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The influence of fear on risk taking: a meta-analysis

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ABSTRACT

A common finding in the study of emotion and decision making is the tendency for fear and anxiety to decrease risk taking. The current meta-analysis summarises the strength and variability of this effect in the extant empirical literature. Our analysis of 136 effect sizes, derived from 68 independent samples and 9,544 participants, included studies that experimentally manipulated fear or measured naturally varying levels of fear or anxiety in both clinical and non-clinical samples, and studies measuring risky decision making and risk estimation. A multilevel random effects model estimated a small to moderate average effect size ($r = 0.22$), such that fear was related to decreased risky decision making and increased risk estimation. There was also high heterogeneity in the effect sizes. Moderator analyses showed that effect sizes were greater when risk tasks used tangible (e.g. monetary) outcomes and when studies used clinically anxious participants. However, there also remained considerable variability in effect sizes, the sources of which remain unknown. We posit several potential factors that may contribute to observed variability in this effect for future study, including factors concerning both the nature of fear experience and the risk taking context.

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A consensus has emerged among researchers that fear decreases risk taking (Charpentier, Aylward, Roiser, & Robinson, 2017; Lerner & Keltner, 2001; Niedenthal, Krauth-Gruber, & Ric, 2006; Raghunathan & Pham, 1999). This finding has motivated practices across multiple domains of social and industrial life. Economists apply it to understand market behaviour (Reinhart & Rogoff, 2009), politicians and the media exploit it to influence public perception (Glassner, 2010), and health experts use it to more effectively communicate the health risks of certain behaviours (Brown & Walsh-Childers, 2002). Given the wide practical interest in the influence of fear on risk taking, it would be valuable to examine the strength and consistency of this relationship. Indeed, a closer examination of the literature suggests that there are studies that fail to report this effect (Charpentier, Hindocha, Roiser, & Robinson, 2016; Hunt, Hopko, Bare, Lejuez, & Robinson, 2005) or even observe the reverse effect whereby fear is associated with increased risk taking (Kugler, Connolly, & Ordóñez, 2012; Zhang & Gu, 2018).

Examining the strength and consistency of the relationship between fear and risk taking may also contribute to ongoing theoretical debates concerning the nature of emotion. There is a large variety of theoretical models for fear that vary in the extent to which they propose that fear ought to have a more uniform (v. more heterogeneous) effect on behaviour. In each model, fear is defined *a priori* by researchers in different ways. Fear is stipulated to be an affect programme that drives specific facial behaviours or physiological responses (Ekman & Cordaro, 2011; Levenson, 2011), a set of stimulus appraisals (rapid evaluations of whether a stimulus is harmful, unexpected, etc.) that are either consistent across all different fear inductions or may involve different suites of appraisals in different moments of fear (Clore & Ortony, 2013; Ellsworth & Scherer, 2003), a single or suite of functional states that drives

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defensive behaviours like fleeing or fighting (Adolphs & Anderson, 2018; Fanselow, 1991; Mobbs, 2018), a personal schema (LeDoux, 2015), or a mental construction of prior experiences that are used to make meaning of current instances (Barrett, 2006; Clore & Ortony, 2013; Lindquist & Barrett, 2008; Satpute & Lindquist, 2019). These models vary in the extent to which they emphasise uniformity or non-uniformity in the relationship between fear and behaviour, which may be informed by a comprehensive examination of the literature on fear and risk taking.

Here, we used meta-analytic methods to investigate the relationship between fear and risk taking. Meta-analysis provides a quantitative summary of the strength and consistency of an effect in the literature and the opportunity to test for potential moderators of effect size by statistically comparing groups of studies to one another. Our meta-analysis included two operationalizations of risk taking: risky decision making and risk estimation. Risky decision making refers to situations wherein an individual must decide between options that differ in the variability of their outcome. For example, participants may choose between a guaranteed $10 payoff or a 50% chance to win $20. This example specifies a 50% chance of success in the more variable, risky choice. Sometimes the risky choice can involve outcomes of unspecified odds as well (e.g. balloon analog risk task; Lejuez et al., 2002). Uncertainty refers to the situation in which the decision is risky, but the odds are unknown (Chua Chow & Sarin, 2002).

According to predominant theories of risky decision making, decision makers deciding among risky options assign value to each option by estimating both the likelihood and subjective value associated with each outcome (Kahneman & Tversky, 1979). For example, participants may be asked to estimate the likelihood that their car would be broken into if left unlocked overnight or how unpleasant experiencing a break-in would be. Such estimates are thus constitutive of the decision making process, and we consider them relevant to our investigation of risk taking. We refer here to risk estimation as subjects' perception of the likelihood and/or subjective valuation of risky outcomes.

The present meta-analysis assesses two overarching categories of moderators: (i) methods surrounding how fear was induced and/or measured, and (ii) methods for how risk taking was measured. Despite pervasive methodological variation in the measurement of these two constructs, justification for selecting certain protocols and speculation concerning the influence that these choices may have on outcomes is rare. One might expect, however, that different methodologies for inducing fear produce emotional experiences of variable nature and intensity (e.g. Condon, Wilson-Mendenhall, & Barrett, 2014), and that different risk taking tasks may vary in their susceptibility to the influence of emotion (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic & Peters, 2006). Understanding their influence is of relevance for both fundamental and translational research questions in fear and risk taking.

Inducing and measuring fear and anxiety

The relationship between emotion and decision making in general has been shown to depend on several methodological factors (Angie, Connelly, Waples, & Kligyte, 2011; Lerner, Li, Valdesolo, & Kassam, 2015). Here, we identified several potential moderating variables relating to methodological variability in the induction and measurement of fear and anxiety. First, we assessed whether fear or anxiety were measured using a non-experimental design (i.e. examining how naturally varying trait fear or anxiety levels relate to risk taking) or an experimental design (i.e. experimentally-induced fear). In the present investigation, "naturally varying fear" refers to trait measures of fear and anxiety. Conversely, as emotion induction experiments aim to manipulate fear in the moment, this category refers exclusively to state fear. Among non-experimental designs, we assessed the timing of fear inventory administration (e.g. whether a trait questionnaire was administered before or after the risk taking task) and the specificity of emotion inventories (i.e. whether emotions in addition to fear were measured). Among experimental designs, we identified whether or not a manipulation check was administered prior to participants completing the risk taking tasks as well as the medium of stimuli used to induce fear (e.g. pictures, sounds, movies). We also assessed whether the conceptual content of the fear induction was idiographic (i.e. tailored to each participant) or normative. Additionally, we compared studies that used neutral emotion as the control condition to those that used anger as the control condition. Finally, variation across studies may also be related to the strength of the fear induction (i.e. the intensity of the fear experience it produces). Thus, we examined whether the intensity of self-reported emotional experience predicted the

strength of the relationship between fear and risk taking. One might expect greater self-reported fear experience to be associated with more pronounced decreases in risk taking (i.e. a dose-dependent relationship across studies) to the extent that the influence of fear on risk taking is uniform and monotonic.

Although applied and theoretical models vary in how they treat the constructs of fear and anxiety (Fanselow, 1991; Öhman, 2008; Reiss, 1991), in the risk taking literature these constructs are not clearly distinguished methodologically or empirically. Studies that use experimental inductions of fear rarely, if ever, ask participants to report on how the induction influences fear and anxiety separately. Similarly, studies using non-experimental designs use scores on scales and inventories that also do not clearly separate fear and anxiety; for example, the commonly used Anxiety Sensitivity Index includes items with the terms "scared", "nervous", "anxiety", and "worried" (Reiss, Peterson, Gursky, & McNally, 1986). Thus, although researchers appear to focus on the impact of anxiety or fear separately, and do not intend to use the terms interchangeably, limited empirical distinction between these constructs is made in the existing literature. To examine whether effect sizes differed when considering studies ostensibly on fear v. anxiety, we coded and then analytically compared studies investigating anxiety and studies investigating fear on the basis of the language used by the authors. We note here that this dimension did not have an influence on the results; for ease, we use the term "fear" throughout the rest of the manuscript to refer to studies assessing fear and anxiety in this meta-analysis except where explicitly stated otherwise.

Assessing risk taking and risk estimation

We also identified moderating variables relating to the format of the risk taking measure to examine whether certain measures of risk taking are more susceptible to the influence of fear than others. We coded for whether studies measured risky decision making (e.g. through responses on a gambling task) or risk estimation (e.g. through subjective reports of the perceived likelihood and/or value of various risky outcomes). Notably, we will use "risky decision-making" to refer to studies using both conditions of risk and conditions of uncertainty. Whereas decision making under risk involves the probabilities of each outcome being directly provided, uncertainty refers to the condition in which probabilities are unknown (or unknowable) to the decision maker (De Groot & Thurik, 2018). Common tasks measuring risk include simple gambles devised by experimenters (such as a 50% chance of winning $10 vs. a 100% chance of winning $5) as well as the Game of Dice Task (Brand et al., 2002). Standard tasks involving uncertainty include the "balloon analog risk" task (BART; Lejuez et al., 2002) and the IOWA Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994). We included both types of tasks in our "risky decision making" category, but coded for and analyzed potential differences between decision-making tasks involving risk v. uncertainty in our moderator analyses. Additionally, among decision-making studies, we assessed whether tasks involved the framing of decisions in terms of gains or losses (for example, whether a decision-making scenario involving a disease epidemic is presented in terms of lives saved or lives lost; Tversky & Kahneman, 1981), and whether they used real (i.e. monetary) vs. hypothetical rewards (Irwin, McClelland, & Schulze, 1992). Among risk estimation studies, we compared the effect of fear on risk likelihood estimates to the effect on estimates of the subjective value of risky outcomes.

Methods

Literature search

Manual searches of the psychological and medical literature were conducted to gather articles investigating the influence of fear on risk taking. Our search included terms for the emotion words "fear" and "anxiety", and terms relevant to measuring risk ("risk aversion", "risk seeking", "risk taking", "perception of risk", "estimates of risk", "risk estimates", "decision-making", "judgment of risk", "risk judgment", "risk-averse", "risk sensitivity", "risk preference", "risk appraisal", "risk perception", "risk avoidance", "risk avoidant"). We entered all combinations of one emotion word with one risk measure term into Pubmed and PsycInfo. Studies published prior to April 24, 2018, were included in the analysis. The literature search yielded an initial database of 2,117 studies (Figure 1).

Criteria for inclusion of studies

Studies were assessed for inclusion based on the following two overarching criteria. First, studies were included if fear was treated as an independent variable or predictor. Here, studies varied in whether fear was experimentally-induced or measured in a

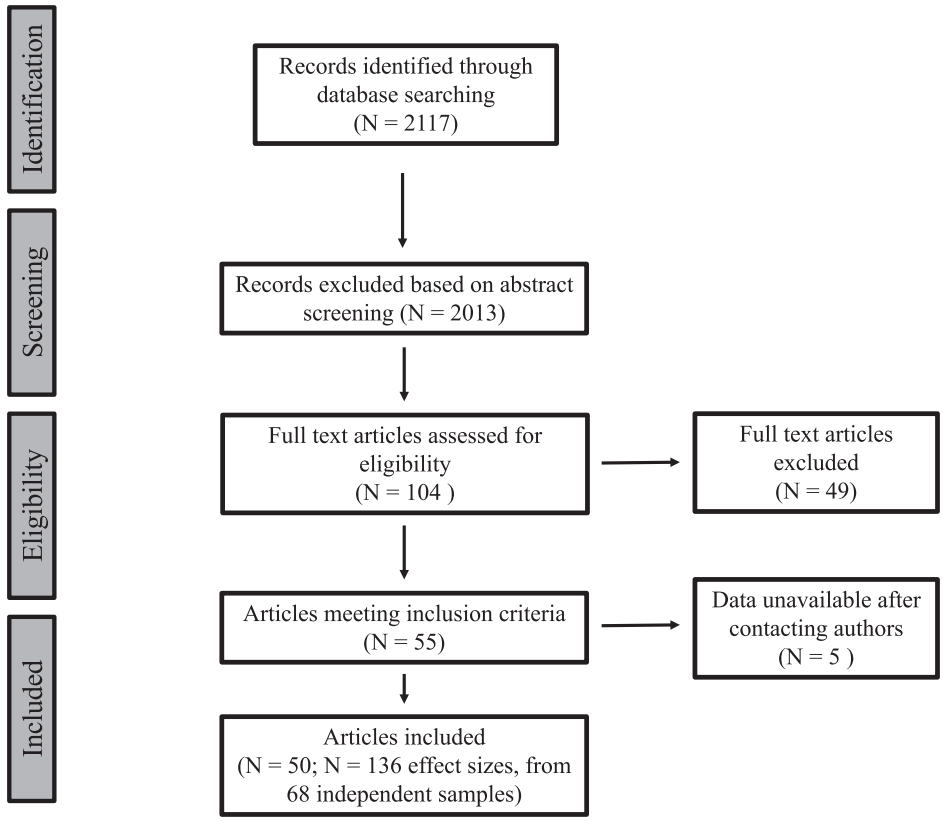

Figure 1. PRISMA chart for study set. The database search yielded 2117 articles. Abstract screening identified 104 relevant articles, 55 of which met criteria for inclusion. In the case of studies reporting data insufficient for effect size calculation, 5 authors did not respond to our request for supplementary results. Fifty studies were included in the current analysis, yielding 136 effect sizes from 68 independent samples. Search terms and criteria for inclusion are provided in methods section. The reduction from the number of articles in the database search to included articles is generally consistent with other meta-analyses that use broad and inclusive search terms for the initial database inquiry (see main text).

non-experimental paradigm. Studies that experimentally induced fear used a variety of fear induction methods (e.g. presenting frightening movie clips, retrieving autobiographical memories; see coding scheme below for a complete list). Studies that implemented a non-experimental design were included if they measured naturally varying trait fear using established inventories: Fear Survey Schedule 2 (Bernstein & Allen, 1969), Fear of Negative Evaluation Scale (Watson & Friend, 1969), Spielberger's State-Trait Anxiety Scale (1970), Mini International Neuropsychiatric Interview (Sheehan et al., 1998), PANAS (Watson, Clark, & Tellegen, 1988), Stanford Acute Stress Reaction Questionnaire (Anxiety Subscale) (Cardeña, Koopman, Classen, Waelde, & Spiegel, 2000), Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988), GADQ-IV (Newman et al., 2002), Web-Based Depression and Anxiety Screen (Farvolden, McBride, Bagby, & Ravitz, 2003), Anxiety Sensitivity Index (Reiss et al., 1986), Multidimensional Anxiety Scale for Children (March, Parker, Sullivan, Stallings, & Conners, 1997), Hospital Anxiety Scale (Zigmond & Snaith, 1983), Worry Domains Questionnaire (Tallis, Davey, & Bond, 1994),[1] Taylor Manifest Anxiety Scale (Taylor, 1953), Brief Symptom Inventory (Anxiety Subscale) (Derogatis & Melisaratos, 1983).

Second, studies were included if they measured risk taking as a dependent or outcome variable. Here, studies varied in whether risk taking was operationalised in a decision-making task or in a risk-estimation task. Decision-making studies involved choice under conditions of risk or conditions of uncertainty. Studies could measure risk taking by presenting participants with tasks to perform in lab (e.g. gambles, GDT, BART, IGT) or questionnaires aiming to quantify real-world risky decision making, such as the Domain Specific Risk Taking (DOSPERT) scale (Weber, Blais, & Betz, 2002). These common tasks are not an

exhaustive list, however – decision-making studies using analogous measures were included as well, provided they involved conditions of risk or uncertainty. We also included risk-estimation tasks, in which participants provided estimates of the likelihood and/or subjective value of risky events. For example, participants might be asked what the likelihood is of being in a car accident in their lifetime or how undesirable they would estimate the experience to be. Notably, the definition of risk utilised in the present meta-analysis excludes distinct operationalizations of risk that are commonly used in epidemiology and health-related fields. Whereas we refer to risky decision making as a choice between options that differ in the variability of possible outcomes, risk in the medical sense refers more strictly to the likelihood of incurring loss or damage (e.g. a negative health outcome; see Kaplan & Garrick, 1981).

Studies were excluded if the results reported were insufficient to compute an effect size. If an otherwise eligible study reported data insufficient for the calculation of an effect size, we contacted the corresponding author (s) requesting the missing component(s). However, this approach failed to yield necessary information in some cases. Since our interest is whether a person feels fear, studies were excluded if they did not induce fear experimentally or measure feelings of naturally varying fear via trait fear inventories in a non-experimental design. Some studies measured attitudes or beliefs about a specific event (e.g. do you fear terrorist threats? cancer? etc.), but if the experiment did not specifically induce or measure whether participants currently feeling fear or were trait anxious, they were excluded.

Of the 2,117 articles identified by the literature search, 50 met our inclusion criteria, which yielded 136 effect size estimates from 68 independent samples (see Figure 1). This reduction from the total search volume to the number of studies included is typical for meta-analyses that use broad and inclusive initial search strategies. For example, several prior studies using PRIMSA guidelines have final samples of 41 out of 28,585 in the search (Morina, Koerssen, & Pollet, 2016), 13 from 3,292 (Dowling et al., 2017), 6 from 634 (Piet & Hougaard, 2011), 101 from 10,894 (Mayo-Wilson et al., 2014), 40 from 5,384 (Bolier et al., 2013), etc.

Coding

A coding scheme was devised by surveying the literature and identifying features that varied across the studies. A summary of the features, their levels, and the numbers of studies contributing to them is provided in Table 1.

Table 1. Effect sizes by Moderator Levels.

	All Effect Sizes			Independent Samples		
Moderator and Levels	*N*	Mean Effect Size	SD	*N*	Mean Effect Size	SD
Emotion Label Used by Authors						
Fear	46	0.15	0.17	22	0.19	0.22
Anxiety	90	0.20	0.23	46	0.22	0.25
Study Design						
Experimental	52	0.15	0.20	28	0.16	0.23
Non-Experimental	65	0.16	0.19	30	0.16	0.20
Non-Experimental Clinical)	19	0.33	0.27	10	0.30	0.37
Timing of Fear Inventory						
In Lab, Prior to Risk Task	27	0.24	0.25	14	0.25	0.28
After Risk Task	9	0.18	0.08	3	0.22	0.10
Prior to Lab Visit	8	0.17	0.26	5	0.36	0.23
Presence of Additional Emotions Measured						
No	13	0.18	0.24	6	0.23	0.35
Yes	11	0.41	0.26	7	0.30	0.25
Manipulation Check Prior to Risk-Taking Task						
Yes	31	0.15	0.17	17	0.26	0.18
No	18	0.14	0.20	10	0.13	0.26
Control Group						
Neutral	44	0.25	0.22	23	0.29	0.23
Angry	15	0.13	0.21	10	0.20	0.22
Fear Induction Medium						
Participant-Imagined Scenario	6	0.11	0.07	3	0.16	0.10
Written Scenario (Provided by Experimenter)	6	0.32	0.16	4	0.34	0.17
Video Clip	6	0.08	0.22	3	0.06	0.34
Static Image	8	0.33	0.19	4	0.35	0.23
Musical Mood Induction	8	0.17	0.13	2	0.27	0.08
Autobiographical Recall	16	0.18	0.20	10	0.16	0.22
Social Evaluative Threat	1	0.71	NA	1	0.71	NA
Anticipation of Pain	1	0.02	NA	1	0.02	NA
Fear Induction Content						
Normative	33	0.15	0.20	16	0.27	0.25
Idiographic	19	0.17	0.18	12	0.16	0.20
Risk-Taking Task						
Risky Decision Making	73	0.19	0.27	44	0.21	0.29
Risk Estimation	63	0.17	0.12	24	0.22	0.11
Decision-Making Task						
Simple Gamble	26	0.14	0.24	18	0.13	0.26
GDT	3	0.01	0.28	3	0.01	0.28
BART	14	0.37	0.40	8	0.38	0.40
IGT	2	0.33	0.01	2	0.33	0.01
DOSPERT	5	0.22	0.21	2	0.28	0.28
Estimation Task						
Likelihood	43	0.17	0.12	19	0.22	0.12
Utility	20	0.18	0.11	5	0.23	0.06
Risk Type						
Risk	40	0.19	0.28	22	0.16	0.29
Uncertainty	33	0.18	0.25	22	0.26	0.29
Frame						
Gains	32	0.23	0.29	18	0.23	0.29
Losses	5	−0.05	0.28	4	0.14	0.32
Tangible Reward						
Yes	42	0.30	0.28	30	0.31	0.27
No	94	0.16	0.16	38	0.14	0.20

Fear measurements

We coded for studies with experimental designs (i.e. manipulating state fear) and non-experimental designs (i.e. naturally varying trait fear). For fear measured in non-experimental designs, we coded for whether the study was conducted within a neurotypical population or compared between neurotypical and clinically fearful groups. Clinically fearful participants were diagnosed with one or more of the following conditions: Generalized Anxiety Disorder ($N = 241$), Social Phobia ($N = 78$), Panic Disorder ($N = 47$), Obsessive Compulsive Disorder ($N = 21$), Separation Anxiety ($N = 3$), Post-Traumatic Stress Disorder ($N = 2$), Adjustment Disorder with Anxious Mood ($N = 1$). Among experimental designs, we coded for the presence of a manipulation check prior to the task (as opposed to a manipulation check administered after the risk task or pre-tested on subjects not participating in the risk measure – or if no check was administered at all). Among non-experimental designs, we coded for the timing of fear inventory measures (i.e. whether fear was measured before participants arrived for the experiment, after arriving but prior to the risk task, or after completing the risk task) and the specificity of trait measures (i.e. the presence/absence of separate emotion trait measures in addition to fear). Additionally, among all studies we coded for the use of either a neutral baseline or anger as the control group condition.

Fear intensity

Among studies that experimentally induced fear and also those that used non-experimental designs but directly compared two groups (i.e. one high and one low in fear), we recorded the strength of the fear induction (e.g. by recording the effect size of the difference in reported fear between conditions or groups). We then normalised these values (see below) to provide a more continuous assessment that could be used to examine how the strength of the fear inductions related to the strength of the differences in risk taking.

Fear induction stimulus medium and content specificity

For fear inductions, we coded for the following features. First, we coded for stimulus medium; studies were coded for whether the fear induction involved video clips, static images, music, retrieval of autobiographical memories, social evaluative threat, anticipation of pain, scenarios imagined by participants, or written scenarios provided by experimenters. Second, these studies were grouped into those that used idiographic stimulus content (i.e. participants were asked to self-generate content that was fear-inducing) and normative stimulus content (i.e. all participants received the same experimenter-selected content).

Treatment of fear and anxiety

Fear and anxiety are rarely systematically distinguished, theoretically or experimentally, in the studies included in this meta-analysis or in the risk taking literature more generally. To provide an initial examination of differences between fear and anxiety, we grouped studies into those that referred to fear and those that referred to anxiety on the basis of the authors' descriptions. A preliminary comparison of studies using the term fear vs. using the term anxiety showed no significant differences in average effect size (see Table 1; $F(1, 134) = 0.48$, $p = 0.49$). Thus, the literature is currently inconclusive as to whether there are differences in risk taking that vary by fear and anxiety.

Risk task

Studies were coded for whether risk was measured using risky decision making or risk estimation. Studies using risk estimation were coded for whether they assessed perceived risk likelihood or the subjective value of risky outcomes. The subset of risky decision-making studies was coded for four moderators. Among decision-making tasks, we identified and coded for five commonly used protocols. These were simple gambles (e.g. a choice between a 50% chance of winning $10 and a 100% chance of winning $5), the Game of Dice Task (Brand et al., 2002), the Balloon Analog Risk Task (BART; Lejuez et al., 2002), the IOWA gambling task (Bechara et al., 1994), as well as the DOSPERT scale (Blais & Weber, 2006). Of 73 decision-making effect sizes, 50 used one of these standardised tasks. Additionally, we coded separately for the following variables: First, studies were placed either into the category of risk (i.e. odds of outcomes specified) or uncertainty (odds unspecified). Second, studies were coded based on whether the outcomes were framed in terms of gains, losses, or a mixture of both. Third, studies were coded based on whether the outcomes involved tangible (i.e. monetary) stakes or not (e.g. hypothetical outcomes).

Analysis

All effect size estimates (e.g. Cohen's *d* for studies with group comparisons) were converted to correlation

coefficients (*r*). For studies (n = 4) reporting multiple regression that did not provide corresponding *r* values, we treated standardised beta coefficients (*β*) as correlation coefficients, consistent with recommendations in the literature (Peterson & Brown, 2005). Effect sizes were assigned a positive sign to indicate a relationship in the theoretically predicted direction (i.e. increased fear associated with decreased risk taking or increased risk estimation), or a negative sign to indicate a relationship in the opposite direction. Fifty articles yielded a total of 136 effect sizes including independent and non-independent effects (i.e. multiple effects reported using the same subject sample) and 68 independent effect sizes, comprising 9,544 participants in total.

To control for non-independence, we conducted multilevel regression analyses of individual effect sizes nested within independent samples,[2] implemented in the Metafor package in R (Viechtbauer, 2010). All analyses treated sample as a random factor and utilised a variance components covariance structure. For each moderator, nominal categories/levels of the moderator were dummy-coded and linear multiple regression models were used to examine the association between varying levels of the moderator and effect size. Heterogeneity in the effect was computed using Cochran's Q, which sums the squared deviations of each study's estimate from the mean effect size estimate produced by the overall meta-analysis (Cochran, 1954).

Additionally, to assess the problem of publication bias, a fail-safe N was computed – this value provides an estimate of the number of null findings that would need to be published to bring the significance of the average effect size (relative to 0) above the 0.05 significance threshold (one-tailed; Rosenthal, 1994). Additionally, *p* values associated with each effect size were calculated and input to a *p* curve, which provides another way of investigating publication bias by tracking the frequency of *p* values at intervals between 0.0 and 0.05. Clustering of *p* values near the $p = 0.05$ threshold presents evidence of potential publication bias or *p*-hacking, whereas clustering of *p* values approaching 0.0 suggests a true effect (Simonsohn, Nelson, & Simmons, 2014).

Results

Overall strength and consistency of effect size

The results of the random effects model are summarised in Figure 2. The estimated mean effect size for the

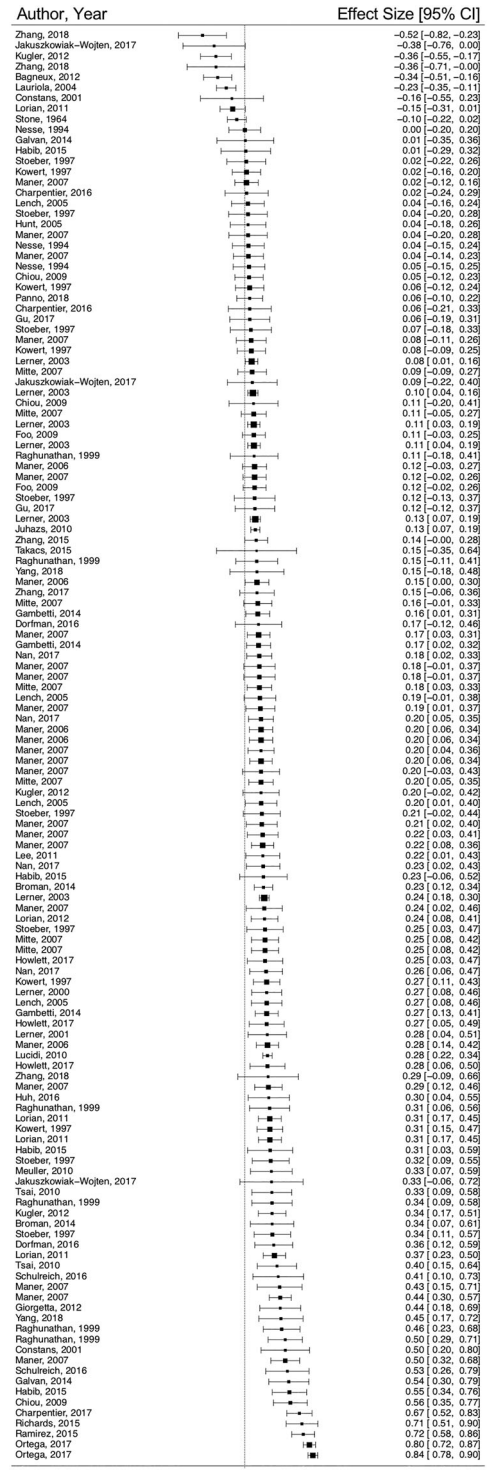

Figure 2. Forest plot summarising the distribution of effect sizes ($N = 136$). The weighted mean effect size is $r = 0.22$. Negative values indicate effects in the opposite direction (i.e. fear increases risk taking). The relationship between fear and risk taking exhibits high variability across studies with a range of [−0.52, 0.84].

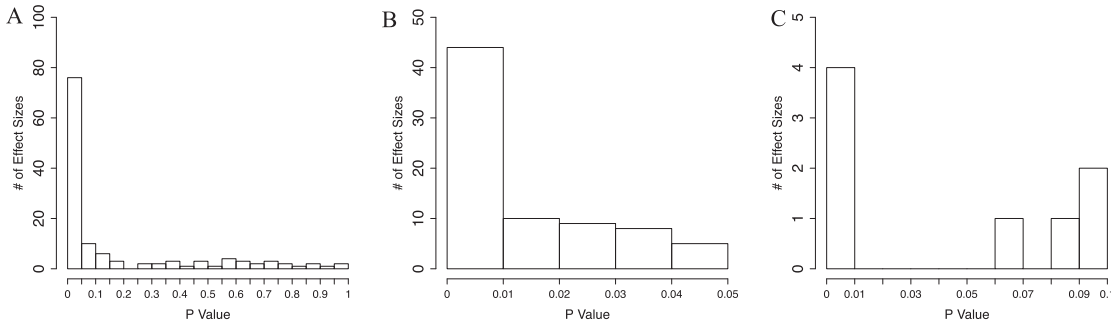

Figure 3. P-Curve analysis. The figure illustrates the distribution of *p* values ($N = 136$) for positive effect sizes (A and B) and negative effect sizes (C). (A) 76 positive effect sizes are statistically significant ($p < 0.05$) compared to 51 insignificant values. (B) Among studies reporting significant decreases in risk taking caused by fear ($0 < p < 0.05$), number of publications increase as *p*-values decrease. This trend suggests that publication bias and *p*-hacking are not major factors in the present distribution of studies investigating fear and risk taking. (C) Among negative effect sizes (i.e. fear increases risk taking) 4 are significant ($p < 0.05$), and 5 are not (including one outlier not shown; $p = 0.44$). Among 4 significant values, 3 are below $p = 0.01$.

relationship between fear and risk taking is $r = 0.219$ ($SD = 0.37$, $Z(136) = 8.65$, $p < 0.0001$, two-tailed). These results suggest a significant relationship between increased fear and decreased risk taking (i.e. decreased risky decision making and/or increased estimation of risk). Based on the criteria set forth by Cohen (2013), this effect is considered small-to-medium in strength. The fail-safe N analysis estimates that 10,264 studies producing null effects would need to be published to bring the significance of the analysis comparing this mean effect size to zero above $p = 0.05$ (one-tailed). P curve analysis demonstrates that studies reporting significant results tended to increase in frequency as *p*-values decreased, suggesting there was limited evidence of any potential *p*-hacking or publication bias (Figure 3). The test for heterogeneity indicated a high degree of heterogeneity in the effect of fear on risk-taking, $Q(135) = 1210.8$, $p < 0.001$. The heterogeneity was not explained by statistical power in that the variability of effect sizes was high both for studies with high and low sample sizes (see funnel plot, Figure 4). Overall, these results suggest

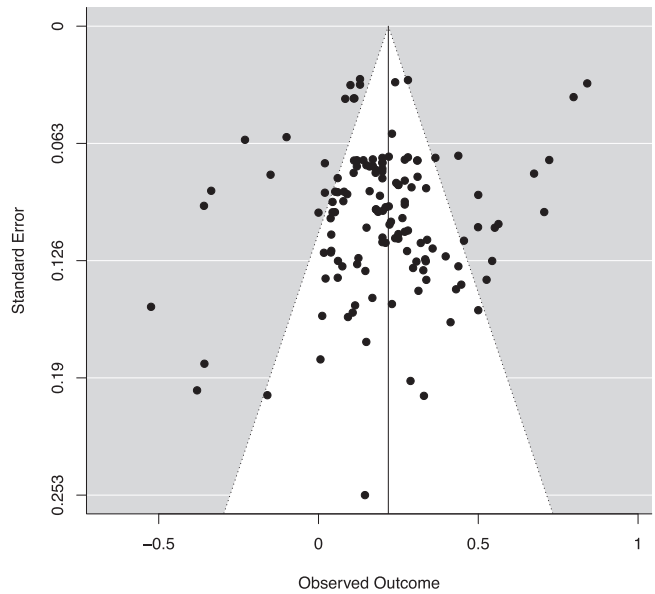

Figure 4. Funnel plot for the relationship between effect sizes and standard error. If the effect size of fear on risk taking is consistent across studies, outcomes should converge towards the mean effect size ($r = 0.22$), as standard error decreases. Absence of this trend suggests heterogeneity is not explained by sampling error alone.

that, on average, there is a moderate and reliable effect of fear on risk taking across studies, but also that this relationship is not homogenous across studies.

Moderator analyses

We next examined whether heterogeneity in the influence of fear on risk taking could be explained by several moderators.

Fear measurements

We first compared study designs that experimentally induced fear with those measuring trait fear (non-experimentally induced) in either clinical or non-clinical populations (see Table 1 for mean effect sizes). Significant differences were observed among the three groups – experimentally induced fear, non-experimentally measured fear (non-clinical population), and non-experimentally measured fear (clinical population), $F(2, 133) = 4.76$, $p = 0.009$. This effect appeared to be driven by differences between clinical and non-clinical populations, rather than experimentally-induced fear vs non-experimentally measured fear: combining the clinical and non-clinical categories of non-experimental fear, the comparison between experimentally-induced fear and non-experimentally measured fear was not significant, $F(1, 134) = 0.01$, $p = 0.92$. A direct comparison of non-experimental designs using clinical and non-clinical populations showed larger effect sizes in the studies with clinical populations than non-clinical populations, $F(1, 82) = 4.81$, $p = 0.02$. At the same time, studies with clinical populations also showed a high variability in effect sizes (SDs in Table 1).

Indeed, studies using clinical samples ranged in effect sizes from $r = -0.15$ (Lorian & Grisham, 2011) and $r = 0.00$ (Nesse & Klaas, 1994) on the low end to $r = 0.67$ (Charpentier et al., 2017) and 0.80 and 0.84 (Ortega, Ramírez, Colmenero, & del García-Viedma, 2017) on the high end. We were unable to investigate differences among particular clinical diagnoses, as the majority of the studies grouped all clinical participants into one category rather than keeping separate the individual diagnoses. Of the 16 effect sizes involving GAD patients, 9 included patients with conditions other than GAD. Among effect sizes using Panic Disorder ($n = 6$), Social Phobia ($n = 9$), OCD ($n = 6$), PTSD ($n = 2$), Separation Anxiety ($n = 2$), and Adjustment Disorder with Anxious Mood ($n = 2$), no analyses had fewer than two diagnoses combined within the clinical group.

Among non-experimental designs, it is possible that the relationship between fear and risk taking would depend on when inventories were used to measure fear and how many other inventories were included in the study. For example, demand characteristics could be greater when inventories are obtained beforehand, or if only a fear inventory was acquired in the study, making it more likely that participants will infer that the intent of the study is to examine the influence of fear on risk taking. Contrary to this idea, the effect of fear on risk taking did not significantly vary between studies that administered fear surveys prior to the day of the experiment, during the experiment but prior to the risk task, or after the risk task, $F(2, 41) = 0.34$, $p = 0.71$. Among studies that issued emotion surveys in lab and prior to the risk task, the presence of inventories measuring emotions other than fear did not impact the relationship between fear and risk taking, $F(1,22) = 0.28$, $p = 0.60$.

Among studies that experimentally induced fear, it is possible that obtaining a manipulation check prior to the risk taking measurement may also influence the effect of fear on risk taking. A manipulation check may heighten awareness of study goals to examine fear and risk taking and increase demand characteristics. In contrast to this notion, the presence of a manipulation check prior to the risk task failed to significantly impact the relationship between fear and risk taking and, if anything, trended in the opposite direction, $F(1, 47) = 3.56$, $p = 0.06$; see Table 1. A few studies ($n = 15$) also used anger rather than neutral baselines as a control condition. The use of anger as a control condition produced slightly lower effect sizes than neutral controls, but this effect was not significant, $F(1,57) = 1.66$, $p = 0.20$.

Fear induction medium and content specificity

We also compared effect size across different fear induction mediums (e.g. movies, autobiographical recall). We found that, among the various mediums used to induce fear, a significant difference was observed with regard to risk taking effect sizes, $F(7, 44) = 2.43$, $p = 0.02$. This difference was likely driven by social evaluative threat, which produced an effect size far larger than the other induction mediums (of $r = 0.71$) whereas the average effect sizes of the other induction mediums were considerably lower and closer to the overall mean effect ($rs <$

.33; see Table 1). However, only one study used social evaluative threat preventing any strong conclusions from being drawn from this finding at present. Finally, we examined the content specificity of fear inductions, or specifically, whether the effect of fear on risk taking differed when the conceptual content of the fear induction was determined by the experimenters (and thus more uniform across participants) versus when participants decided the induction content via their own conception of fear (i.e. autobiographical memories or imagery that was more unique or tailored to participants). Content specificity had no significant relationship with effect size, $F(1, 50) = 0.43$, $p = 0.51$.

Fear intensity

It could be hypothesised that what might matter most in the strength of the relationship between fear and risk taking is not the specific experimental methods used to elicit or assess fear, but the relative intensity with which fear is experienced. If fear influences risk taking in a dose-dependent way (i.e. greater fear, greater risk aversion), then one might expect a monotonic relationship between increasing fear intensity and the extent of reduction in risk taking across studies. Here, we operationalised fear intensity as the magnitude of the self-reported difference in fear separating low-fear and high-fear groups both in experimental and non-experimental (trait fear) studies. For each of the studies included in this analysis, we calculated effect size (Z) for differences in fear and anxiety levels using methods consistent with those we used to calculate effect sizes for risk taking. Group differences in fear produced Cohen's *d* values, which were converted to *r* before Fisher transforming. We then used a Pearson's correlation analysis to examine associations between fear effect sizes and risk taking effect sizes (i.e. the difference in self-reported fear and the difference in risk taking across conditions) across studies. As illustrated in Figure 5, we failed to find any significant relationship between the magnitude of the fear effect size and the magnitude of the risk taking effect size across studies, $r(51) = 0.11$, $p = 0.44$. Using fear intensity as a continuous moderator within the multi-level model, the analysis similarly found no significant effect, $F(1, 51) = 0.88$, $p = 0.35$. Thus, studies in which groups differed the most in self-reported fear did not systemically exhibit the greatest reductions in risk taking or increases in risk estimation.

Risk taking task

Next, we focused on whether the various ways to measure risk taking also contributed to variability in effect sizes. Here, the only moderator that was significantly related with effect size was the consequences at stake for participants completing risky decision-making tasks. Among decision-making studies, fear induced greater risk aversion in studies presenting tangible rewards (mean $r = .31$, SD = .27) compared to studies that offered no tangible reward (mean $r = .14$, SD = .20), $F(1, 71) = 5.15$, $p = 0.02$. However, the variability in effect sizes for studies with tangible rewards also remained high and spanned the full range from $r = -0.52$ (Zhang & Gu, 2018) and $r = -0.38$ (Jakuszkowiak-Wojten et al., 2017) on the low end to $r = 0.72$ (Ramírez, Ortega, & Reyes Del Paso, 2015) and 0.80 and 0.84 (Ortega et al., 2017) on the high end.

The remaining moderator variables relating to the measurement of risk taking were non-significant. Specifically, we found no significant differences

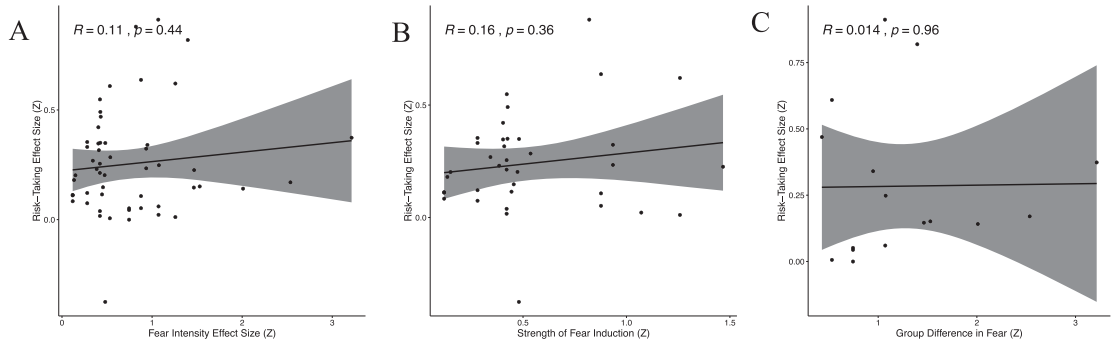

Figure 5. Risk taking effect sizes (Z) do not significantly increase as fear intensity increases (Z) for (A) all studies combined ($r = 0.11$, $N = 53$, $p = 0.44$), (B) experimental designs ($r = 0.16$, $N = 37$, $p = 0.36$), or (C) non-experimental designs ($r = -0.014$, $N = 16$, $p = 0.96$).

between tasks requiring subjects to make decisions involving risk and those requiring them to estimate risk (see Table 1; $F(1, 134) = 0.17$, $p = 0.69$). Among risk estimation effect sizes, we observed no significant difference between studies involving estimates of likelihood and estimates of subjective value, $F(1,61) = 0.08$, $p = 0.78$. For studies using either simple gambles, GDT, BART, IGT or the DOSPERT scale, we observed no significant differences in the relationship between fear and risk taking among these five tasks, $F(4, 45) = 0.83$, $p = 0.50$. The effect of fear on risk taking also failed to differ significantly between decision making tasks utilising conditions of uncertainty vs conditions of risk, $F(1, 71) = 0.66$, $p = 0.41$. Furthermore, the effect of fear on risk taking did not significantly differ between studies where outcomes in the risky decision-making task were presented in a gain frame vs a loss frame, $F(1,35) = 0.60$, $p = 0.44$.

Discussion

In this study, we used meta-analytic methods to examine the strength and consistency of the relationship between fear and risk taking. Our goal was to provide a quantitative summary of extant results and a systematic examination of potential moderators of the relationship. Using a multi-level, random effects model across 136 effect sizes, we observed a highly reliable influence of fear on risk taking with an average effect size of $r = 0.219$, suggesting that fear is associated with decreased risk taking (i.e. decreased risky decision making and increased risk estimation). This relationship is considered to be "small to moderate" in strength (Cohen, 2013). At the same time, we observed substantial variability in effect sizes (quantified by $Q(135) = 1210.8$, and visualized in the funnel plot in Figure 4). In a small set of studies, fear was even associated with significantly greater risk taking (Figure 2; Bagneux, Bollon, & Dantzer, 2012; Jakuszkowiak-Wojten et al., 2017; Kugler, Connolly, & Ordóñez, 2012; Lauriola, Russo, Lucidi, Violani, & Levin, 2005). These findings suggest that the relationship between fear and risk taking is also heterogeneous and underscores the importance of investigating moderating variables for this effect.

We coded for several features that varied across studies to investigate their role in moderating the relationship between fear and risk taking (Table 1). With regard to the measurement and induction of fear, there were larger effect sizes on average when the study used a non-experimental design with clinical samples ($r = .32$) than when it involved a non-experimental design with non-clinical samples ($r = .16$) or even an experimental induction of fear ($r = .15$). Yet, even just among the studies with clinical samples, the variability in effect sizes was quite high as indicated by the SD (Table 1) and range. With regard to the measurement of risk, there was a stronger effect when the risk task involved a tangible reward (e.g. monetary; $r = .30$) than a non-tangible reward ($r = .16$). Yet again, the variability in effect sizes was high for studies with tangible rewards (Table 1). These findings require a balanced conclusion. They suggest that studies with clinical populations and tangible rewards may demonstrate larger effects of fear on risk taking, but that even in these cases, the relationship between fear and risk taking is heterogeneous and requires further investigation.

Consistent with our finding that the effect of fear on risk taking was stronger in risk-taking contexts with tangible rewards, there is evidence to suggest that people are less risk-taking on average when dealing with real money than hypothetical money (Irwin et al., 1992). It has been theorised that hypothetical rewards do not provide adequate motivation to decision makers, and thus they tend to choose low-effort options by default over options that would optimise their gains (Smith & Walker, 1993). Perhaps adequate motivation is required for decision makers to detect and incorporate emotional cues in a robust way, and thus the process is less susceptible to the influence of fear when dealing with hypothetical rewards than tangible ones. Another possible explanation stems from the view that making a risky decision is itself affectively evocative (Loewenstein et al., 2001; Slovic & Peters, 2006). Decision making involving actual rewards may perhaps be more affectively evocative than hypothetical rewards. Future work may examine possible causal mechanisms to explain the increased influence of fear on risk taking when utilising tangible vs. hypothetical outcomes. In doing so, it would be of importance to examine the mean influence of fear on risk across a wide variety of paradigms as well as the extent and possible causes of variability in effect sizes. For example, research using monetary decision making tasks has shown that the payout schedule (i.e. whether payouts are honoured for all trials or a subset of trials) may also influence risk taking (Schmidt & Hewig, 2015); although we coded for this characteristic, there were too few studies that used only one

($n = 2$) or a subset of trials ($n = 6$) to determine payouts to conduct an informative moderator analysis.

Our meta-analytic review also makes clear several gaps in the literature on fear and risk taking. Different theoretical traditions in emotion research make competing suggestions for how the fear and risk taking relationship may depend on the specific nature of the fear induction. For example, constructionist models of emotion propose that the experience of fear may vary widely depending on both the individual and the situational context (Barrett, 2017; Lindquist & Barrett, 2008; Satpute & Lindquist, 2019). Fear of a predator may involve different features (Mobbs & Kim, 2015) than fear of heights, fear of having a difficult conversation with a parent, or fear of test taking (Barrett, 2006; James, 1884; Satpute & Lindquist, 2019). Some fears are experienced as unpleasurable, but others as pleasurable (Condon et al., 2014). From this perspective, it would be of interest to measure the variety of features that constitute fear in different situations and examine how these features relate with risk taking (see also Baumann & DeSteno, 2012, for an example of how context impacts the influence of anger on risk taking).

Future work may also investigate the complexity of the risk situation. Most research studies emphasise a single dimension along which risk is manipulated (e.g. monetary risk), holding other sources of potential risk constant. Yet, in everyday situations, risk may be present along multiple dimensions (Lynn, Wormwood, Barrett, & Quigley, 2015). For example, Kugler, Connolly, and Ordóñez (2012) measured "person-based risk", in which a safe monetary outcome required participants to take a risk in the social domain by forsaking cooperation and thus risking social repercussion. There has also been a call for developing risk taking tasks that are more naturalistic (Schonberg, Fox, & Poldrack, 2011). Future work that examines both fear and risk taking as complex, multifaceted constructs, may help uncover moderators that explain the heterogeneity we observed and also support generalisation of extant findings to fear and risk taking in everyday life.

Our meta-analysis focused on incidental influences of fear and anxiety on risk. That is, we specifically examined situations in which fear and anxiety were incidental to (i.e. not directly related to) the content of the risky situations themselves. Presumably, such studies enable a better look at the underlying psychological mechanisms (e.g. by reducing demand characteristics or mitigating internal consistency goals). However, there is also a large body of work in applied contexts that examines fears and anxieties that are integral to (i.e. normatively relevant for or tailored to) the risk taking context (Consedine & Moskowitz, 2007; Ferrer & Klein, 2015). For example, researchers have examined how anticipated fear and regret when evaluating a gamble influences gambling decisions (Larrick & Boles, 1995; Mellers, Schwartz, Ho, & Ritov, 1997) and how fears and anxieties pertaining to cancer relate with obtaining screenings for breast cancer (Consedine, Magai, Krivoshekova, Ryzewicz, & Neugut, 2004). This work suggests that cancer-related fears and anxieties are not monolithic but heterogeneous. They include fear of pain during examination, fear of the uncertainty about whether one has cancer or not, fear of having cancer, and more dimensions that can interact to promote or prevent a person from obtaining a screening (Consedine et al., 2004). Such work dovetails with the idea that laboratory paradigms, too, may benefit from more finely deconstructing experiments in terms of the specific contents elicited by the fear induction and their relation to the attributes of particular risk taking situations.

While our focus was on behavioural research, there is also a sizeable literature on the neural basis of fear and risk. Most neural studies examine fear and anxiety separately from risk (Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012; Satpute & Lindquist, 2019; Vytal & Hamann, 2010), or risk separately from fear and anxiety (Mohr, Biele, & Heekeren, 2010; Wu, Sacchet, & Knutson, 2012), even though it has been noted across these literatures that fear and anxiety, risk perception and risk taking, frequently engage some of the same areas in common including the insula, dorsal anterior cingulate cortex/pre-supplementary motor area, and amygdala (Hartley & Phelps, 2012; Kuhnen & Knutson, 2005; Mohr et al., 2010). One study that specifically examined the neural mediators between trait anxiety and risk found that frontal midline theta power during the decision phase was associated with reduced risk taking and also mediated the relationship between trait anxiety and reduced risk (Schmidt, Kanis, Holroyd, Miltner, & Hewig, 2018). Frontal midline theta power has been previously linked with activity in the mid cingulate cortex (Cavanagh & Shackman, 2015), which in turn has been linked to both anxiety and cognitive control (Cavanagh & Shackman, 2015; Eisenberger, Lieberman, & Satpute, 2005). Physiological arousal also plays a role in risk seeking and risk avoidant behaviour (Schmidt, Mussel, & Hewig, 2013) and may also involve some of these same neural loci

(Critchley, Mathias, & Dolan, 2001). In relation to our meta-analytic findings, a better understanding of these neural and physiological components may help reveal when fear and anxiety are associated with increased risk aversion or at times with risk seeking.

In conclusion, our meta-analytic review suggests that many studies have observed a relationship between fear and risk taking, but this relationship is highly variable across studies. The literature in general involves a wide variety of heterogeneous methods for inducing and measuring fear, and also for measuring risk. This variance across studies was partially explained by some of our moderators. Studies with clinically anxious samples showed greater risk aversion on average, and studies using tangible rewards (e.g. monetary rewards) also showed greater effects of fear on risk aversion. Nevertheless, there remains high variability in effect sizes across studies suggesting that there is need to test the uniformity of the relationship between fear/anxiety and risk. Research that manipulates and measures fear and anxiety, risk perception and risk taking, using methods that systematically capture different underlying features will be important to understand whether their functional relationship is singular or heterogeneous and also for which situations laboratory studies generalise to more naturalistic settings.

Notes

1. One non-independent effect size included self-reported scores on the Worry Domains Questionnaire in addition to STAI. Critically, we inspected the WDQ v. the STAI and found that both scales have similar items. In fact, the STAI uses "worry" among its items in the questionnaire. Correlations between the two are also high: $r = 0.71$ and $r = 0.73$ in two separate studies (Davey, 1993; Rijsoort, Emmelkamp, & Vervaeke, 1999). Moreover, the WDQ provides no instructions to distinguish worry from anxiety. Because the WDQ includes questions analogous to anxiety surveys, but simply refers to the scale as "worry", we considered it simply a linguistic distinction rather than a conceptual one. Notably, including this one non-independent effect had no impact on the results nor the conclusions of our meta-analysis.
2. Parallel analyses where non-independent effect sizes were aggregated to allow for standard multiple regression analyses revealed the same pattern of results.

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*indicate that the reference was in the meta-analysis.

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