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A systematic review and multilevel meta-analysis of the relationship between boredom and arousal

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Boredom is on the rise, indicating an urgent need to understand its nature and impact. While there is broad agreement on the negative affect associated with its experience, its typical level of arousal remains heavily contested. Therefore, we conducted a three-level random-effects meta-analysis on the boredom-arousal relation across multiple domains. This study was pre-registered via OSF on April 4th, 2024, and we provide the data, the coding manual, and the analysis code at https://osf.io/45zuh/. The databases Web of Science, PsycInfo, PubMed, and ProQuest Dissertations & Theses Global were searched on the 27th of November, 2023. We included all quantitative correlational and experimental studies that targeted human, non-clinical participants and provided effect sizes on the boredom-arousal relation or information to calculate effect sizes. Overall, 214 effect sizes from 72 unique samples that comprised a total of 6570 participants fulfilled the inclusion criteria. Correlational evidence ($i = 75$ effect sizes) suggested that more intensely experienced boredom was related to reduced arousal, $\bar{r} = -.13$, 95% CI [−.22, −.05]. Experimental evidence ($i = 122$ effect sizes) showed that boredom was associated with significantly lower arousal as compared to various control conditions; $\bar{d} = -0.40$, 95% CI [−0.59, −0.22]. However, there was significant heterogeneity in effect sizes, and the relation between boredom and arousal was moderated by the type of boredom measure, the type of arousal measure, and the type of control group in experimental designs. Specifically, the relation was not significant when boredom measures included items that denoted mixed or high arousal, when arousal was assessed via heart rate variability, or when experimentally induced boredom was contrasted with a neutral control condition (e.g., waiting, doing nothing). The assessment of study quality, testing publication status as a moderator, as well as visually and quantitatively assessing funnel plot asymmetry indicated minor to no risk of bias. Implications for the theoretical conceptualization of boredom and future research are discussed. The authors received no external funding for this work.

Over the past 15 years, researchers have noted a population-level increase in boredom[1–3]. This development is concerning, given that boredom has been associated with a range of undesirable outcomes, such as reduced academic achievement[4] and work performance[5], unhealthy eating habits[6], depression[7], and antisocial behavior[8]. Consequently, it is imperative to better understand its nature and underlying mechanisms.

In characterizing emotions, the circumplex model of affect[9,10] proposes two core dimensions: valence (positive vs. negative) and physiological arousal (activating vs. deactivating). There is broad agreement that boredom is an emotion that is experienced as unpleasant[11,12] (i.e., negative valence). However, the level of arousal associated with boredom is the subject of a longstanding yet unresolved debate[13–17]. Not only do theoretical definitions of boredom differ in their approaches to arousal, but empirical studies also seem inconclusive. Empirically, boredom has been found to correlate with self-reported sleepiness, but also with restlessness[14,18,19], with lower and higher cortisol levels[20], and with reduced and increased heart rates[20,21].

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Several reviews have addressed the arousal controversy in boredom research and have suggested explanations and potential moderators[15,22–24]. Still, the prevailing heterogeneity in empirical findings has been described as "split almost perfectly between findings of high and low arousal"[25]. This has led researchers to either conclude that boredom can be related to both high and low arousal[25], or to argue "against using physiological arousal as a determining characteristic of boredom" (p. 493)[15]. There is a clear need for meta-analyses to synthesize the existing empirical results and add a quantitative perspective to the discussion. Importantly, findings from neighboring research disciplines should also be taken into account. For example, in the field of user experience, boredom has increasingly been investigated (among other emotional states) during video game playing, often assessing its relation to engagement and flow, alongside physiological correlates[26].

In sum, the status quo is characterized by a longstanding debate and a range of contradictory findings, some of which have been discussed while others have been overlooked, and no clear solution has been agreed upon. This calls for a quantitative synthesis of evidence to provide estimates of the relation between boredom and arousal, evaluate the heterogeneity of findings, and test proposed moderators. In the following, we first give an overview of the theoretical background of the boredom-arousal controversy. Secondly, we review empirical evidence on arousal in boredom research and discuss potential moderators. Finally, we provide meta-analytic findings on boredom and arousal.

In early psychological theories, optimal level of arousal (OLA) theories proposed an intricate relation between boredom and (increased) arousal—as individuals are motivated to maintain their homeostatic arousal level, deviations prompt discomfort and motivate for adjustment[27,28]. Applied to boredom, these theories suggested that boredom stems from low stimulation but involves increased arousal as individuals seek to restore optimal engagement[13]. Flow theory similarly suggested boredom would arise when skills exceed challenges (i.e., understimulation), prompting efforts to reestablish engagement[29]. Boredom susceptibility was later integrated into sensation-seeking theory as a trait characterized by restlessness (i.e., a high-arousal state) under low stimulation[30]. Overall, earlier psychologists[13,30,31] proposed a dynamic relation between affect and arousal, with low arousal as an antecedent, but increasing arousal as a focal characteristic of boredom.

In contrast to earlier reasoning based on OLA theories, the current understanding of boredom is strongly influenced by appraisal theories of emotions[32–34] (for appraisal theories addressing boredom, see refs. 35,36). Appraisal theories highlight the importance of individuals' cognitive appraisals as antecedents of discrete emotional experiences, emphasizing that emotions arise not merely from physiological arousal but from how individuals cognitively assess and interpret important situations and outcomes. In current boredom research, the appraisal of too much or too little control (i.e., under- or overchallenge) and a lack of value have specifically been named as antecedents to boredom[12,36–38]. Others have noted low situational affordances and low effort[39], attentional difficulties[11], and meaninglessness[40,41] as focal appraisals in the experience of boredom. The increasing acknowledgement of individual appraisals as causes of emotions has reduced attention to physiological arousal and increased awareness that relations between observable stimuli and emotions are diverse and individualized.

In parallel to this change in the understanding of emotions, there was a shift in definitions of boredom. The predominance of concepts of high-arousal boredom in earlier psychological research (i.e., prior to the cognitive turn in the 1960s) has evolved into more diverse approaches to the definition of boredom. Not all of them include the level of arousal as a determining characteristic of boredom. Table 1 provides an overview of major definitions of boredom that either include a high-arousal component, a low-arousal component, both components, or refrain from including arousal in the definition.

In line with opposing definitions of boredom, empirical studies have yielded inconsistent findings regarding the boredom-arousal relation. It has been argued that these might in part be explained by the use of self-report measures of arousal (e.g., self-reported sleepiness and tiredness), as compared to physiological indicators[23]. Indeed, individuals' perceptions of arousal do not always reflect physiological indicators of arousal[21,42]. Further, individuals might not have conscious access to all aspects of their autonomic nervous system[15], and it is therefore inevitable that self-reported arousal does not always align with physiological indicators of arousal. Even though different self-report measures of arousal vary in their relation to boredom scores[14,18,19], qualitative reviews have concluded that effect sizes based on self-report of arousal tend to align more closely, compared to physiological indicators[23].

Physiological indicators of arousal include endocrine measures (e.g., cortisol levels), respiratory measures (e.g., respiration rate), and indicators of activity of the autonomic nervous system, such as cardiovascular parameters (e.g., heart rate, heart rate variability, blood pressure) and electrodermal activity (EDA, including tonic and phasic parameters). The type of physiological arousal indicator has been considered as another factor responsible for contradictory findings on the boredom-arousal relation. Indeed, in many studies that related boredom to physiological arousal, findings based on different arousal indicators did not align[18,20,21]. For example, heart rate levels were not related to boredom, but EDA levels suggested that boredom was related to low arousal[20] (as compared with interest and even sadness). In an experience-sampling study, boredom was found to be negatively related to heart rate, but unrelated to heart rate variability[21].

Besides the measurement of arousal, characteristics of the study designs may cause heterogeneity in findings. In experimental studies on boredom and arousal, different types of control conditions have been used. Some studies have attempted to create baseline conditions that are perceived as neutral as possible, for example, by instructing individuals to rest and wait for several minutes[43]. However, the use of non-neutral comparison conditions is also common. For example, the arousal level in boredom has been compared to arousal in experimentally induced states of fun and excitement[44–46], anger, anxiety, sadness[45], engagement[47], and interest[18,20,48,49]. Thus, it is often not possible to draw any general conclusions about the level of arousal in boredom, but only in relation to the respective affective comparison states. This should not be considered a flaw in the design of the original studies, since the question of typical levels of arousal in boredom was not the main research interest in many of these studies. Nevertheless, the heterogeneity in study designs makes it difficult for boredom researchers to evaluate the existing findings in a coherent manner, thus calling for a quantitative synthesis.

In this meta-analysis, we first calculated the overall effect size for the relation between boredom and arousal (Research Question 1). Second, we estimated the heterogeneity in effect sizes (Research Question 2). We expected to find significant heterogeneity. Third, we used moderator analyses to explain heterogeneity in effect sizes (Research Question 3). As moderators, we considered (a) study design (i.e., correlational vs. experimental, and within- vs. between-subjects designs); (b) type of boredom measure (i.e., whether the instrument included items operationalizing boredom as a low-arousal state, a high-arousal state, a mixed-arousal state, or with no reference to arousal); (c) type of arousal measure (i.e., physiological vs. self-report, and differences between types of physiological measures); (d) type of control condition (i.e., positive and negative affect vs. neutral, and high- and low-arousal vs. neutral); and (e) mean participant age in the original studies.

Methods

Search strategy and keywords

The databases Web of Science, PsycInfo, PubMed, and ProQuest Dissertations & Theses Global were searched on the 27th of November, 2023, using the search algorithm (boredom OR boring OR bored) AND (alertness OR letharg* OR arousal OR psychophysiology OR "heart rate" OR cardiovascular OR "blood pressure" OR "skin conductance" OR "electrodermal activity" OR "galvanic skin potential" OR "skin resistance" OR EDA OR saliva OR cortisol OR fidgety OR restlessness OR calm). The database search resulted in a total of $k = 1625$ identified studies.

Table 1 | Different approaches to arousal in definitions of boredom

Low-arousal boredom	High-arousal boredom	High- and low arousal boredom	Arousal level not considered
Categorization of boredom as a state of negative valence and low arousal within the circumplex model of affect[10,36])	“drive that is reduced through divertive exploration and aroused when external stimuli are excessively scarce or monotonous”; “boredom works through a rise in arousal” (p. 187, p. 189)[13]	“the aversive experience of wanting, but being unable, to engage in satisfying activity”; “boredom can be characterized by low arousal associated with inadequate external stimulation, as well as high internal arousal and frustration” (pp. 482, 487)[11]	“boredom per se is not associated with psychophysiological changes” (p. 237)[17]
“a state of relatively low arousal and dissatisfaction, which is attributed to an inadequately stimulating situation” (p. 3)[125]	“an aversion to routine activities or work and to dull and boring people and a restlessness in an unchanging environment” (p. 189)[134]	“the aversive experience of having an unfulfilled desire to be engaged in satisfying activity […], either agitated, high arousal and/or lethargic, low arousal […], a slow passage of time and an inability to focus his or her attention” (p. 71)[115]	“a transient affective state in which the individual feels a pervasive lack of interest in the current activity” (p. 396)[135]
“relatively mild negative valence, combined with low arousal, low perceived challenge, low perceived meaningfulness, little attention, and little relevance to morality” (p. 7)[41]	“a unitary construct characterized as a restlessness borne of unsatisfactory engagement” (p. 24)[14]	“boredom may be best understood as multiple “boredoms” that differ based on valence and arousal” (p. 413)[118]	“arousal should not be taken to be a determining characteristic of boredom” (p. 499)[15]

This table provides major examples of boredom definitions and their stance on arousal (for a more comprehensive overview of boredom definitions, see Vogel–Walcutt et al.[24].

Eligibility and screening

After the removal of 514 duplicates using Mendeley[50] and the revtools package[51], 1111 studies remained for screening. Studies were considered eligible when they met the following criteria. They were included if (1) the study was quantitative; (2) the study targeted human, non-clinical participants; (3) in experimental studies, boredom (or arousal) was successfully manipulated (i.e., the manipulation check confirmed a statistically significant difference between the conditions), and arousal (or boredom) was measured; (4) in correlational studies, both boredom and arousal were measured; (5) boredom was related to one’s own experience (as opposed to rating the boringness of relationships, people, or food); (6) effect sizes or information to calculate effect sizes were provided; (7) the data made it possible to estimate the synchronous (rather than lagged) relation between boredom and arousal.

In the screening process, we excluded $k = 835$ publications based on these criteria. Of the remaining 276 publications, we further excluded 220 publications during the coding process due to the reasons specified in the flow chart (Fig. 1). If the relevant variables were assessed, and the study was published within the past ten years (i.e., since 2014), but effect sizes were not reported, the study was considered for author consultation ($k = 35$). The corresponding authors of these studies were contacted via e-mail in March 2024. In sum, 12 authors responded, and eight authors provided the relevant information, which led to the inclusion of $i = 69$ additional effect sizes. During the screening process, the study authors held regular meetings to discuss unclear cases. The inter-rater congruency for inclusion (yes/no) in a subsample of 25 studies was 86%. We included 56 records for coding[14,20,21,26,41,43,44,48,49,52–98]. Numbers of studies, unique samples, and effect sizes are denoted using k, j, and i, respectively.

Coding of study information

The coding manual, including a detailed description of all coding categories and guidelines for coding decisions, can be found on OSF. The intercoder reliability was assessed for a randomly drawn subsample of $k = 14$ coded studies. There were very few incongruencies (7 coded values out of 1456), related to the coding of the overall participant sample size, group sample sizes, and percentages of male and female participants. The congruency in the double-coded sample was 99.52%, and the congruency with respect to the coded effect sizes was 100%.

Meta-analytic approach

Effect size calculation. For effect sizes from experimental studies using between-subjects designs, we calculated standardized mean differences with bias-corrected sampling variances (Hedges’ g) to avoid overestimation of effects[99]. For effect sizes from experimental studies using within-subjects designs, we calculated mean differences with a raw score standardization for heteroscedastic population variances. We set the correlation between the measurements of the dependent variable (i.e., before and after the manipulation, or in the experimental vs. control conditions) to $ri = 0.70$, choosing a rather conservative approach[99] (see also Supplementary Fig. S1 in the supplementary information for a sensitivity analysis on varying specifications of ri). For correlational designs, effect sizes (i.e., Pearson’s r or non-specified types of correlations) were z-transformed prior to inclusion in the meta-analytic model to approximate normality, and back-transformed to r for presentation of results in text and tables. For experimental designs, we calculated standardized mean differences (Cohen’s d; see Supplementary Fig. S1 in the supplementary information for more detailed information). Effect sizes and sampling variances were computed using the metafor package[100] in R[101].

Meta-analytic model. Whenever multiple effect sizes are reported within one study or for the same sample, the meta-analytic data structure is hierarchical. We addressed this issue by using multilevel modeling. Specifically, we modeled the sampling variance for each effect size on Level 1, the within-study variance of effect sizes on Level 2, and the between-study variance on Level 3. Restricted Maximum-Likelihood estimation (REML) was used for parameter estimation. We applied the Knapp and Hartung[102] adjustment to the calculation of standard errors to reduce the risk of inflated type 1 error (i.e., by using an F-/t-distribution instead of a chi-square distribution) in all models. Further, we used likelihood-ratio tests to evaluate the significance of variance components on Levels 2 and 3. Note that independent samples—even when included within one publication (i.e., multi-study papers)—were treated as separate studies. This means that Level 3, or the study level, refers to independent samples, denoted by j. For moderator analyses, we extended the three-level intercept-only random-effects model to a mixed-effects model. As the dependent variable is the boredom-arousal effect size (i.e., already a standardized variable), we report unstandardized b for all moderator analyses using categorical predictors (e.g., moderation of overall effect by study design). Only with continuous moderator variables (e.g., the inverted sample size for bias analyses), we report standardized β, which then indicates the change in the outcome (i.e., overall effect size) in standard deviations of the overall effect size. In specifying the three-level

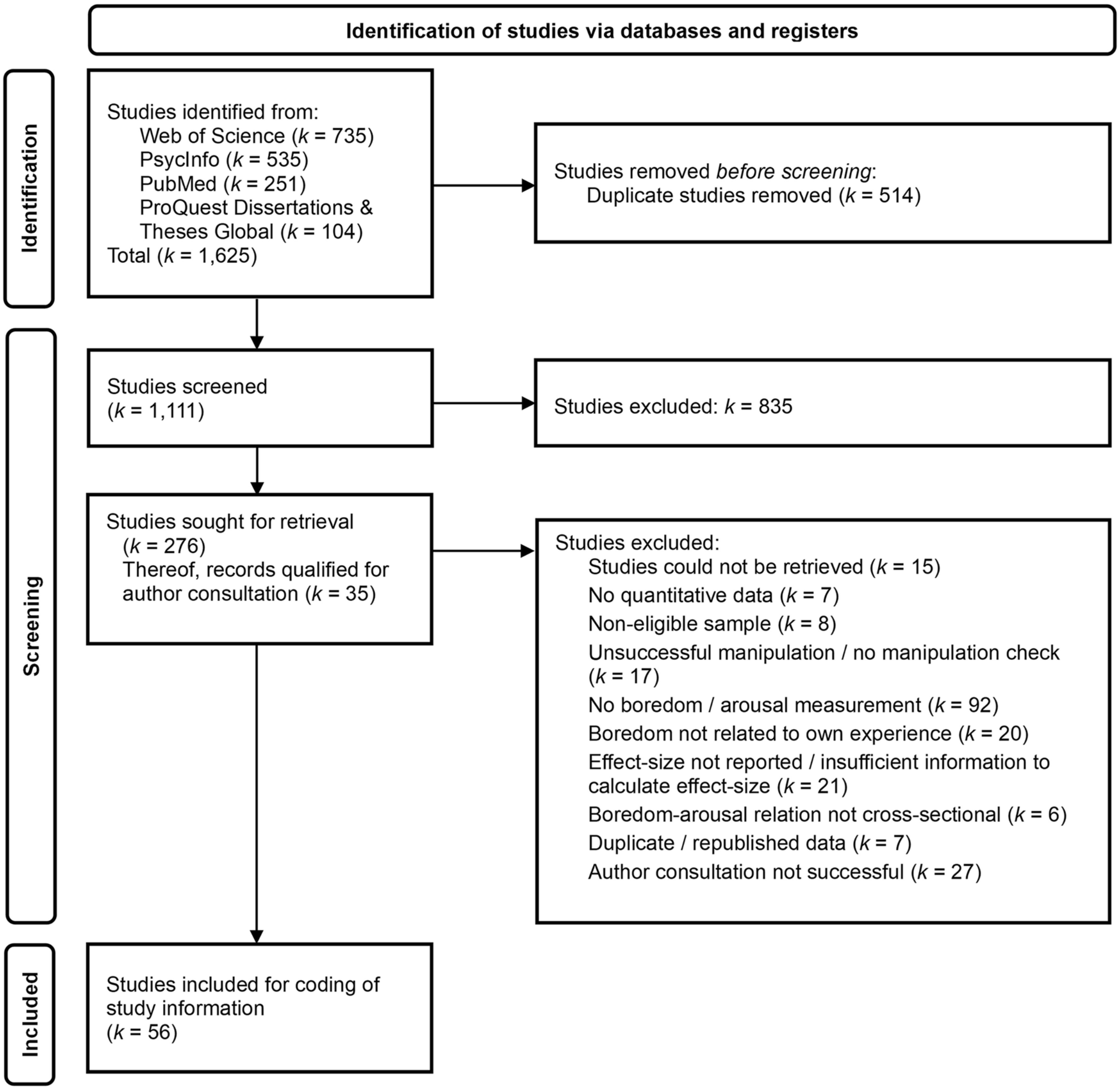

Fig. 1 | Prisma flow diagram. *Note*. The number of studies is denoted with *k*.

meta-analytic models, as well as the moderator models, we followed the approach proposed by Assink and Wibbelink[103].

Risk of bias assessment

We tested publication status as a moderator of the boredom-arousal relation, visually inspected the funnel plot, and used Egger's regression test in the multilevel context for a quantitative test of funnel plot asymmetry[104] (i.e., adding the inverse sample size as a predictor to the multilevel meta-analytic model). Moreover, we provide a color-coded funnel plot (i.e., sunset plot) which indicates the studies' power to detect the overall effect size, given the respective sample size.

Further, we coded all occurrences of non-significant effects that did not specify effect sizes as zero effects. These zero effects were not included in the main analyses but were tested for their impact on the main results in a sensitivity analysis.

Descriptively, we provide an estimate of the overall risk of bias attached to each coded effect size, based on the approach suggested in the Cochrane risk-of-bias tool 2[105]. We assessed the quality of effect size coefficients using different criteria, specific to the study design, and assigned the values low risk (= 0), some risk (= 1), and high risk (= 2). For effect sizes from correlational designs, we assessed (a) the number of items used to measure boredom and arousal (0 = scale with three or more items; 1 = two-item scales; 2 = single-item measures), (b) and (c) the reliability of boredom and arousal scales, respectively (0 = Cronbach's $\alpha \geq 0.80$; 1 = Cronbach's α 0.70–0.79; 2 = Cronbach's $\alpha < 0.70$), and (d) the conceptual alignment of constructs (0 = conceptual match, i.e., state related to state or trait related to trait; 2 = conceptual mismatch, i.e., state related to trait). The risk of bias in experimental studies was assessed with four indicators: (a) random assignment of participants to experimental conditions (0 = yes; 2 = no); (b) standardized mean difference in the manipulation check (0 = Cohen's $d > 0.65$; 1 = Cohen's d 0.35–0.65; 2 = Cohen's $d < 0.35$); (c) report of data missing for participants (0 = yes; 2 = no); (d) report of data missing for observations (e.g., incomplete data from continuous assessments of a physiological variable; 0 = yes; 2 = no).

Transparency and openness

This study was pre-registered via OSF on April 4th, 2024, and we provide the data, the coding manual, and the analysis code at https://osf.io/45zuh/. Data were analyzed using R[101], version 4.5.1, specifically, the packages metafor[100] (version 4.6-0), metaviz[106] (version 0.3.1), and ggplot2[107] (version 3.5.2). In preparing the manuscript we adhered to PRISMA[108] and MARS[109] guidelines. We report on the sample size (i.e., number of effect sizes) and all exclusions of samples or effect sizes (see Fig. 1). We report all manipulations (i.e., effect size calculation and transformations) in the methods section. This study did not require ethical approval, as we extracted all information from published studies or via author consultation.

Table 2 | Descriptive study characteristics

Study characteristic	Experimental	Correlational	*t* (*p*)
Total numbers, *i* (*j*)	122 (36)	75 (33)	
Peer-reviewed journal articles, *i* (*j*)	79 (23)	69 (30)	
Gray literature, *i* (*j*)	43 (13)	6 (3)	
Sample size, *M* (*SD*)	58.78 (53.12)	134.97 (160.53)	**−2.69 (0.009)**
Age, *M* (*SD*)	25.64 (6.61)	26.21 (6.24)	−0.31 (0.76)
Percent female in sample, *M* (*SD*)	53.62 (27.47)	41.69 (33.79)	1.47 (0.15)
Reliability boredom, *M* (*SD*)	0.80 (0.06)	0.76 (0.13)	1.39 (0.19)
Reliability arousal, *M* (*SD*)	0.87 (0.03)	0.78 (0.10)	0.39 (0.70)
Boredom measured as state, *i*	101	55	
Boredom measured as trait, *i*	21	20	
Arousal measured as state, *i*	102	66	
Arousal measured as trait, *i*	20	9	
Manipulated variable: boredom, *i* (*j*)	92 (25)		
Manipulated variable: arousal, *i* (*j*)	30 (11)		
Significantly positive effect sizes, *i*	8	7	
Significantly negative effect sizes, *i*	64	16	
Non-significant effect sizes, *i*	50	52	

p-value indicates if values differ significantly between experimental and correlational designs. The t-test assessed two-sided significance. **Bold** values indicate significant differences.
j = number of unique samples, *i* = number of effect sizes, *M* = mean, *SD* = standard deviation.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Results

Study and effect size characteristics

We included a total of $k = 56$ studies, which provided $i = 214$ effect sizes nested in $j = 72$ unique samples. For $i = 17$ out of those 214 effect sizes, the original articles did not provide numeric effect size information but reported that the relation was not significant. For the main analyses, we therefore moved forward with $i = 197$ effect sizes nested in $j = 69$ unique samples from $k = 54$ studies. However, we repeated the analyses with the dataset including the $i = 17$ null effects in a sensitivity analysis (see Moderator Analyses—Publication Bias).

The $k = 54$ studies were published between 1939[52] and 2023[21]. The studies could be assigned to the following research fields: psychophysiology ($k = 14$ studies, $i = 79$ effect sizes), personality and individual differences ($k = 13$ studies, $i = 36$ effect sizes), gaming/user experience ($k = 10$ studies, $i = 31$ effect sizes), and other contexts (e.g., educational and occupational psychology, $k = 17$ studies, $i = 51$ effect sizes). A mean of 2.86 effect sizes ($SD = 2.43$) was reported per unique sample (range = 1–10, $Mdn = 2$). The number of significantly positive, significantly negative, and non-significant effect sizes is denoted in Table 2. A forest plot of all included effect sizes can be found in the supplementary information (Supplementary Figs. S2 and S3). The overall sample size was $N = 6570$ participants (n range = 4–739, $M = 95.22$, $SD = 122.67$, $Mdn = 44$). Across studies, on average, 47.45% of the participants were female ($SD = 31.22$), and 49.67% were male ($SD = 31.45$). There were only three studies that reported the share of gender-diverse individuals in their samples (i.e., 0.2%[110]; 1.49%[53]; 1.57%[54]). Most samples were collected from the United States of America ($j = 31$), followed by samples from Canada ($j = 7$), the United Kingdom ($j = 6$), Germany ($j = 4$), Australia and Sweden (each $j = 3$), and other countries (each $j \leq 2$; i.e., Austria, Denmark, Finland, Japan, Netherlands, Portugal, Russia, Turkey, and multiple countries within one sample). Sample ethnicity and race were not coded due to inconsistent reporting in primary studies. Table 2 gives an overview of the descriptive study characteristics for experimental and correlational studies. There was a significant difference between experimental and correlational study designs only regarding sample size (i.e., samples were significantly smaller in experimental studies; $\beta = -0.62$, $p = 0.009$, 95% CI [−1.08, −0.16]; see Table 2). A full list of study characteristics for all included studies can be found in the supplementary information (Supplementary Fig. S4).

Overall effect size and heterogeneity

For correlational designs, the overall effect size was $\bar{r} = -0.13$ (95% CI [−0.22, −0.05]). For experimental designs, the overall effect size was $\bar{d} = -0.40$ (95% CI [−0.59, −0.22]). As such, higher boredom was significantly related to lower arousal (in correlational studies), and the state of boredom was associated with significantly lower arousal as compared to control conditions (in experimental studies). There was significant heterogeneity among effect sizes, distributed across the three levels of the models (see Table 3), with one exception. Among effect sizes from correlational designs, there was no significant heterogeneity in effect sizes on Level 3 (i.e., between studies, $p = 0.08$, 95% CI[0.00, 0.08]). The overall effect sizes are visualized in a forest plot in Fig. 2.

Moderator analyses

Study design. We found no statistically significant evidence for a moderation effect of study design on the overall effect size (Table 4). This applied to both experimental versus correlational designs and within- versus between-subjects designs.

Type of boredom measure. Across studies, a heterogeneous set of self-report instruments was used to assess boredom. Some of the instruments included items that denoted some level of arousal, creating construct overlap between boredom and arousal. To address this problem, we categorized the boredom scales by whether their items denoted low, mixed, high, or no arousal. Boredom was assessed without arousal implications for $i = 119$ effect sizes (e.g., "Rate the extent you feel at the moment… bored"; Positive and Negative Affect Schedule[111]). For a total of $i = 10$ effect sizes, items denoted low arousal (e.g., using the circumplex affective space grid where boredom is presented as low-arousal state[112]). Mixed arousal was denoted in $i = 15$ (e.g., scales including both "I start yawning" and "I get restless"; see Achievement Emotions Questionnaire[113]), and high arousal for $i = 6$ effect sizes (e.g., scales including "I get restless […]", but no items indicating low-arousal states;

Table 3 | Results of the three-level random effects model of boredom and arousal

Parameter	Estimate	95% CI	*t* / LRT	*p*	Heterogeneity	
					Q(df)	I^2
Correlational (*i* = 75)						
Intercept ($\bar{r}$)	−0.13	[−0.22, −0.05]	−3.05	0.003	638.20(74)	9.92
σ^2 (L2)	0.04	[0.02, 0.09]	99.51	<.001		57.42
σ^2 (L3)	0.03	[0.00, 0.08]	3.02	0.08		32.67
Experimental (*i* = 122)						
Intercept ($\bar{d}$)	−0.40	[−0.59, −0.22]	−4.34	<0.001	2672.82(121)	3.85
σ^2 (L2)	0.16	[0.12, 0.23]	788.06	<0.001		41.13
σ^2 (L3)	0.22	[0.12, 0.41]	54.31	<0.001		55.02

Note. L2 and L3 = Levels 2 and 3. LRT = likelihood ratio test, indicates comparison between the three-level model with a model with fixed variance at L2/ L3. *t* is denoted for the intercept, LRT for σ^2 (L2) and σ^2 (L3). The LRT and Q-test inherently assessed one-sided significance. The t-test assessed two-sided significance. *Q*(df) is significant at $p < 0.01$. *i* = number of effect sizes. I^2 = explained variance relative to total explained variance.

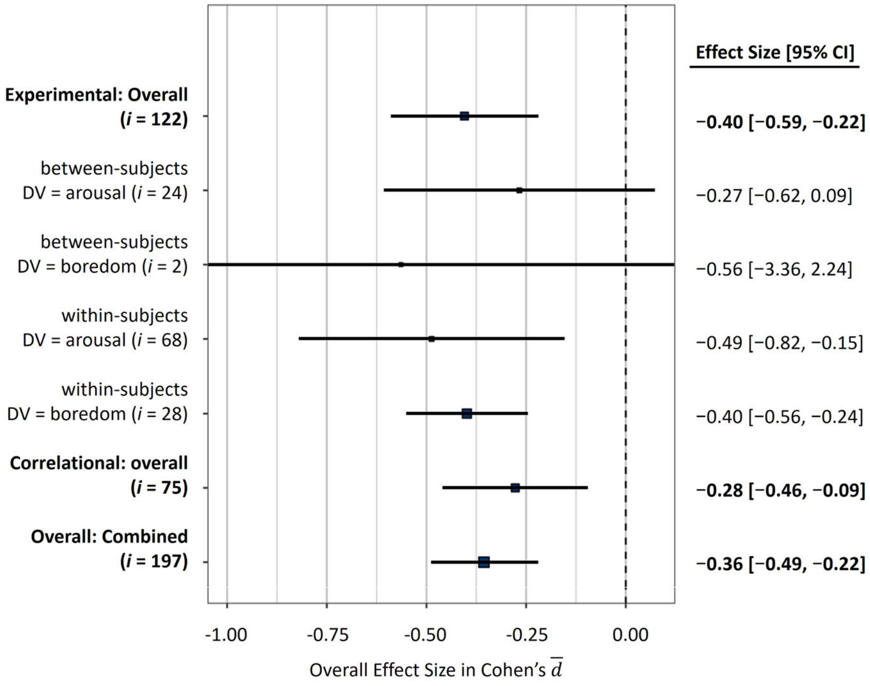

Fig. 2 | Forest plot of overall effect sizes grouped by design. *Note.* All overall effect sizes are presented as $\bar{d}$ (i.e., the overall effect size from correlational study designs was transformed from *r* to *d*). *i* = number of effect sizes. DV = dependent variable. Boxes represent effect sizes. Horizontal lines represent the width of the 95% confidence intervals.

see Boredom Susceptibility Scale[114]). The remaining 47 effect sizes were excluded from the moderator analysis because item wordings were not reported.

The moderator model was significant, $F(3, 146) = 7.48$, $p < 0.001$ (see Table 4). Among the group of effect sizes that operationalized boredom without arousal-related items (i.e., the baseline category and intercept of the moderator model), the aggregate effect size was $\bar{d} = -0.37$, $p < 0.001$, 95% CI [−0.50, −0.25]. The aggregated effect size for the category "low-arousal boredom assessment" did not significantly differ from the baseline category, $b = -0.14$, $p = 0.48$, 95% CI [−0.54, −0.25]. However, the effect sizes in the categories "mixed-arousal boredom assessment" and "high-arousal boredom assessment" were significantly smaller ($b = 0.65$, $p < 0.001$, 95% CI [0.34, 0.96], and $b = 0.50$, $p = 0.02$, 95% CI [0.09, 0.91], respectively). In fact, the meta-analytic effect sizes based on mixed-arousal ($\bar{d} = 0.27$, $p = 0.06$, 95% CI [−0.01, 0.56]) and high-arousal boredom measures ($\bar{d} = 0.13$, $p = 0.52$, 95% CI [−0.26, 0.52]) revealed no significant relation to arousal.

Type of arousal measure. We tested characteristics of the arousal measure as moderators. First, we tested whether the type of arousal measure (i.e., self-report vs. physiological assessment) moderated the overall effect size from experimental and correlational studies. We found no statistically significant evidence for moderation effects for type of arousal measurement (see Table 4). Second, we tested for the moderating effects of the type of (objective) physiological measure. We compared measures of heart rate, heart rate variability (recoded; higher values indicating higher arousal), EDA, blood pressure, cortisol level, and a miscellaneous category. The miscellaneous category combined blink duration ($i = 2$), breathing ($i = 2$), and immunoglobin concentration ($i = 2$).

We found no statistically significant evidence for a moderating effect of type of physiological indicator. However, there was a significant difference between heart rate variability and heart rate among experimental designs, $b = 0.43$, $p = 0.04$, 95% CI [0.01, 0.85]. This suggested that when measuring arousal via heart rate variability, the relation between boredom and arousal was significantly closer to zero. In fact, the overall effect size for the boredom-arousal relation when including only measures of heart rate variability ($i = 16$) was not significant ($\bar{d} = 0.05$, $p = 0.81$, 95% CI [−0.36, 0.45]).

Table 4 | Results of moderator analyses

Moderator	Subgroup comparison	*F*	df	*b*	*t*	*p*	95% CI
Study design							
Correlational ($i = 75$)	within ($i = 5$) vs. between ($i = 70$)	0.003	1, 73	0.01	0.05	0.96	[−0.32, 0.33]
Experimental ($i = 122$)	within ($i = 96$) vs. between ($i = 26$)	0.46	1 120	−0.14	−0.68	0.50	[−0.56, 0.27]
Boredom measure							
Overall ($i = 150$)	no-arousal ($i = 119$) vs. low-arousal boredom items ($i = 10$)	**7.48**	**3 146**	−0.14	−0.71	0.48	[−0.54, 0.25]
	no-arousal ($i = 119$) vs. mixed-arousal boredom items ($i = 15$)			**0.65**	**4.09**	**<0.001**	**[0.34, 0.96]**
	no-arousal ($i = 119$) vs. high-arousal boredom items ($i = 6$)			**0.50**	**2.42**	**0.02**	**[0.09, 0.91]**
Arousal measure							
Correlational ($i = 75$)	self-report ($i = 49$) vs. physiological ($i = 25$)	0.56	1, 72	0.06	0.75	0.46	[−0.10, 0.23]
	heart rate ($i = 9$) vs. heart rate variability ($i = 10$)	0.05	5, 19	0.03	0.36	0.72	[−0.15, 0.21]
	heart rate ($i = 9$) vs. EDA ($i = 2$)			0.01	0.07	0.95	[−0.35, 0.38]
	heart rate ($i = 9$) vs. blood pressure ($i = 1$)			0.03	0.08	0.94	[−0.82, 0.88]
	heart rate ($i = 9$) vs. cortisol ($i = 2$)			0.06	0.36	0.72	[−0.29, 0.41]
	heart rate ($i = 9$) vs. miscellaneous category ($i = 1$)			0.02	0.05	0.96	[−0.82, 0.87]
Experimental ($i = 122$)	self-report ($i = 49$) vs. physiological ($i = 73$)	3.08	1 120	−0.26	−1.75	0.08	[−0.56, 0.03]
	heart rate ($i = 37$) vs. heart rate variability ($i = 6$)	**1.35**	**5, 67**	**0.43**	**2.05**	**0.04**	**[0.01, 0.85]**
	heart rate ($i = 37$) vs. EDA ($i = 12$)			0.14	0.83	0.41	[−0.20, 0.49]
	heart rate ($i = 37$) vs. blood pressure ($i = 9$)			0.05	0.33	0.74	[−0.26, 0.36]
	heart rate ($i = 37$) vs. cortisol ($i = 4$)			−0.07	−0.35	0.73	[−0.44, 0.31]
	heart rate ($i = 37$) vs. miscellaneous category ($i = 5$)			−0.23	−0.78	0.44	[−0.82, 0.36]
Type of control condition							
Experimental ($i = 92$)	neutral ($i = 16$) vs. negative affect control condition ($i = 45$)	2.02	2, 89	−0.46	−1.97	0.05	[−0.93, 0.01]
	neutral ($i = 16$) vs. positive affect control condition ($i = 31$)			−0.19	−0.81	0.42	[−0.66, 0.28]
	neutral ($i = 16$) vs. high arousal control condition ($i = 57$)	**17.34**	**2, 89**	**−0.52**	**−2.64**	**0.009**	**[−0.91, −0.13]**
	neutral ($i = 16$) vs. low arousal control condition ($i = 19$)			0.09	0.44	0.66	[−0.31, 0.49]

Note. Effect sizes from experimental designs and the combined dataset in *d*, effect sizes from correlational designs in *r*. If the type of arousal measure was not indicated, then the effect size coefficient was excluded from the analysis. The moderation effect (*b*) is unstandardized, i.e., represents the absolute difference in overall effect sizes in the respective metric (*r*, *d*). The F-test inherently assessed one-sided significance. Significant effects are printed in **bold**.

i number of effect sizes.

Type of control condition. The investigation of the arousal level associated with boredom in experimental designs is always based on a comparison. If boredom is manipulated and arousal is measured, then the effect size (Cohen's *d*) for the boredom-arousal relation results from comparing the arousal level in the boredom condition to the arousal level in a control condition. The choice of control condition can be very different and presumably has an influence on the difference in arousal. Therefore, we tested for types of control conditions as moderators in experimental studies that manipulated boredom and measured arousal ($i = 92$ effect sizes).

As a first moderator, we compared effect sizes based on designs using neutral control conditions (waiting, doing nothing; $i = 16$) to effect sizes based on designs using negative affect control conditions (i.e., anger, anxiety, depressed affect, disappointment, sadness, regret, guilt, shame, disgust, fear, frustration; $i = 45$) and positive affect control conditions (excitement, engagement, fun, sexual arousal, interest, and physical/cognitive activity; $i = 31$). For a second moderation analysis, we re-grouped the categories and compared effect sizes based on designs using neutral control conditions (waiting, doing nothing; $i = 16$) to effect sizes based on designs using high arousal control conditions (anger, anxiety, frustration, sexual arousal, excitement, physical/cognitive activity, fun, engagement, guilt, shame, disgust; $i = 57$) and low arousal control conditions (depressed, disappointment, sadness, regret; $i = 19$).

Type of control condition significantly moderated the effect sizes (Table 4). The difference in arousal between the boredom condition and the high-arousal condition was significantly larger (i.e., more negative; $\bar{d} = -0.60$, 95% CI [−0.95, −0.25]) than the difference in arousal between the boredom condition and the neutral control condition. In fact, when the overall effect size was estimated only for studies where arousal in the boredom condition was contrasted with a neutral condition ($i = 16$), there was no significant relation between boredom and arousal, $\bar{d} = -0.03$, $p = 0.75$, 95% CI [−0.26, 0.19].

Mean participant age. The mean participant age of the original studies did not significantly moderate the effect sizes, $i = 156$, $F(1, 154) = 0.80$, $p = 0.37$, $b = -0.01$, 95% CI [− 0.03, 0.01].

Risk of bias

Risk of bias in effect sizes. Overall, most effect sizes (54.53%) showed a low risk of bias (see Fig. 3). For correlational effect sizes, risk of bias was primarily driven by the use of single-item measures. In effect sizes obtained from experimental designs, the highest risk of bias ratings

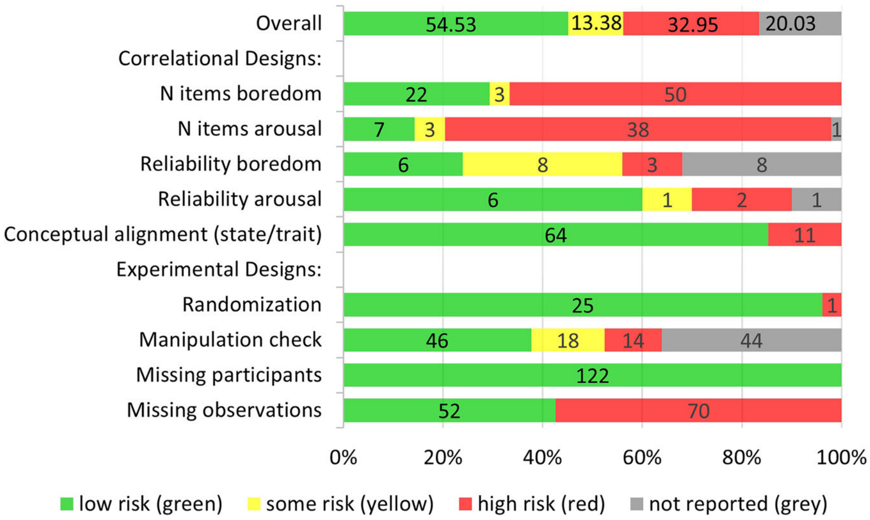

Fig. 3 | Risk of bias ratings for included effect sizes. *Note*. Figures are percentages for the overall assessment and frequencies for all other categories. Each category refers to a different set of effect sizes that qualify for the respective category. For instance, the reliability of the boredom measurement could only be rated for $i = 25$ effect sizes from correlational designs for which boredom was measured via self-report using more than one item.

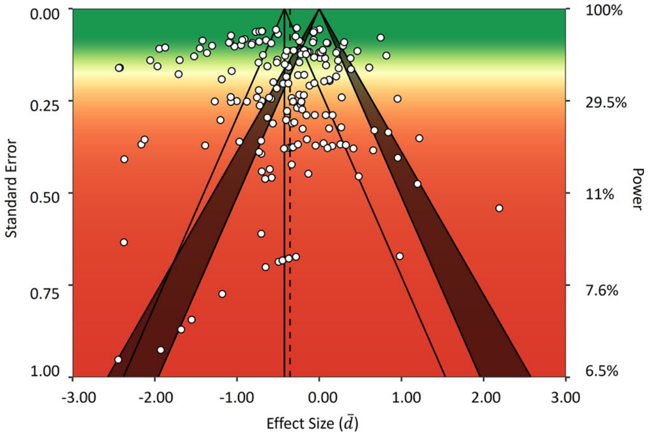

Fig. 4 | Power-enhanced funnel plot. *Note*. The vertical line represents the overall effect size of $\bar{d} = -0.36$ ($i = 197$ effect sizes). The solid black lines symmetric around the overall effect size represent its 95% confidence interval. The shaded area represents significance contours at the 0.05 (within shaded area) and 0.01 (outside shaded area) levels. The white dots represent the individual effect sizes. The colored background represents the power to detect the overall effect size, given the standard error. Green represents high power, red represents low power.

resulted from a lack of transparency regarding the reporting of missing observations. Neither the reliability of the boredom measure, $i = 47$, $F(1, 45) = 1.09$, $p = 0.30$, $\beta = 0.10$, 95% CI $[-0.09, 0.28]$, nor the reliability of the arousal measure, $i = 20$, $F(1, 18) = 2.45$, $p = 0.13$, $\beta = -0.22$, 95% CI $[-0.50, 0.07]$, significantly moderated the effect sizes. The conceptual alignment of state and trait (i.e., congruent) as compared to a mismatch (i.e., incongruent; baseline category) did not moderate the effect sizes, $i = 197$, $F(2, 194) = 0.47$, $p = 0.63$, β (state match) $= -0.24$, 95% CI $[-0.72, 0.25]$, β (trait match) $= -0.23$, 95% CI $[-0.81, 0.35]$.

Publication bias. There was no significant difference between effect sizes (in Cohen's d) from peer-reviewed journal articles ($i = 148$; baseline category) and doctoral dissertations ($i = 49$), $F(1, 195) = 0.20$, $p = 0.65$, $\beta = 0.07$, 95% CI $[-0.24, 0.37]$. The visual inspection of the funnel plot indicated a lack of observations on the bottom right of the funnel, which is an indicator of publication bias[99] (see Fig. 4). However, Egger's regression test, as a quantitative test of funnel plot asymmetry, was not significant, $Q(1) = 0.70$, $p = 0.40$, $\beta = -0.07$, 95% CI $[-0.22, 0.09]$. Consequently, there was no indication that publication bias did impact the overall effect size. The result of the sunset plot indicates that the medium power in the original studies, given their sample sizes and the overall effect size estimate, was 43%.

Including $i = 17$ zero effects did not significantly affect the overall results (neither for the overall dataset nor for effect sizes from correlational or experimental studies). The overall effects when including $i = 17$ null-effects were comparable in direction and strength and differed only marginally in size ($\Delta\bar{d} < 0.03$; see Supplementary Fig. S5 in the supplementary information) from the estimates not including zero effects (see Table 2).

Discussion

In this quantitative synthesis of findings on boredom and arousal, we included 214 effect sizes from 75 unique samples, including a total of 6570 participants. The result for correlational designs ($i = 75$, $\bar{r} = -0.13$) indicates that more intensely experienced boredom is related to lower arousal, as compared to less intensely experienced boredom. Experimental evidence ($i = 122$, $\bar{d} = -0.40$) indicates a significantly lower average arousal in the state of boredom as compared to the average arousal in the comparison conditions. These comparison conditions included positively and negatively valenced, as well as high- and low-arousal affective states. This finding contrasts with the prevailing view that the available empirical findings do not suggest any clear direction for the boredom-arousal relation[15,25]. However, there was significant heterogeneity among the included effect sizes, which highlights the relevance of moderator analyses as opposed to merely interpreting the overall effects. The results therefore do not indicate that boredom is invariably a low-arousal state, but that the existing studies converge on a modal pattern of low-arousal boredom, with substantial heterogeneity that warrants further exploration through moderator analyses.

Moderation by types of boredom measures

First, the type of boredom measure significantly moderated the effect sizes. Specifically, when the boredom instruments contained items indicating mixed or high arousal, the relations between boredom and arousal were closer to zero than when the instruments did not refer to arousal. This finding is relevant because it highlights that negative relations may be due to construct overlap between boredom and arousal, as implied by definitions of boredom that include levels or patterns of arousal as a component. Construct overlap and partially tautological relations between boredom and arousal are not due to psychometric deficits of boredom measures. If boredom is defined as including low, high, or variable arousal, there is construct overlap by definition, and relations with other measures of arousal follow from the definition of boredom. For measures based on this type of definition, relations with physiological indicators of arousal are desirable and document construct validity.

This applies, for example, to the widely used Multidimensional State Boredom Scale[115] and the Achievement Emotions Questionnaire[113], which include items for high and low arousal, as well as to the Boredom Susceptibility Scale[114], which includes high-arousal items. However, the group sizes for the categories "no arousal implication" ($i = 119$) and "mixed" ($i = 15$) or "high arousal implication" ($i = 6$) were highly unbalanced, calling for a cautious interpretation of this result. Moreover, other relevant moderators potentially overlap with the moderator of type of boredom measure (e.g., characteristics of the experimental design, arousal measure), which could lead to spurious effects. To validate differences in effect sizes across measures, experimental studies with a fully-crossed factorial design are needed to contrast subgroups in a balanced manner. At the meta-analytical level, however, the evidence is currently too limited for such an analysis.

Moderation by type of physiological indicator

In contrast to conclusions in previous reviews[23], there was no significantly moderating effect of type of arousal measure (i.e., self-report versus physiological). However, contrasting different types of physiological arousal indicators revealed a significant moderation. Specifically, there was a significant difference in the strength of the boredom-arousal relation when arousal was measured via heart rate (HR) versus heart rate variability (HRV). In fact, when arousal was assessed via HRV (recoded, i.e., higher values indicate higher arousal), the boredom-arousal relation was not significant (note that this moderation effect was based on experimental studies only, as it could not be observed in correlational studies).

Even though the subgroup of effect sizes based on HRV measures ($i = 6$) was considerably smaller than the subgroup of effect sizes based on HR measures ($i = 37$), this difference is not trivial. This finding contributes to an ongoing debate on the understanding of arousal in emotions[116]. First, the finding provides further support that different indicators of nervous system activity (i.e., sympathetic activation and parasympathetic deactivation) do not always align. Rather than treating arousal as a unitary construct, recent work argues that arousal is multidimensional[117] and cannot be sufficiently captured by the arbitrary selection of a single indicator of nervous system (de-)activation. From this perspective, differential activation of distinct parts of the nervous system does not constitute a contradiction (i.e., decreased HR in boredom, which may hint towards sympathetic deactivation, but no relation to HRV as an indicator of parasympathetic activation). Emotions may even be better characterized by complex activation patterns than by a simple high-low arousal dimension.

Such a multidimensional understanding of arousal also helps reconcile seemingly contradictory descriptions of boredom as both under-aroused and restless[14]. The negative relation between boredom and HR may reflect feelings of deactivation or tiredness; however, boredom is not experienced as restful or replenishing, as would be implied by increased parasympathetic activation (i.e., a significant positive relation with HRV).

The question remains why heart rate variability was nevertheless correlated with boredom in correlational studies. Unlike in experimental studies, in correlational studies, both HR and inverted HRV were significantly and negatively related to boredom (i.e., uniformly suggesting low arousal). These different arousal patterns in experimental studies compared to correlational studies could result from different contextual conditions of the research designs. In experimental studies, boredom is most often induced by highly monotonous routine tasks that aim to rule out any type of active engagement in participants. For example, participants were instructed to count vowels[55], write the letters "cd" over and over again[18], watch a video of two men hanging laundry[20], or place marbles from one bowl into another bowl[56]. There is agreement that a certain degree of monotony is a core determinant of the experience of boredom. However, boredom experienced under these rather exceptional conditions of extreme mental underload may exhibit a different physiological pattern than "everyday boredom" addressed in many correlational studies. Similarly, an experience sampling study identified different types of boredom that varied in their levels of valence and arousal, with "reactant boredom" being perceived as the most unpleasant boredom type, which was also associated with higher levels of arousal[118]. While the idea of distinct types of boredom remains contested[15], it nevertheless illustrates that boredom can involve different levels of arousal depending on both situational and individual factors.

Further, in these experimentally induced states of boredom, participants might need to exercise a significant amount of self-regulation and mental effort[119] (also indicated by low HRV) just to execute these highly monotonous tasks. Consequently, levels of HRV might not differ between experimentally induced boredom states and comparison conditions involving tasks that also require top-down regulation (albeit less aversive regulation, for example, when writing an interesting story).

Moderation by type of control group

Lastly, in experimental designs, the type of control condition significantly moderated effect sizes. Arousal was substantially lower in boredom conditions than in control conditions involving high-arousal affect, suggesting that boredom is linked to reduced arousal at least as compared with affective states such as anger, anxiety, frustration, sexual arousal, excitement, physical/cognitive activity, fun, engagement, guilt, shame, and disgust ($\bar{d} = -0.60$). However, arousal was not significantly lower relative to neutral baseline conditions. This finding suggests that boredom does not reduce arousal below individual baseline levels. In order to be considered a deactivating emotion, this criterion would have to be met. Still, the significantly negative overall effect size from correlational studies ($i = 75$, $\bar{r} = -0.13$) supports the view that boredom typically is a deactivating emotion. To explain the findings, it is essential to examine the design of the neutral control conditions more closely. For example, sitting still for several minutes with eyes closed—will this actually put participants in a state that reflects baseline arousal? If neutral control conditions unintentionally place participants in low-arousal states, then differences to the arousal signature in boredom states may no longer be detectable. Alternatively—to determine individuals' true neutral reference states—future studies could collect baseline data using experience sampling methodology[120] throughout a longer time period and compare arousal in instances of boredom to individual mean arousal over time. Ketonen et al. [21] used such a procedure and found that boredom was related to reduced HR, but unrelated to HRV, reflecting the same arousal pattern we identified in our moderator analysis contrasting different indicators of physiological arousal.

Limitations

When interpreting the results of this meta-analysis, several limitations should be noted. Some effect size categories showed risk of bias (Fig. 3), especially those from correlational studies that relied heavily on single-item measures of boredom and arousal. While such items can be valid[121], arousal is likely multidimensional, and single-item measures may reduce reliability —potentially underestimating the true boredom-arousal relation[122]. In experimental studies, a key issue was poor reporting of missing data, particularly in physiological measures, possibly inflating significance by underestimating standard errors. Additionally, many studies were underpowered to detect the average effect size ($\bar{d} = -0.36$), with a median statistical power of just 43.90%. Experimental studies had small and highly variable sample sizes ($M = 58.78$, $SD = 53.12$), likely contributing to heterogeneity[123,124].

Further, this meta-analysis could not consider the dynamic nature of boredom unfolding over time. It has often been noted that the arousal level in boredom might depend on temporal dynamics[14,15]. For example, it has been shown that boredom was associated with arousal later in experimental procedures, in contrast to the beginning[14], and that boredom was related to an increase in heart rate over time rather than absolute levels[20]. However, our results represent an aggregation of snapshots of boredom and arousal rather than their dynamics over time.

The results of the moderation analyses showed significant differences for several subgroups. However, the number of effect sizes in the respective subgroups used for comparisons varied greatly in some cases. For example, when categorizing effect sizes based on the operationalization of boredom that was used in primary studies (i.e., instruments including no arousal-related items versus including items that imply high arousal). The highly unbalanced subgroup sizes (in this case, 119 vs. 6 effect sizes) can distort the moderation results by leading to unstable estimates in the smaller subgroups and increasing the risk of spurious findings. Furthermore, the unbalanced group sizes made it impossible to test multiple moderators against each other in a multivariate moderator model. Given these limitations, we emphasize that the results of some moderator analyses need to be interpreted tentatively.

Summary of findings and implications

On average, there was a small negative correlation between boredom and arousal, and boredom was associated with lower arousal compared to negative and activating states, such as anger. But describing boredom as deactivating would imply deactivation below baseline, which was not supported. Instead, the evidence suggests complex activation patterns that may be explained by several moderating factors. First, heterogeneity may in part be due to measurement artifacts (e.g., scales containing mixed or high-arousal items). However, differential arousal patterns also emerged when considering different physiological indicators. Moreover, as the findings differed for correlational and experimental designs, the arousal signature of boredom might be shaped by context. Variable arousal patterns in boredom align with many studies describing boredom as involving ambivalent arousal states—feeling both agitated and lethargic[115], and patterns of arousal depending on temporal dynamics[14] or reflecting different types of boredom[118].

Future studies should consider these findings and employ carefully designed experiments that (1) assess boredom with measures free of arousal items, (2) capture individual baseline arousal levels that represent average everyday arousal rather than experimentally reduced arousal, (3) monitor multiple indicators of arousal, and (4) implement differentiated manipulations—both of boredom (e.g., underchallenge, overchallenge) and of control conditions (e.g., fun, excitement, neutral, relaxed). Special attention should be given to the design of neutral control conditions to avoid baseline states inducing decreased arousal. Moreover, it will be important to examine which outcomes are triggered by certain levels of arousal in states of boredom, for example, with respect to attention, goal engagement or disengagement, creativity, or performance. While this represents a demanding research agenda, this level of scrutiny is necessary to advance our understanding of the role of arousal in boredom and to address two central questions: (1) whether boredom has a distinct physiological signature, and (2) whether and how such a signature serves a functional purpose.

In relation to its theoretical understanding, the conception of boredom as a low-arousal emotion—as suggested by the overall effect sizes across correlational and experimental studies—fits with its close relations to tiredness, depressed affect[10], and a lack of inspiration and motivation. This is also in line with low-arousal definitions of boredom[12,41,125]. However, considering boredom as a variable-arousal state—as suggested by the results of the moderator analyses—is in line with mixed-arousal conceptualizations. These are, for example, represented in the common definition of boredom by Eastwood et al. [11] (see also Table 1), the widely used Multidimensional State Boredom Scale[115], and findings suggesting that there are different types of boredom with varying levels of arousal[118]. Furthermore, recent functional accounts emphasize the variability of arousal as typical of the experience of boredom[25,126]. According to these accounts, boredom is characterized by a deviation from optimal engagement, and both high and low arousal may be functional in restoring cognitive homeostasis.

Finally, the question remains—if boredom does not have a uniform arousal signature, does this mean we should consider arousal irrelevant for the definition of boredom[15]? This meta-analysis cannot answer this question. Rather, answers may depend on the definitional approach taken. If boredom is defined based on its components, we believe that arousal represents a relevant element. Even if the arousal signature of boredom cannot be described simply as high or low arousal, a more complex arousal pattern may be typical of boredom and thus used as part of its definition. However, if a functional account is adopted—defining boredom through its function and underlying mechanisms—then neither a specific level nor a particular pattern of arousal may be a necessary part of the definition.

Understanding boredom in terms of core affect[10,127] (i.e., valence and arousal; is critically important for research on the outcomes of boredom. When investigating emotions in applied fields like education, groups of emotions (e.g., positive-activating vs. negative-deactivating emotions) are often associated with common correlates[36,123,128]. For example, positive-activating emotions have been found to be typically beneficial to learning and performance, whereas negative-deactivating emotions like boredom have been found to be detrimental[123,129]. If emotions were incorrectly assigned to a certain location within the valence-arousal space, findings could be misinterpreted. However, the findings suggest that a simple dichotomy into high- versus low-arousal boredom may not be adequate. Consequently, these categories are potentially misleading. Distinct boredom states should be recorded and analyzed separately.

Further, understanding the arousal component in boredom relates to the issue of emotion regulation and tailored intervention strategies[130,131]. Assuming high-arousal boredom that involves a strong motivation to act might be more successfully addressed by a regulatory approach that aims to reduce arousal, in order to avoid boredom to transit into frustration or aggression[17,132]. In contrast, low-arousal boredom might benefit more from increasing meaning and personal relevance[41], aiming for an increase in physiological arousal to counteract mind-wandering and further disengagement[11,38,133]. A more nuanced understanding of the variable arousal signature in boredom could help to tailor regulatory strategies to the individual and the context.

Conclusion

As boredom becomes increasingly prevalent across many areas of daily life, it is imperative to better understand its nature and function—of which arousal may be a crucial component. The present meta-analysis contributes to the debate on boredom and arousal by demonstrating that the available correlational and experimental evidence points towards low-arousal boredom. However, effect sizes differed across original studies and moderator analyses revealed a complex arousal signature that researchers have only begun to unravel.

Building on the identified moderating factors, future research should investigate under what conditions boredom is associated with increased arousal, thus deviating from the modal low-arousal boredom experience, and in what ways different arousal patterns vary in their effects on important outcomes, such as social behavior, educational and occupational performance, and mental health.

Data availability

The data used in this meta-analysis consist of summary statistics (e.g., correlations, means, standard deviations, and sample sizes) extracted from published studies. The codebook and all data to replicate the results presented in this manuscript are available at https://osf.io/45zuh, or via https://doi.org/10.17605/OSF.IO/45ZUH.

Code availability

The original code (i.e., R script, version 4.5.1; R Core Team, 2020) to replicate the results presented in this manuscript are available at https://osf.io/45zuh, or via https://doi.org/10.17605/OSF.IO/45ZUH.

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