleiman and Riskind	2014	0	304	0.75	Corr	0	J	DASS, LMSQ	1.42	Dep = .18 Anx = .17
Kleiman and Riskind	2012	0	325	0.88	Corr	1	J	DASS, LMSQ	1.25	Dep = .14 Anx = .20
Lauderdale (S1)	2017	0	180	0.58	Corr	0	NP	PSWQ, LMSQ	–	Worry = .50
Lauderdale (S2)	2017	0	244	0.51	Corr	0	NP	PSWQ, LMSQ	–	Worry = .49
Lauderdale (S3)	2017	0	167	0.56	Corr	0	NP	PSWQ, LMSQ	–	Worry = .53
Levin et al	2007	1	105	0.37	Corr	0	J	BAI, BDI, LMSQ	1.42	Dep = .39 Anx = .21
Liu et al	2016	0	281	0.52	Corr	0	J	BAI, LMSQ	1.08	Anx = .26
Long	2005	0	53		Corr	0	D	BDI, BAI, FSS-II, LMSQ	1.08	Dep = .29 Anx = .33 Fears = .45
McDonald	2013	0	124	0.51	Corr	0	D	Self-reported anxiety ratings, LSCS	1.25	Anx = .60
McDonald et al	2010	0	72	0.44	Expt	0	J	VAS-state anxiety, Looming as experimentally induced	1.05	Anx = .30
Palacio-González and Clark	2015	0	183	0.68	Corr	0	J	VASs-fear and anxiety, LMSQ	1.25	Anx = .15 Fears = .10
Reardon and Williams	2007	0	466	0.78	Corr	0	J	OCI-R, SPDQ, BDI, GAD-Q-IV, LMSQ	1.17	Dep = .24 SocAnx = .41 OC = .13 Worry = .36
Reynolds	2011	0	60	0.87	Corr	0	D	BSI-anxiety subscale, LMSQ	1.17	Anx = .25
Riskind and Kleiman	2012	0	249	0.8	Corr	0	J	BAI, LMSQ	0.92	Anx = .26
Riskind and Maddux	1994	0	120	0.58	Corr	0	J	Self-reported fear ratings, HIV Looming Questionnaire	0.83	Fears = .68
Riskind and Maddux	1993	0	50	0.56	Expt	0	J	Self-reported fear ratings, Looming experimentally induced	0.67	Fears = .38
Riskind and Rector	2007	1	36	0.32	Corr	0	J	Y-BOCS, OC Looming vulnerability measure	1.00	OC = .47
Riskind and Wahl (S1)	1992	0	41	0.54	Expt	0	J	Self-reported anxiety ratings, Looming experimentally induced	0.60	Anx = .36
Riskind and Wahl (S2)	1992	0	34	0.59	Expt	0	J	Self-reported anxiety ratings, Looming experimentally induced	0.60	Anx = .27
Riskind and Williams (S1)	2005	0	93	0.6	Corr	0	J	BAI, BDI, FSS, PI, LMSQ	1.08	Dep = .29 Anx = .45 OC = .38 Fears = .40
Riskind and Williams (S2)	2005	1	52	0.71	Corr	0	J	BAI, BDI, PSWQ, LMSQ	1.17	Dep = .44 Anx = .55 Worry = .47

Table 1 (continued)

Study	Year	Sample	*N*	Prop. female	Design	Interval	Publication	Measures	Study Quality	Effect size (*r*)
Riskind et al	2014	0	100	0.72	Corr	0	J	BSI-anxiety and depression subscale, LMSQ	1.25	Dep = .36 Anx = .34
Riskind et al	2013a	0	547	0.61	Corr	0	J	SAQ-A30, SCL-90R-depression, LMSQ	1.17	Dep = .26 SocAnx = .43
Riskind et al	2010	0	72	0.78	Corr	0	J	BAI, BDI, LMSQ	1.00	Dep = .22 Anx = .31
Riskind et al	2007	0	216	0.6	Corr	1	J	BAI, BDI, PI, PSWQ, LMSQ	1.08	Dep = .11 Anx = .23 OC = .30 Worry = .36
Riskind et al. (S1)	2000	0	158	0.56	Corr	0	J	BAI, BDI, LMSQ	0.92	Dep = .24 Anx = .39
Riskind et al. (S2)	2000	0	33	0.55	Corr	1	J	BDI, CCAS, LMSQ-R-Worry subscale, LMSQ	0.58	Dep = .19 Anx = .37 Worry = .73
Riskind et al. (S4)	2000	0	52	0.63	Corr	0	J	BDI, BAI, PSWQ, LMSQ	1.83	Dep = .10 Anx = .40 Worry = .32
Riskind et al.	1997a	0	104	0.61	Corr	0	J	MOCI-Cleaning subscale, LOC-Worry subscale, Looming as LOC	1.00	OC = .50 Worry = .72
Riskind et al.	1995	0	72	0.68	Corr	0	J	Watt and Sharrock Spider Phobia Index, Looming as MSLQ	0.83	Fears = .65
Riskind et al. (S1)	1992	0	77		Corr	0	J	STAI-T, BDI, Watt and Sharrock Spider Phobia Index, Looming as HLQ	1.00	Dep = .06 Anx = .23 Fears = .35
Riskind et al. (S2)	1992	0	84		Corr	0	J	STAI-T, BDI, Watt and Sharrock Spider Phobia Index, Looming as HLQ	1.00	Dep = .37 Anx = .43 Fears = .14
Riskind et al.	1997b	0	81	0.52	Expt	0	J	PI, Looming experimentally induced	0.70	OC = .47
Riskind et al.	2016	0	100	0.57	Corr	0	J	BAI, BDI, LMSQ	1.33	Dep = .42 Anx = .40
Rose	2004	0	207	0.57	Corr	0	D	BDI, BAI, PSWQ, LMSQ	1.25	Dep = .18 Anx = .32 Worry = .37
Schaefer et al.	2012	0	100	0.72	Corr	0	J	STAI-T, BSI-Depression subscale, LMSQ	1.33	Dep = .42 Anx = .52
Scott	2010	0	196	0.82	Corr	0	D	OCI-R, LMSQ	1.25	OC = .30
Sica et al., Riskind et al. (community)	2012/2017	0	429	0.55	Corr	0	J	OCI-R, BDI, BAI, PSWQ, LMSQ	1.33	Dep = .30 Anx = .15 OC = .30 Worry = .34
Sica et al., Riskind et al. (undergraduate)	2012/2017	0	261	0.55	Corr	0	J	OCI-R, BDI, BAI, PSWQ, LMSQ	1.33	Dep = .25 Anx = .21 OC = .22 Worry = .43
Voon and Phillips	2015	0	123	0.71	Corr	0	J	PSWQ, LMSQ	1.08	Worry = .47

Table 1 (continued)

Study	Year	Sample	*N*	Prop. female	Design	Interval	Publication	Measures	Study Quality	Effect size (*r*)
Williams (S2)	2002	0	291	0.71	Corr	0	D	BAI, BDI, LMSQ	1.08	Dep = .14 Anx = .46
Williams (S3)	2002	0	169	0.83	Corr	1	D	BAI, BDI, LMSQ	1.00	Dep = .06 Anx = .37
Williams and Riskind	2004	0	150		Corr	0	J	BAI, BDI, LMSQ	0.92	Dep = .25 Anx = .31
Williams et al.	2005	0	123	0.75	Corr	0	J	BDI, PI, GAD-Q, FSS-II, LMSQ	1.08	Dep = .31 OC = .33 Fears = .40 Worry = .35
Williams et al.	2006	0	256	0.78	Corr	0	J	VOCI, Looming as LODQ	1.17	OC = .63

S1, S2, S3, and S4 refers to Studies 1 to 4, respectively. SA1 and SA2 refers to Samples 1 and 2 of the study, respectively. Sample denotes sample type; *0* non-clinical, *1* clinical, *Prop.female* proportion of female in sample. Design denotes design type; *Corr* correlational, *Expt* experimental. Interval denotes whether it is a cross-sectional or longitudinal study; *0* cross-sectional, *1* longitudinal. Publication denote publication type; *J* published journal articles, *NP* unpublished data, *D* dissertations. Effect size (*r*) denotes the association between looming and specific symptoms (e.g., *Dep* depression, *Anx* nonspecific anxiety, *SocAnx* social anxiety, *OC* obsessions-compulsions, *Fears* specific phobias and fears, *Worry* worry/generalized anxiety disorder). *AMAS* adult manifest anxiety scale. *LMS-OA* Looming maladaptive style older adult version, *BAI* Beck Anxiety Inventory, *PSWQ* Penn State Worry Questionnaire, *BDI* Beck Depression Inventory, *TAI-Worry* Test Anxiety Inventory Worry subscale, *CIDI* Composite International Diagnostic Interview, *SPS* Social Phobia Scale, *SAQ-A30* Social Anxiety Questionnaire for Adults, *SCL-90-R* Symptom Checklist 90 Revised, *STAI-T* State Trait Anxiety Inventory trait subscale, *IPIP-Trait anxiety* International Personality Item Pool trait anxiety subscale, *AnTI-Type 1 worry subscale* Anxious Thoughts Inventory Type 1 worry subscale, *LSCS* Looming Smoking Consequence Scale, *OCI-R* Obsessive Compulsive Inventory Revised. *BAT scale-anxiety* Behavioral Approach Task anxiety subscale, *WAQ* Washroom Appraisal Questionnaire-Looming Germ spread subscale, *PI-WSUR* Padua Inventory-Washington State University Revision, *TAS* Test Anxiety Scale, *IDAS* Inventory of Depression and Anxiety Scale, *DASS* Depression Anxiety and Stress Scale, *FSS-II* Fear Survey Schedule II, *VAS* Visual Analogue Scale, *SPDQ* Social Phobia Diagnostic Questionnaire, *GAD-Q-IV* Generalized Anxiety Disorder Questionnaire IV, *BSI* Brief Symptom Inventory, *Y-BOCS* Yale-Brown Obsessive Compulsive Scale, *CCAS* Costello Comrey Anxiety Scale, *MOCI* Maudsley Obsessive Compulsive Inventory, *LOC* Looming of Contamination Scale, *MSLQ* Modified Spider Looming Questionnaire, *HLQ* Harm Looming Questionnaire, *GAD-Q* Generalized Anxiety Disorder Questionnaire, *VOCI* Vancouver Obsessive Compulsive Inventory, *LODQ* Looming of Disgust Questionnaire

recommended over conducting multiple univariate meta-analyses, as traditionally has been done (Jackson et al. 2011).

Although a previous meta-analysis on a similar topic was recently published (Hong et al. 2017), the current study differed from the former in important ways. The main purpose of the Hong et al. (2017) paper was to examine the measurement invariance of the LSMQ across ten cultures and gender, with a secondary aim of conducting a "within-study" meta-analysis to estimate the relations between the LMSQ subscales and anxiety/depression. In contrast, the current meta-analysis employed a comprehensive and systematic search strategy to ensure relevant LCS studies had been identified, including studies that had operationalized the "looming" construct in experimental settings. This meta-analysis expanded on LCS's associations with various anxiety subtypes compared to the Hong et al.'s restriction on nonspecific anxiety only.

Method

Literature Search

The search strategy employed was a combination of two types of terms—the first term being the concept of looming (e.g., *looming maladaptive style*, *looming cognitive style*) and the second term being the subtypes and symptoms of anxiety and depression (e.g., *anxiety, social anxiety, generalized anxiety disorder, obsessions-compulsions, fears, phobias, worry, depression*). Common alternate spellings (e.g., generalized anxiety) as well as wildcard characters (e.g., depress*) were used to ensure that no studies were missed out. This search strategy was uniformly applied to all the targeted databases explored in this study. The PRISMA reporting framework for meta-analysis was closely followed throughout this paper (Liberati et al. 2009).

Information Sources

The first process of obtaining the relevant articles was to search online research databases such as PsycINFO, PubMed, and Scopus. This began in January 2017 and the last search was conducted in December 2018. As the concept of the LCS is relatively new (formally introduced in the year 2000), no restriction of date was employed so as to obtain the maximum number of relevant articles. An additional search was done on the Proquest Theses and Dissertations database.

Aside from searching electronic databases, the third author (Riskind) provided additional articles that were not found during the initial search on the research databases. Finally, emails were sent to researchers that have published at least one study on the construct of looming, requesting for any unpublished datasets or manuscripts that investigated the relationship between the LCS and psychological symptoms.

Study Selection

Once the initial pool of potential articles had been identified, a two-step screening procedure was then carried out to finalize the articles to be included. The purpose of this two-step screening procedure was to boost the efficiency of screening a high number of articles without the risk of ruling out any potential studies of high methodological rigor. During the first step, abstracts of all the identified articles were screened for their relevance. Articles with abstracts that contained key words such as "*looming cognitive style*", and "*looming maladaptive style*" were retained for the next screening step automatically. For those abstracts that did not contain key words, to be deemed as acceptable, they had to contain relevant constructs that were pertinent to looming, such as any mentioning of danger or threat that is perceived as increasing in intensity or moving forward and closer in proximity as time lapses (e.g., Dorfan and Woody 2006; Haikal and Hong 2010).

In the second step of the screening procedure, articles were then fully scrutinized thoroughly. Four exclusion criteria were applied at this stage and the remaining pool of articles after this step were included in the meta-analysis. All of the data were coded by the first author. To establish inter-rater agreement, a subset of 18 studies (30% of the total included studies) were randomly selected and compared to the coding done by a trained research assistant. Cohen's κ for categorical variables (e.g., sample type, study design type) ranged between .90 and 1.0 while the intraclass correlation coefficient (ICC) for continuous variables (e.g., sample sizes, proportion of female in sample, effect sizes) ranged between .98 and 1.0. Disagreements were resolved through discussion.

Eligibility Criteria

Study Types

No restrictions were imposed on the type of studies to be eligible. The concept of the LCS is relatively new, and so this meta-analysis aims to identify any systematic patterns relating to the LCS. Moderation analyses were instead conducted to determine how differences in study designs affected the strength of the relation between LCS and the anxiety subtypes and depression.

Participants

No restrictions were imposed based on the characteristics of the participant samples. Similar to the previous

point, the variations in the characteristics of participants are modelled in the moderation analyses. This was to determine whether sample type (clinical vs. non-clinical samples) and sample characteristics (proportion of female) affected the relation between LCS and the anxiety subtypes and depression.

Outcomes and Measures

Studies to be included contained both measures of the LCS and at least one anxiety subtype (or depression). The measures used to quantify looming and clinical symptoms should be appropriate and psychometrically validated. As some articles did not utilize the LMSQ as a measure of looming, other variants of the LMSQ were also acceptable (e.g., Looming of Contamination Scale). For some experimental studies that did not use LMSQ but operationalized the concept of looming as a form of an experimental induction procedure, these articles were included only if they contained the core essence of the LCS. For example, participants were exposed to guided imagery manipulations (e.g., imagining oneself being carried along faster and faster on a conveyor belt leading to a negative consequence; McDonald et al. 2010) or being asked to prepare for an impromptu speech while being shown a timer indicating time running out (Haikal and Hong 2010). Experimental studies were an important complement to the majority of correlational studies in estimating the strength of the association between looming and symptoms.

Additional Exclusion Criteria

The first exclusion criterion was the absence of empirical data. The second exclusion criterion specified that articles were excluded if they did not report sufficient statistical information to calculate the necessary effect size and its associated variance. The effect size metric used in this meta-analysis was the Pearson correlation coefficient (r). If studies did not report this effect size directly, they had to have the required statistics to calculate it indirectly (for example, using means and standard deviation to calculate the Cohen's d, which was then converted to the Pearson r). An additional attempt was made by sending emails to authors of the articles that did not report sufficient statistics for effect size calculation and requesting for the necessary inputs. Twelve emails were sent out but only three researchers responded and provided the necessary information. Lastly, as one of the key assumptions of meta-analysis is the independence of effect sizes between studies, articles were excluded if they were non-independent. In other words, for studies that used the same or overlapping samples, only the study with the larger sample size would be retained in the meta-analysis.

Data Items

Upon finalizing the set of studies to be included in the meta-analysis, the following essential information from each article were coded. First, the Pearson correlation coefficient between looming and a symptom measure was coded. It should be noted that more than one effect size could be extracted from a single study as the methodology of multivariate meta-analysis permits such a procedure. In the current study, the constructs of worry and GAD were assumed to be equivalent as there were only three studies that measured GAD. Having many outcomes consisting of small number of studies can make it difficult to obtain reliable parameter estimates in the meta-analysis. As worry is a central defining feature of GAD, effect sizes coded for either of GAD or worry was categorized under a single symptom outcome of "worry/GAD".

Second, the sample size of each study was extracted and was used for the calculation of the variance of the effect sizes, which then represented the weight assigned to each study. Third, the inter-correlation among symptom measures (e.g., correlation between depression and social anxiety) were coded for the calculation of the dependency of effect sizes in the context of multivariate meta-analysis. Multivariate meta-analysis (Gasparini et al. 2012; Jackson et al. 2010) is able to handle multiple effect sizes contributed from each of the studies by taking into consideration the relationship amongst effect sizes. Hence, the additional element required for multivariate meta-analysis is the conditional sampling covariances between effect sizes, that is required to be known, and the calculation of this covariances utilizes the inter-correlation among symptom measures.

Summary Measures

The correlation coefficient (r) extracted from individual studies was converted to the Fisher's Z as the effect size input for the meta-analysis (Hedges and Olkin 1985). The sample size for each study was used to calculate the variance of Z. The mean effect size and its 95% confidence interval were converted back to r at the end for the purpose of interpretation. Therefore, r is the primary measure of association between the LCS and the different anxiety subtypes and depression in this meta-analysis. For a subset of studies that did not report r directly, several alternative methods were used to convert the effect size to r (see Appendix B in the Online Supplementary Materials; OSM).

Synthesis of Results

Both random-effects and mixed-effects models were utilized to address the research objectives. A random-effects model allows the estimation of the summary weighted effect sizes

of looming and the symptoms measures, and the determination of the heterogeneity of effect sizes without any moderator included. On the other hand, a mixed-effects model allows the inclusion of moderator variables that provides finer analyses by examining how study and sample characteristics affect the strength and variability of the effect sizes. All the parameter estimates were obtained using maximum likelihood (ML) estimation. All studies contributed only a subset of the six effect sizes in question (i.e., not all studies reported the relation between looming and all the six symptoms). Due to the relatively large number of missing data, a modified procedure was used in to estimate the between-study variance component, T^2 (see Appendix C in OSM).

Both the *metaSEM* (Cheung 2015a) *and mvmeta* (Gasparrini et al. 2012) package in R (R Development Core Team 2013) was used to conduct all the analyses. The summary effect size for each of the symptom outcomes, the heterogeneity of effect sizes between studies, and the slope parameters for the moderator analyses were estimated using ML.

Risk of Bias Across Studies: Publication Bias

Three diagnostic procedures were conducted to elucidate various issues pertaining to publication bias. They were (a) funnel plots, (b) Orwin's fail-safe *N* (Orwin 1983), and (c) *p*-curve analysis (Simmons and Simonsohn 2017; Simonsohn et al. 2014). Details of these analyses are presented in the OSM (see Appendix D and Fig. S1).

Risk of Bias Within Studies: Quality Assessment

We assessed individual study quality by adapting a 12-item and a 21-item checklist to assess study quality of correlational and experimental studies, respectively (Moncrieff et al. 2001). Details about study quality assessment are presented in Appendix E of the OSM.

Results

Study Selection

A total 224 articles were retrieved from electronic databases (see Fig. 1 for the PRISMA flowchart). Twenty-two articles were provided by the third author that consisted of unpublished data from himself and those of other researchers. Additionally, nine manuscripts were obtained after asking other authors for unpublished data. After taking into account duplicates among the sources, we arrived at 169 potential articles that could be included in the meta-analysis. After screening of the abstracts, 98 articles were retained for the subsequent screening stage. Seventeen and six articles were excluded due to absence of empirical data and the lack of appropriate measures in the article, respectively. Four articles were excluded because they were non-independent and one was removed because only PTSD symptoms were reported. Finally, nine articles were excluded as they did not report sufficient statistical information.

Therefore, the finalized number of articles that were included is 61, with a total of 69 studies (some articles contained more than one study), that examine the relations between LCS and the following symptoms: (nonspecific) anxiety, social anxiety, OC, fears, worry/GAD, and depression. Characteristics of the included studies are presented in Table 1.

Risk of Bias Across Studies: Publication Bias

Based on the analyses on publication bias (see Table 2), it was concluded that publication bias (a) were unlikely to skew the current effect sizes and (b) did not affect the evidential value of the studies used in the present multivariate meta-analysis.

Risk of Bias Within Studies: Quality Assessment

The mean average study quality rating of the included studies was 1.14 ($SD = .23$; range 0 to 2), suggesting moderate quality across studies. There were 11 and eight studies that received an average rating of less than 1 and more than 1.40, respectively. Studies of lower quality are primarily penalized for small sample size, and the non-specification of inclusion and exclusion criteria. Study quality was used as a potential moderator.

Synthesis of Results: Main Analyses

Cheung (2015b) recommended that all the effect sizes be simultaneously tested when multiple dependent outcome variables are present. Thus, a model was fitted by constraining the six mean effect sizes at zero, and this model was fully nested under the original model without any constraints of the effect sizes. By comparison of the two models, the likelihood ratio statistic was $\Delta\chi^2(df = 6) = 283.25$, $p < 0.001$. Therefore, the null hypothesis that all the six effect sizes are zero was rejected. This multivariate test ensured that the overall Type I error was kept to a minimum when testing the mean effect sizes as a whole. Because the overall multivariate test was significant, the six individual mean effect sizes were then tested.

The results of the main analysis are summarized in Table 2 (see Fig. S2 for forest plots). We tested the mean effect sizes by conducting separate univariate meta-analyses and found that the results were similar to that of the multivariate approach. Therefore, we proceeded to report and interpret the results under the multivariate framework. As

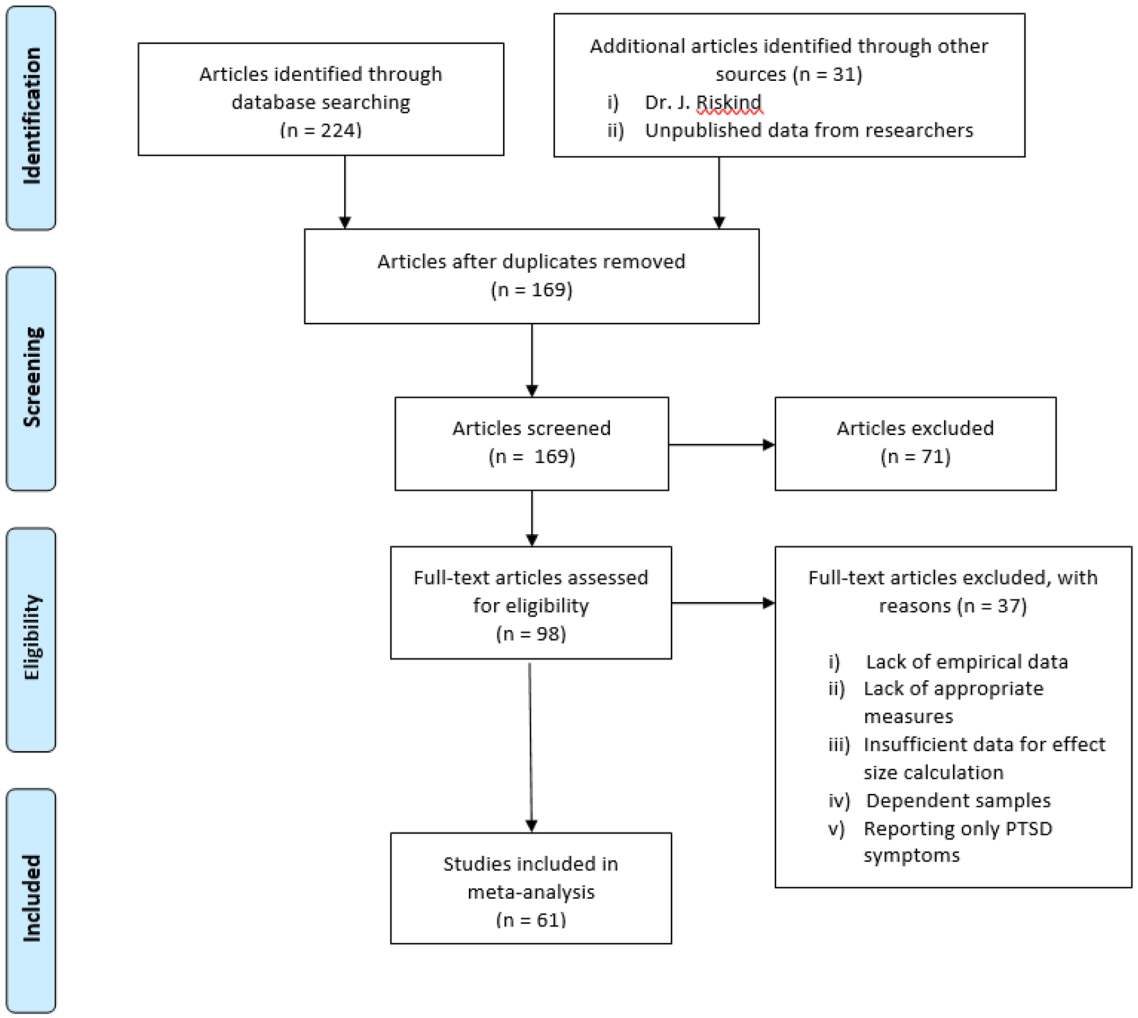

Fig. 1 PRISMA flowchart of the article screening process

Table 2 Results of main analysis and publication bias analyses

Main analysis							Publication bias analysis			
Symptom	*k*	*N*	*r*	95% CI	τ^2	I^2	*FSN*	Z_{half}	Z_{full}	Z_{flat}
Nonspecific anxiety	46	7914	.32*	.29–.36	.008	.59	120	− 18.19*	− 17.92*	12.15
Social anxiety	10	4513	.41*	.35− .46	.000	.00	31	− 18.63*	− 19.05*	14.42
OC	14	2618	.35*	.27− .42	.020	.79	38	− 11.18*	− 12.08*	8.58
Fears	10	1079	.37*	.23− .50	.052	.86	30	− 10.17*	− 10.69*	7.98
Worry/GAD	25	4528	.39*	.32− .46	.040	.88	90	− 21.91*	− 21.38*	16.20
Depression	36	7882	.27*	.23− .30	.004	.47	70	− 14.84*	− 16.49*	11.46

k number of studies, *N* total number of participants, *r* mean effect size in Pearson correlation coefficient, 95% *CI* = 95% confidence interval of the mean effect size, τ^2 true between-studies variability, I^2 I^2 statistic that is the ratio of true heterogeneity to total variance observed, *FSN* Orwin's fail-safe *N*, Z_{half} *Z* statistic for the right skewness of the half *p*-curve, Z_{full} *Z* statistic for the right skewness of the full *p*-curve, Z_{flat} *Z* statistic for the test of whether the observed full *p*-curve is significantly flatter than that of a 33%-power *p*-curve, *OC* obsessions-compulsions, *GAD* generalized anxiety disorder

*$p < .001$

Table 3 Differences in meta-analytic estimates between the effect size of depression and anxiety subtypes

Anxiety subtypes	Effect size as independent				Effect size as dependent			
	$Q_{Residual}$ (*df*)	*b*	*SE*	*Z*	$Q_{Residual}$ (*df*)	*b*	*SE*	*Z*
Nonspecific anxiety	103.22** (48)	.09	.03	2.97**	189.07** (80)	.06	.03	2.21*
Social anxiety	70.96** (36)	.16	.03	5.02**	78.32** (44)	.16	.03	5.95**
OC	145.53** (42)	.08	.04	1.75	152.31** (48)	.08	.04	2.02*
Fears	139.73** (38)	.10	.06	1.78	145.11** (44)	.10	.05	1.86
Worry/GAD	180.75** (44)	.17	.05	3.69**	270.11** (59)	.14	.04	3.15**

$Q_{Residual}$ Cochran *Q* test for residual heterogeneity, *b* slope estimate, *SE* standard error of slope estimate, *Z* *Z* statistic for the significance of slope estimate, *OC* obsessions-compulsions, *GAD* generalized anxiety disorder

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

mentioned previously, Fisher's *Z* instead of Pearson's *r* was utilized during the analyses, but once that was completed, the metric of the mean effect sizes and its confidence intervals were converted back to Pearson's *r* in Table 2 to facilitate interpretation. The mean effect sizes ranged from .27 (depression) to .41 (social anxiety), typically considered to be of moderate magnitude (Cohen 1992).

The multivariate homogeneity test (Jackson et al. 2012) for all the 141 individual effect sizes across the six symptom measures was significant, $Q(135) = 610.98$, $p < .001$, indicating the existence of heterogeneity between studies. The multivariate I^2 in the current meta-analysis is .78. However, when heterogeneity varies across different mean effect sizes, it is unclear as to how useful a single index can summarize the heterogeneity between studies. For example, some mean effect sizes have more heterogeneity compared to others. Cheung (2015b) recommended that the I^2 be calculated for all outcomes as this will provide greater understanding to the heterogeneity of the different effect sizes. The individual I^2 for the respective six individual mean effect sizes are presented in Table 2. From the estimated values of I^2, the degree of heterogeneity on the population effect sizes between studies ranged from moderate ($I^2 = .47$ for depression) to high ($I^2 = .88$ for worry) with the exception of the I^2 relating to the outcome of social anxiety which was very small and thus truncated at zero. Furthermore, the estimated variance component of the six effects presented in Table 2 indicated the largest variability in effect sizes for fears ($\tau^2 = .052$) and worry/GAD ($\tau^2 = .040$).

We next evaluated the differences in the magnitude of looming and symptoms, comparing in particular the differences between various anxiety subtypes and depression. As many studies yielded more than one effect size (i.e., correlations of looming with different symptoms), the comparisons were thus complicated by the independence assumption in meta-analysis. Following previous research (e.g., Gentes and Ruscio 2011), two sets of analyses were conducted—one based on independent samples and the other based on dependent samples—to examine if effect sizes associated with anxiety were significantly stronger than the effect size for depression (mean $r = .27$). In the independent samples approach, only one effect size was randomly selected and used in the analysis when several effect sizes were available. In the dependent samples approach, each study contributed multiple effect sizes associated with the various symptoms.

The results of the comparisons are presented in Table 3. In comparing the mean loom-anxiety effect size (mean $r = .32$) and the mean loom-depression effect size (mean $r = .27$), the *Z* statistics for both the independent and dependent samples approaches were significant. This indicated a significant difference between the loom-anxiety and loom-depression correlations. Significant differences could be seen for the effect sizes associated with social anxiety and worry/GAD, relative to depression. For OC, only the dependent samples procedure yielded a significant difference. Nonetheless, the *p*-values of the nonsignificant *Z* statistics (e.g., for fears) were all less than .08, indicating a trend toward significance. The differences in effect sizes among all anxiety subtypes were also evaluated (see OSM Appendix F and Table S1 for details). Other than a significant difference between the effect sizes (independent samples) for social anxiety and OC, all pairwise comparisons of the anxiety subtypes yielded nonsignificant differences. We concluded that the magnitude of associations was largely similar across the various anxiety subtypes.

Additional Analyses: Moderator Analyses

Because multivariate heterogeneity of effect sizes was evident, mixed-effects models with the included moderators were conducted to determine whether such heterogeneity can be explained by the selected moderators. The corresponding estimates for slopes, standard errors, and the $Q_{Residual}$ statistics are presented in Table 4. As seen, with the exception of nonspecific anxiety, not all symptom outcomes are represented in the analyses due to the lack of studies. For example, in examining the moderating role of sample type (i.e., non-clinical versus clinical samples), the lack of

Table 4 Moderator analyses

Predictor	$Q_{Residual}$	Symptom	*K*	*b*	SE	*Z*
Sample type	503.38**	Nonspecific anxiety	46 (nc = 42, c = 4)	.19	.09	2.06*
	(*df* = 113)	OC	14 (nc = 13, c = 1)	.16	.23	0.69
		Worry/GAD	25 (nc = 22, c = 1)	.22	.16	1.39
		Depression	36 (nc = 32, c = 4)	.23	.08	2.90**
Proportion female	558.30**	Nonspecific anxiety	42	− .04	.14	− 0.30
	(*df* = 117)	Social anxiety	10	− .21	.12	− 1.71
		OC	13	− .12	.38	− 0.32
		Fears	7	− .55	1.62	− 0.34
		Worry/GAD	25	− .66	.34	− 1.93
		Depression	32	− .15	.12	− 1.25
Design	287.52**	Nonspecific anxiety	46 (co = 42, e = 4)	.04	.07	0.50
	(*df* = 64)	OC	14 (co = 12, e = 2)	.01	.14	0.05
		Fears	10 (co = 9, e = 1)	.01	.26	− 0.03
Interval	511.08**	Nonspecific anxiety	46 (cr = 40, l = 6)	− .04	.05	− 1.43
	(*df* = 113)	OC	14 (cr = 13, l = 1)	− .02	.16	− 0.10
		Worry/GAD	25 (cr = 22, l = 2)	.11	.21	0.76
		Depression	36 (cr = 30, l = 6)	− .06	.14	− 1.43
Author	566.72**	Nonspecific anxiety	46 (r = 21, nr = 25)	− .01	.04	− 0.13
	(*df* = 129)	Social anxiety	10 (r = 5, nr = 5)	.07	.04	1.86
		OC	14 (r = 10, nr = 4)	.10	.10	1.07
		Fears	10 (r = 6, nr = 4)	.23	.14	1.59
		Worry/GAD	25 (r = 8, nr = 17)	.12	.09	1.32
		Depression	36 (r = 21, nr = 15)	− .02	.03	− 0.90
Study Quality	454.41**	Nonspecific anxiety	45	− .06	.08	− .67
	(*df* = 124)	Social anxiety	10	− .22	.09	− 2.61**
		OC	14	− .41	.26	− 1.60
		Fears	10	− .61	.21	− 2.89**
		Worry/GAD	22	− .65	.19	− 3.43**
		Depression	35	.21	.08	2.57*

$Q_{Residual}$ Cochran *Q* test for residual heterogeneity, *b* slope estimate, *SE* standard error of slope estimate, *Z* *Z* statistic for the significance of slope estimate, *k* number of studies, *OC* obsessions-compulsions, *GAD* generalized anxiety disorder, *nc* non-clinical, *c* clinical, *co* correlational, *e* experimental, *cr* cross-sectional, *l* longitudinal, *r* Riskind, *nr* non-Riskind

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

clinical samples in the outcomes of social anxiety and fear precluded the moderation analysis. In addition, interpretation of estimates should be done with caution for social anxiety, OC, and fears because of the small number of studies available. Finally, for all moderator variables, the $Q_{Residual}$ statistics remained significant. This suggested substantial variability in the effect sizes after taking into consideration the moderator variables. We describe the findings of the individual moderator variable in greater detail in the following paragraphs.

Sample Type

This analysis investigated the effects of sample type (i.e., non-clinical versus clinical samples) in explaining the variation in effect sizes. Dummy coding was applied where non-clinical samples were coded as "0" and clinical samples as "1". There were 59 non-clinical and five clinical samples in total. The non-clinical samples comprised primarily undergraduate students, although there were some community samples (McDonald et al. 2010; Sica et al. 2012; Riskind et al. 2017b). The majority of the samples (74%) in the current meta-analysis were from North America. The slopes that emerged as significant were for depression ($b = .23$, $SE = .079$, $p < .01$) and anxiety ($b = .19$, $SE = .091$, $p < .05$). Because both of the estimated slopes were positive, the results suggested that clinical samples yielded significantly stronger associations between looming and the outcomes of depression and anxiety. Although sample type explained 19.9% and 7.1% of the between-studies variability for depression and anxiety, a significant amount of unexplained variance remained.

Proportion of Females

Five studies did not report the percentage of females in the sample. The percentage of females across studies ranged from 32% to 100%, with a mean of 65% and a median of 62%. From the inspection of the estimates of the slope parameters, the associations between percentage of females and the outcomes were all not significant.

Design

There were only seven experimental studies and the remaining 62 studies were correlational in design. Analyses were conducted on the effect sizes of anxiety, OC, and fears as most experimental studies measured these symptom outcomes. None of the analyses were significant, implying that there was no significant difference in effect size strength between experimental and correlation designs.

Interval

This binary moderator variable compares the effect sizes in cross-sectional and longitudinal studies. There were nine longitudinal samples with measurement interval ranging between one week to one year, and the remaining 60 samples had measurements that were assessed concurrently. Results indicated that all the slopes were nonsignificant.

Author

An authorship variable captured any study that listed J. H. Riskind as the author or co-author. Such studies were given a value of "1" ($k = 36$), whereas other studies not co-authored by him were given a value of "0" ($k = 33$). Results indicated that all the slopes were nonsignificant.

Study Quality

Study quality ratings were used as a continuous moderating variable. The slopes that emerged as significant were for depression ($b = .21$, $SE = .08$, $p < .05$), social anxiety ($b = -.22$, $SE = .09$, $p < .01$), fears ($b = -.61$, $SE = .21$, $p < .01$), and worry/GAD ($b = -.65$, $SE = .19$, $p < .01$). For depression, the positive slope suggested that higher study quality was associated with stronger effect sizes. For the other significant anxiety subtypes, the slopes were negative, indicating that higher study quality was associated with weaker effect sizes. Although study quality explained 25.9%, 10%, 31.1%, and 23.0% of the between-studies variability for depression, social anxiety, fears, and worry/GAD, respectively, a significant amount of unexplained variance remained.

Combining Symptoms

A number of the abovementioned moderator analyses could be argued to be underpowered due to the small number of available studies for certain symptom outcomes (e.g., moderation of sample type for OC where only one clinical sample was available). We conducted additional moderation analyses by combining across anxiety subtypes and all symptoms to increase statistical power (see OSM Appendix G and Table S2). These results mirrored those presented in Table 4.

Discussion

Summary of Evidence

The present meta-analytic study supported crucial tenets underlying the looming vulnerability model: that LCS is an overarching transdiagnostic vulnerability factor in anxiety and various anxiety subtypes, and that LCS is less strongly related to depression. A key feature in the present study was that we used multivariate meta-analysis which considered the dependence of multiple effect sizes provided by studies and analyzed all effect sizes simultaneously while ensuring precision in the parameter estimates. Consistent with expectations of the looming model of anxiety, robust associations were found between LCS and anxiety. The five mean effect sizes related to the anxiety subtypes differed significantly from zero, with moderately strong effect size magnitude (mean *r*s between .32 and .41). Evidential value of these findings was confirmed by publication bias analyses (i.e., funnel plots, Orwin's fail-safe *N*, and *p*-curve analysis). As expected, the results also produced new evidence that LCS was more closely related to anxiety than depression. Specifically, the results confirmed that LCS had significantly stronger links with several anxiety symptoms (i.e., anxiety, social anxiety, and worry/GAD) than with depression ($r = .27$). The difference between OC and depression was significant only for the dependent effect sizes procedure and the difference between fears and depression verged on significance (*p*s < .08).[3]

[3] We speculated that the nonsignificant difference between the effect sizes for depression versus (a) OC (independent samples only) and (b) fears (see Table 3) was partly due to low statistical power (i.e., few number of studies available). For social anxiety, which showed a significant difference in effect size magnitude compared to depression, the number of available studies was also low. However, the strong mean effect size for social anxiety could be attributable to the observation that half of the LSMQ vignettes depict social threats (e.g., an impending breakup of a romantic relationship).

Theoretical Implications

The current results are consistent with the proposition that the LCS is an overarching vulnerability to the psychopathology of anxiety. The majority of the studies included in this meta-analysis had used correlational designs, thus they do not directly examine the postulate that LCS is a vulnerability factor that have causal influence on symptoms. However, it is noteworthy that irrespective of whether the effects sizes were from experimental lab-based studies that manipulated looming or from correlational studies, they were similar in magnitude for nonspecific anxiety (.33 versus .37), OC (.36 versus .37) and fears (.39 versus .40). More support for the idea that LCS may be construed as a cognitive vulnerability comes from longitudinal studies demonstrating that LCS predicts residualized changes in anxiety symptoms over time (Adler and Strunk 2010; González-Díez et al. 2015, 2016; Kleiman and Riskind 2012; Riskind et al. 2000, 2007; Sica et al. 2012).

The current meta-analytic findings support the notion that threat appraisal with dynamic properties appears to be a key mechanism underpinning the experience of anxiety. This is consistent with the expanding body of research showing the broad effects of LCS and the dynamic experience of threat to the phenomenology of anxiety in general (Reardon and Williams 2007; Riskind and Calvete 2019; Riskind and Rector 2018; Riskind et al. 2007; Williams et al. 2005). Studies have also shown that LCS predicts additional variance of anxiety symptoms above and beyond the effects of static and global threat cognitions, such as judgements of probability, lack of control and unpredictability (Elwood et al. 2011; Riskind et al. 2000, 2011; Riskind and Rector 2007). Similarly, LCS predicts anxiety above and beyond the effects of other cognitive vulnerability variables such as anxiety sensitivity (Elwood et al. 2011; Reardon and Williams 2007) and intolerance of uncertainty (Riskind et al. 2007). These other cognitive models do not consider the dynamicity of threat properties (e.g., velocity and/or rate of change), but focus on static perceptions of threat (e.g., estimated unchanging probability of threat occurring). Overall, the observation that LCS is substantively associated with various anxiety subtypes support the looming vulnerability model in its emphasis on the dynamic features of threat appraisal in the etiology of anxiety.

Despite the fact that the LCS was generally more strongly linked to anxiety and its subtypes than to depression, mean effect size for depression was found to be statistically significant different from zero. As such, a sense of looming vulnerability could also plausibly be a cognitive marker for depression (although to a lesser degree) and may even contribute to depression under certain conditions, such as when individuals become hopeless because they perceive themselves as helpless to evade future threat of harm (Riskind et al. 2013b). For example, a significant relationship between LCS and depression was observed in a sample of patients suffering from terminal leukemia (Levin et al. 2007). Another finding that supports this idea is that Kleiman and Riskind (2012) demonstrated the combined effects of co-occurring LCS and depressive cognitive style (which creates a sense of helplessness/hopelessness) on depression. They found that individuals high on LCS and depressive cognitive style experienced increases in depression over a 6-week period. Furthermore, LCS might have secondary links to depression among individuals with comorbid anxiety, as severity of symptoms are heightened when both depression and anxiety are present (Kessler et al. 2005).

We should also note that the current mean effect sizes might seem somewhat lower than those reported for other cognitive vulnerability factors. For instance, the summary effect sizes for the associations between anxiety sensitivity and anxious/depression symptoms ranged between .32 and .52, with an approximate average of .45 (Naragon-Gainey 2010). For intolerance to uncertainty, the effects sizes with symptoms ranged between .50 and .57 (Gentes and Ruscio 2011). Common method variance and item content may provide possible explanations for the stronger effect sizes for these two vulnerability factors. Self-report measures for those factors use a declarative statement format similar to those used to measure symptoms, hence potentially inflating their associations. At the same time, items from both vulnerability and symptom measures have overlapping content, inflating their associations. For example, items from the Anxiety Sensitivity Index-3 (Taylor et al. 2007), such as "I worry that other people will notice my anxiety" includes words like worry and anxiety, which are also assessed in panic symptom measures with declarative statements. To the contrary, the LMSQ is a vignette-based assessment tool that requires participants to imagine and simulate the approach of imagined threats in terms of the rapid escalations in their probabilities and proximities.[4] This difference in response format, along with non-overlapping item content, from symptom measures might have reduced the effects of a common (albeit still self-report) method. A second explanation is that multivariate meta-analyses, which typically yield more precise estimates, may arguably have yielded effect sizes

[4] With regard to the vignette-based assessment of the LMSQ, we acknowledge that there are conflicting accounts on the role of visualization on anxiety. The avoidance theory of worry (Borkovec et al. 2004) suggests that worry is linked to reduced concreteness in visualization (McGowan et al. 2017). However, there is evidence suggesting that, compared to healthy counterparts, individuals with anxiety symptoms/disorders more readily visualize vivid negative images (e.g., Hirsch and Holmes 2007; Moscovitch et al. 2011). The LMSQ vignettes might tap into more imagery-based representation of impending threats compared to a statement-based questionnaire. LCS could also predict worry if it is an attempt to reduce visualization.

comparable to LCS had they been used for these other vulnerability factors. Hence, the smaller effect sizes seen in our meta-analysis might arguably reflect more accurate depictions of the vulnerability-symptom associations.

Moderators of Effect Sizes

Findings from the moderator analyses suggest that the relations between LCS and symptoms of depression and anxiety were stronger in clinical than in non-clinical samples. One possible reason for the disparity could be that clinically impaired individuals are more likely to possess patterns of additional cognitive vulnerabilities in addition to LCS (e.g., anxiety sensitivity, negative cognitive style) and past research indicates that these vulnerabilities may synergistically combine with LCS to exacerbate symptoms (Kleiman and Riskind 2012, 2014; Riskind et al. 2010, 2013b). In addition, replicating Hong et al. (2017), gender does not moderate the strength of association between LCS and symptoms. Still, it is noteworthy that women may possess higher levels of LCS than men (González-Díez et al. 2015; Hong et al. 2017; Riskind et al. 2017b), which may help to partly explain a portion of the gender differences that are found in the anxiety disorders (Steel et al. 2014).

Study quality moderated the effect sizes for certain symptoms. For depression, higher study quality was associated with stronger associations with LCS. For social anxiety, fears, and worry/GAD, higher study quality was associated with weaker effect sizes. Close inspection of the studies suggested that studies rated as lower on quality tended to have small sample sizes. We speculate that effect sizes associated with these anxiety subtypes might be inflated due to sampling error based on small sample sizes, especially when the number of available studies are not large (i.e., for social anxiety and fears). We recommend that future research should strive for large sample sizes so as to yield precise estimates. One implication is that future meta-analysis might yield effect size estimates lower than those reported here for social anxiety, fears, and worry/GAD when study quality improves. The issue of LCS's specificity to anxiety subtypes relative to depression would need to be reexamined.

It is somewhat surprising that the moderator analyses do not account much for the variability seen in the effect sizes. As we elaborate in the limitation section, the dearth of studies which used longitudinal designs, experiments, and clinical samples studies could have affected the ability of the moderator analyses to yield meaningful findings. Other moderators not investigated in this study that might potentially affect the effect sizes could be age, culture, imaginative propensity, presence of comorbidity among disorders, and differences in the measures. For instance, Hong et al. (2017) found that older community participants exhibited a stronger association between social looming and depression compared to younger student participants. In addition, as alluded two paragraphs above, other cognitive vulnerabilities may interact with LCS to influence the strength of its association with symptom. Future research will be necessary to clarify these other moderation effects.

Clinical Implications

With regard to clinical implications of this study, Riskind and Rector (2018; see also Riskind et al. 2012) have suggested ways that the looming vulnerability model can be integrated into cognitive-behavioral treatment protocols. To give one example, Dorfan and Woody (2006) tested the looming vulnerability model by placing drops of sterilized urine on the arms of college student participants who were assigned to one of three mental imagery conditions. In one of their conditions, the participants were instructed to visualize germs as moving and spreading (moving around on their bodies), while in two other conditions they were instructed to imagine the germs as static (i.e., they visualized urine of drops as motionless on the original site of contamination), or as safe (i.e., it contains no harmful germs). The use of moving imagery prevented habituation and sensitized distress during a 30-min exposure, whereas the static and safety imagery reduced distress. Thus, these results suggest that the use of mental imagery to reduce the experience of rapid gains in threat may enhance or augment exposure interventions (see also, Riskind et al. 1997b). As another example, Davis et al. (2011) showed that teaching individuals to use their imagination to move negative stimuli (e.g., images of corpses) further away led to reduced negative emotional reactions. Riskind and Rector (2018) also provide evidence for a set of other characteristic cognitive distortions that may heighten looming vulnerability and anxiety (e.g., time dilation and space compression).

Speculatively, there is also an intriguing possibility that changes in LCS may represent an actual mediator of therapeutic change or at least serve as a useful cognitive marker of therapeutic change. Katz et al. (2017) found that LCS scores in anxiety disorder patients were reduced by a standard 12-week cognitive-behavioral therapy program. Moreover, changes in LCS predicted end-treatment anxiety when controlling for pre-treatment anxiety. Future research would be needed to pursue these possibilities.

Limitations and Future Directions

One limitation of the current meta-analysis is that only ten studies were available for social anxiety and fears. Having a small number of studies can result in poor estimates of the between-study variance (τ^2) and can also affect the estimate of the mean effect sizes and its associated confidence intervals (Borenstein et al. 2009). Although the present effect

sizes for social anxiety and fears appeared to be robust and have evidential value, more studies are needed to ensure the stability of estimates.

Another limitation is that the majority of the included studies had predominantly used cross-sectional designs and non-clinical samples in the United States. While looming has been found in a multinational study of ten countries to be related to anxiety in a variety of populations across Asia, Europe, the United States (e.g., Hong et al. 2017), as well as clinical populations including anxiety disorder patients and psychotic patients (e.g., Clemente et al. 2013; Riskind and Rector 2007; Riskind and Williams 2005), future work should increasingly employ clinical samples and prospective designs, and include samples drawn from a diversity of countries. The emergence of such studies should also help clarify specific mechanisms of the LCS in clinical conditions, its predictive effects on symptoms, and whether the LCS is a pan-cultural evolutionary mechanism in anxiety symptomatology. Furthermore, they would help to reduce the imbalance in the levels in categorical moderating predictors seen in the current meta-analysis (e.g., five studies on clinical samples and 59 on non-clinical samples). As the ratio of levels deviate from 50%, power of detecting a significant difference between the two levels is diminished (Hempel et al. 2013).

The current meta-analysis was also largely restricted to college students and adult community samples. Previous research suggests that adults may exhibit less susceptibility to LCS than college students (Hong et al. 2017); possibly because the latter group is more threatened by social and physical harms. There is also a paucity of developmental research on the emergence and effects of LCS in child samples. However, there is some evidence that the development of the LCS is linked to faulty parental bonding and attachment (for a review, see Riskind and Rector 2018; Riskind et al. 2017b; William and Riskind 2004). To address such issues, the LMSQ has to be modified to developmentally suit the understanding of children and adolescents. In sum, a developmental psychopathological perspective would be one next logical step to expand on this subject matter.

It should be recognized that the current meta-analytic results cannot be generalized to all anxiety subtypes. Only five symptoms subtypes of anxiety were examined in the current study (anxiety, social anxiety, OC, fears, worry/GAD), and more studies are therefore required to be conducted to examine the links between LCS and other conditions of anxiety such as panic and posttraumatic stress disorder. A related limitation was that GAD and worry were grouped together due to the small number of studies associated with each syndrome. However, individuals who worry do not necessarily have GAD. Thus, the effect size associated with worry/GAD reported here should be interpreted as more appropriate for the LCS-worry than the LCS-GAD association. Finally, the marginal significance of the comparisons of OC/fears to depression could be due to the small number of studies available for the meta-analysis. These differences in effect sizes could likely have been statistically significant had more studies been available.

Conclusion

The current meta-analysis consolidates a larger literature and provides empirical support for the proposition that the LCS is a significant transdiagnostic factor of cognitive vulnerability for anxiety and anxiety symptoms subtypes. More specifically, the LCS was significantly associated with anxiety and its subtypes, with social anxiety and worry having the strongest links. Although the LCS has been posited as a broad vulnerability factor to anxiety in general, the magnitude of effect sizes between LCS and the anxiety subtypes have not been differentiated in the literature. Future studies could determine the specificity of the LCS by ascertaining which anxiety subtype would still be significantly associated to the LCS, after statistically controlling for other subtypes. The mean effect size between LCS and depression was significant and of moderate magnitude. Furthermore, the differences in effect sizes between depression and two anxiety subtypes (fears and, obsessions-compulsions) were close to significance. It appears that although LCS is less associated with depression than anxiety, this association is nontrivial. Aside from the issue of comorbidity of depression and anxiety, studying the mechanisms underlying the development of anxiety and depression in the framework of the LCS would be helpful to understand the connection between LCS and depression.

Ultimately, advancing understanding of cognitive vulnerability factors for anxiety is important because the totality of our knowledge of these vulnerabilities is still incomplete. Recognizing that the LCS is a significant factor of cognitive vulnerability can play a beneficial role in designing interventions for the alleviation of symptoms. More broadly, the LCS makes novel predictions (e.g., about estimates of approaching threat, or freezing responses to threats) not generated by other vulnerability constructs. Future research can further explore LCS as a cognitive vulnerability for both anxiety and depression, about which there is still much to be learned.

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Compliance with Ethical Standards

Conflict of Interest Gerard C. Yeo, Ryan Y. Hong and John H. Riskind declare that they have no conflict of interest.

Informed Consent This meta-analysis does not directly involve human participants, hence the ethical requirements associated with human participants (e.g., informed consent) do not apply in this case.

Animal Rights No animal studies were carried out by the authors for this article.

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