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Emotional bias varies with stimulus type, arousal and task setting: Meta-analytic evidences

Jiajin Yuan[a,1,*], Yu Tian[a,b,1], Xiting Huang[b], Huiyong Fan[c], Xuemei Wei[d]

[a] The Laboratory for Affect Cognition and Regulation (ACRLAB), Key Laboratory of Cognition and Personality of Ministry of Education (SWU), Faculty of Psychology, Southwest University, Chongqing, 400715, China

[b] Key Research Base of Humanities and Social Sciences of Southwest University, Chongqing, 400715, China

[c] School of Education and Sports Science & Institute of Educational Psychology, Bohai University, Jinzhou, 121013, China

[d] Department of Nursing, Affiliated Hospital of North Sichuan Medical College, Nanchong, 637000, China

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ABSTRACT

Emotional bias, which describes human's asymmetric processing of emotional stimuli, consists of negativity bias (Increased response to negative over positive stimuli) and positivity offset (the reversed phenomenon). Previous studies suggest that stimulus arousal (high/low), stimulus type (scenic/verbal), cultural background (Eastern/Western), and task setting (explicit/implicit) may modulate emotional bias, but with inconclusive findings. To address how the profile of emotional bias varies with these factors, a meta-analysis of emotional P3 event-related potential amplitudes was performed. Forty-nine effect sizes from 38 studies involving 1263 subjects were calculated using Hedges's*g*. The results highlight significant moderators of arousal, stimulus type, and task setting. Specifically, high-arousal stimuli enhance negativity bias relative to low-arousal stimuli; scenic stimulus leads to a negativity bias while verbal stimulus is linked with a positivity offset; explicit emotion tasks lead to negativity bias, whereas implicit emotion tasks do not exhibit emotional bias. These results indicate that emotional bias is labile depending on stimulus arousal, stimulus type and task setting. The implication of these findings for emotion regulation is discussed.

1. Introduction

Human's reaction to emotional materials has been considered an important gift from evolution. It not only drives us to approach benefits but also motivates us to withdraw from danger. Though a common classification is to bisect emotional stimuli symmetrically into positive and negative categories (Lang et al., 1998; Russell, 1980), human reactions to emotional stimuli are usually asymmetrical, which is called emotional bias. Specifically, there are two phenomena of emotional bias. One is negativity bias that describes more intense response to negative stimuli than to positive stimuli (Carretié et al., 2001; Huang and Luo, 2007; Ito et al., 1998a,b); while the other is positivity offset that describes enhanced responses to positive than to negative stimuli (Cacioppo, 2004; Keil, 2006; Carretié et al., 2008). These emotional biases have been considered to reflect the activation of motivation system, which is evolutionarily important for human survival (Ito et al., 1998a,b; Ito and Cacioppo, 2000; Nisbett, 1990). Specifically, the negativity bias is associated with the aversive motivational system that facilitates human's defensive behavior such as avoiding danger, whereas the positivity offset is associated with the appetitive motivational system that promotes human's approach behavior such as seeking food (Cacioppo and Gardner, 1999; Taylor, 1991; Yang et al., 2013).

In order to investigate the emotional bias, many researchers have used event-related potential techniques to compare the difference in brain activity induced by positive and negative stimuli at different temporal stages and scalp locations. One of the most salient findings is that the event-related potential component P3 amplitudes change due to using different stimuli and tasks. The P3 (also known as P3b, P300, Late Positive Potential, or Late Positive Component) is the third positive-going event-related potential component at centro-parietal locations. It could be evoked by either visual or auditory stimuli (e.g., van Dinteren et al., 2014a; Yuan et al., 2012), and it has been linked to multifarious cognitive processing, so its function has been considered complex and cannot be linked to specific cognitive processes (Luck, 1998; van Dinteren et al., 2014b; Vogel and Luck, 2002; Vogel et al., 1998). A prominent view is that P3 amplitudes may be a manifestation

* Corresponding author at: Faculty of Psychology, Southwest University, No. 2 of Tiansheng Road, Beibei, Chongqing, 400715, China.
E-mail address: yuanjiaj@swu.edu.cn (J. Yuan).

[1] Shared first authorship.

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of the processes whereby cognitive schemas are modified (Donchin, 1981; Verleger, 1988; Donchin and Coles, 1988), so that P3 amplitudes can be considered as indicating the amount of central nervous system activity related to incoming information processing (Johnson, 2010; Polich and John, 2004). In emotion studies, P3 amplitudes have been thought to reflect the functional mobilization of attentional resource and the activation of the motivational circuits in the brain that mediate emotional engagement (Bradley et al., 2007; Schupp et al., 2007), and can be used as a criterion variable to indicate the intensity of emotional stimuli (Delplanque et al., 2006; Keil et al., 2007; van Schie et al., 2005; West and Holcomb, 1991). The empirical studies suggested that the arousal (high/low) of stimulus, stimulus type of stimulus (scenic/ verbal), processing type of the stimuli (explicit/ implicit emotion task), and the participant's cultural background (Eastern/Western) may play important roles in emotional bias (Cacioppo and Berntson, 1994; De Leersnyder et al., 2015; González-Villar et al., 2014; Hinojosa et al., 2009; Ito and Cacioppo, 2005, 2000). The current study focused on the role of these factors in emotional bias.

1.1. The effect of arousal on emotional bias

Arousal, which refers to physiological activation strength elicited by emotional stimuli (Lang et al., 1998; Russell, 1980), has been proposed to have an influence on the emotional bias (Cacioppo and Berntson, 1994; Ito and Cacioppo, 2005). Specifically, exposure to the high-arousal stimuli is linked with a negativity bias; by contrast, the brain may respond to low-arousal emotional stimuli with a positivity offset. This proposal was supported by empirical evidence. The studies using low arousal stimuli observed that positive stimuli induced a greater P3 relative to negative stimuli (Kissler et al., 2009; Rohr and Rahman, 2015; Zhang et al., 2014b),while the studies using high arousal stimuli found that negative stimuli result in a greater P3 relative to positive stimuli (Chen et al., 2015; Ito et al., 1998a,b; Wangelin et al., 2012). More directly, a study which manipulated the arousal of stimuli observed the negativity bias of P3 in high arousal condition, and such bias was reversed in low arousal condition (Kaestner and Polich, 2011). However, there are also inconsistent results in the studies concerning the effects of arousal, including the studies which did not observe the arousal effect on P3 (Bayer et al., 2012; Rozenkrants et al., 2008), the studies that found negativity bias or positivity offset when arousal was low or high (Long et al., 2015; Van Dongen et al., 2016; Yao et al., 2016), or the studies finding no emotional bias when arousal was low or high (Grzybowski et al., 2014; Schacht and Sommer, 2009). Therefore, the effect of arousal on emotional bias remains controversial.

1.2. The effect of stimulus type on emotional bias

Scenic display and verbal description are the two most common stimulus types through which people receive emotional information. An important and recurrent question is whether verbal description and scenic display are equally capable of inducing emotional responses (Bayer and Schacht, 2014; Hinojosa et al., 2009). In empirical studies, the scenic display is focally embodied by emotional pictorial materials, while the verbal description is usually manifested by emotional words (Gross and Jazaieri, 2014; Ito et al., 1998a,b; Liu et al., 2010). A theoretical perspective concerning the difference between word and picture processing considers that word processing comprises additional process compared to picture processing before access to its emotional aspects (Glaser and Glaser, 1989; Wilhelm, 1992). The additional processing of word involves the top-down processing, which generates the psychological representation to help us access emotional aspects of stimuli (Ishai, 2010; Kosslyn et al., 2007; Manzoni et al., 1983; Marslen-Wilson and Welsh, 1978). Due to the instinct of self-preservation (Janssen et al., 2012), the negative psychological representation of word may be weakened. Thus, the emotional bias may differ between word and picture. Nevertheless, the results of empirical studies are inconsistent. Using P3 amplitudes as an indicator, some studies observed that word elicited a positivity offset(Palazova et al., 2011; Phavichitr et al., 2008; Rostami et al., 2016; Yao et al., 2016), while other studies showed picture led to a negativity bias (Hajcak and Dennis, 2010; Smith et al., 2005; Van Strien et al., 2009). By contrast, several studies showed the negativity bias in word (Amrhein et al., 2004; Cuthbert et al., 2000), the positivity offset in picture (Hinojosa et al., 2009; Zurrón et al., 2013), or no emotional bias (Flaisch et al., 2008; Lu et al., 2011; Tapia et al., 2008). Thus, a meta-analysis is in need to clarify this ambiguity.

1.3. The effect of cultural background on emotional bias

Cultural background modulates affective preferences by preparing people for the experience and expression of emotions in a culturally consistent manner (De Leersnyder et al., 2015). Specifically, European Americans prefer positive states involving high activation, such as excitement and elation, whereas East Asians prefer to experience positive states involving low activation, such as peacefulness and serenity (Tsai et al., 2006). The different emotional preference between Eastern and Western cultures may lead participants with Western cultural background to experience more emotional positivity relative to those with Eastern cultural background. Thus, it is reasonable to infer that cultural background may play an important role in emotional bias. Moreover, using P3 amplitudes as the criterion variable, some studies observed positivity offset in participants with typical Western cultural background (Kissler et al., 2009; Phavichitr et al., 2008; Rohr and Rahman, 2015), while negativity bias occurred in those with Eastern cultural background (Chen et al., 2015; Liu et al., 2010). However, some studies have shown the opposite (Citron et al., 2013; Ito et al., 1998a,b; Wang et al., 2011; Yao et al., 2016). At least, these findings suggest that emotional bias may be modulated by the cultural background, which needs to be clarified by a meta-analysis.

1.4. The effect of task setting on emotional bias

There are many tasks that are used in literature to study emotional processing. For example, participants are required to rate the valence and arousal of the stimuli using a computerized Self-Assessment Manikin procedure (Lang, 1980; Delplanque et al., 2006; Smith et al., 2005), to classify the emotional type of stimuli (Ito and Cacioppo, 2000; González-Villar et al., 2014; Huang and Luo, 2006; Liu et al., 2010), to complete the emotional stroop task (González-Villar et al., 2014) or emotional oddball task (Campanella et al., 2002; Rozenkrants and Polich, 2008), to perform the old/new discrimination using emotional stimuli (Van Strien et al., 2009; Kaestner and Polich, 2011), to read emotional words (Bayer et al., 2012; Grzybowski et al., 2014; Herbert et al., 2008), and to passively watch emotional pictures (Feng et al., 2014; Flaisch et al., 2008; Hajcak et al., 2007). Despite numerous task categories, a common classification is to divide them into the explicit or implicit emotion tasks. Explicit emotion tasks required participants to explicitly identify stimulus valence, arousal, or emotional category, while implicit emotion tasks required them to perform a non-emotional cognitive task such as watching, reading, and classification according to non-emotional attributes. It was reported that explicit emotion tasks evoked greater allocation of the attentional resource to emotional stimuli relative to implicit emotion task (Delaney-Busch et al., 2016; González-Villar et al., 2014; Rostami et al., 2016). Due to the instinct of self-preservation and evolution (Janssen et al., 2012; Nisbett, 1990), greater recruitment of attentional resources may facilitate one's awareness of negative stimuli, such as danger. Therefore, it is more likely that negativity biases are observed in explicit emotion tasks. Using P3 amplitudes as the criterion variable, some studies indicate that explicit emotion tasks led to negativity bias (Liu et al., 2010; Smith et al., 2005), and implicit emotion tasks led to positivity offset (Kissler et al., 2009; Phavichitr et al., 2008; Rohr and Rahman, 2015). One study has used the same materials to compare emotional processing between explicit and implicit emotion tasks. The results showed that the negativity bias was greater during explicit emotion task than during implicit emotion task (Ito and Cacioppo, 2000). However, these findings were not extensively replicated, and there are still inconsistent results. For example, it was reported that implicit task elicits either negative bias (Bayer and Schacht, 2014; Huang and Luo, 2007) or no emotional bias (Flaisch et al., 2008; Van Strien et al., 2009), and that explicit emotion task elicits positive bias (Zhang et al., 2014a). Therefore, it is necessary to clarify whether task setting has an effect on emotional bias in a meta-analytic approach.

1.5. The current study

Numerous studies used P3 amplitudes as an indicator to assess people's emotional bias. As reviewed above, prior studies suggest that the arousal, stimulus type, cultural background, and task setting may play important roles in emotional bias. However, the results are mixed, requiring a meta-analysis for clarification. Given that many of the studies reviewed above have relatively small sample sizes, it is clear that some results were limited in statistical power and had increased risk of type I and random errors. These results can be well-suited for meta-analysis, a powerful statistical method that can identify trends across numerous small sample studies based on effect sizes. Therefore, the aim of the present study is to clarify whether the arousal, stimulus type, cultural background, and task setting modulate emotional bias through meta-analysis. Specifically, a meta-analysis was conducted to examine the impact of potential moderators (i.e., arousal, stimulus type, cultural background, and task setting) on emotional bias based on the P3 amplitudes induced by emotional stimuli.

2. Method

2.1. Literature search

We performed the meta-analyses in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Iwaihara et al., 2015). Published articles were selected via searches of the Sciencedirect.com, John Wiley, Taylor & Francis, PsycInfo, and PubMed databases. The in press articles were selected via searches of the Google Scholar online databases. The combinations of the key search terms were as follows: "picture" or "word" or "scenic" or "verbal", "affective" or "emotion," "positive" or "pleasant," "negative" or "unpleasant," combined with "ERP" or "event-related potential." In addition, we performed a search of the reference lists of all included articles, to ensure that no relevant articles were omitted. When study results were ambiguous or insufficient for inclusion in the meta-analysis (e.g., information required to calculate effect size was not reported), we contacted the corresponding authors of the studies to request further information. Multiple studies conducted by the same researchers were flagged for further review, to ensure that the samples did not overlap. The start date for the literature search was January 1, 1993, because we believe the first article related to the current research topic was published in 1993 (i.e., Cacioppo et al., 1993); the end date for the literature search was September 1, 2018.

2.2. Study selection

The inclusion criteria for the articles were as follows: first, the studies included healthy participants; second, the studies employed both positive and negative pictures and/or both positive and negative words; third, the studies reported the arousal level of stimulus; fourth, the arousal of negative and positive stimuli matched; fifth, the studies reported P3 in response to emotional stimuli; sixth, the studies reported statistics that allowed for the calculation of effect size; seventh, the studies used emotional stimuli as task-relevant stimuli; eighth, the studies were published in a peer-reviewed journal.

The P3 was distinguished by both the timing and topography of the component because the nomenclature and specification of P3 varied in different studies (Zhang et al., 2014a). The P3 component, also known as the late positive component, P3b, P300, or late positive potential, was identified as a positive-going component, the third positive waveform following stimulus presentation of central-parietal or parietal distribution, and an emotion-evoked ERP component.

The analyzed articles were published between 1993 and 2018. The title and abstract of every article identified were manually reviewed to ensure that the articles were suitable for inclusion in the meta-analysis.

2.3. Data extraction

Data were extracted independently by two doctoral candidates and cross checked until consensus was reached. The following variables were extracted from each eligible article: study identification data (i.e., first author and publication year), participants' mean age with standard deviation (*SD*), the proportion of female participants, sample size, stimulus valence and arousal, stimulus type (i.e., pictures or words), task setting, the window time of P3, the electrodes of P3, the statistics for the calculation of effect size, and participants' country of residence (based on primary participants).

In order to cover as many studies as possible to strengthen the current meta-analysis, we included the studies involving factors unrelated to topics. For these studies, we merely extracted the data related to the theme of the present meta-analysis. Specifically, only data for healthy samples (Wangelin et al., 2012), young adult samples (Smith et al., 2005), and tasks completed in participants' first languages (Chen et al., 2015) were included in the meta-analysis for the studies involving mental disorders, aging, and bilingualism, respectively. For studies that included multiple conditions beyond the variables of interest (i.e., high and low valence extremity), mean ERP responses to emotional stimuli across conditions were used to perform calculations.

2.3.1. Arousal and valence

The arousal and valence data were uniformly converted to 9-point Likert-scale (1 = "low arousal" or "negative", 9 = "high arousal" or "positive"), as most studies used this scale.

The current study adopted the bisection method to extract the arousal data in each study, because the criteria to classify arousal values are inconsistent across studies (Yao et al., 2016; Kaestner and Polich, 2011; Rozenkrants et al., 2008; Bayer et al., 2012), and there is no recognized criterion to divide arousal into high and low. Specifically, we sorted the averaged arousal values across the included studies by an ascending order, with the first half as low-arousal and the second half as high-arousal. Typical examples of high-arousal stimuli were words or scenes of spider, violence and cheers while typical examples of low-arousal stimuli were those of insect, refugee and banquet. Though this bisection method is rough, it helps to check whether arousal affects the emotional bias. The bisection was performed for the scenic studies and the verbal studies separately, because stimulus type may also affect the emotional bias. If the studies didn't report specific arousal values (e.g., Citron et al., 2013; Ito and Cacioppo, 2000), the classification depended on their description of the stimuli. An independent *t*-test revealed that the arousal values of high arousal studies (mean ± SD = 6.65 ± 0.35) are significantly higher than that of low arousal studies (5.20 ± 0.63), $t(43) = -9.14$, $p < 0.001$, suggesting that the bisection method is effective in dividing the arousal level.

2.3.2. Stimulus type

The data of stimulus type in each study were extracted according to the authors' description of stimuli. In scenic studies, if the studies used both face images and scenic pictures, only the data of scenic pictures were extracted as emotional processing of face differs from that of scenic picture (Bayer, et al., 2014). In verbal studies, only the data of participants' first languages were extracted; if the studies used both word and picture as stimuli, the data of them were extracted separately.

2.3.3. Cultural background

The data of cultural background were extracted according to the authors' description of participant. As none of included studies reported the cultural background of participant, the classification of cultural background was based on the place where participants took part in the experiment. Specifically, the participants from East Asia (e.g., China) were divided into Eastern, the participants from European or North America (e.g., France, Britain, Dutch, Poland, Spain, Germany and America) were divided into Western.

2.3.4. Task setting

The data of task setting were extracted according to the description of experimental procedure. The study which instructed participants to make explicit emotional classification was identified as explicit emotion task (e.g., identify stimulus valence, arousal, or emotional category). By contrast, the study requiring participants to perform non-emotional tasks was identified as implicit emotion task (e.g., watching, reading, or classification according to non-emotional attributes).

Since the task-relevance of emotional stimuli (i.e., whether emotional stimuli were used as the task-related stimuli or as distractors) may have potential influence on the results (see Blair and Mitchell, 2009), and few studies have used emotional stimuli as task-irrelevant distracters (e.g. Delplanque et al., 2005), we only extracted the data from the studies that used emotional stimuli as the task-relevant stimuli (regardless of whether the task required emotional or non-emotional judgement).

The data extraction was presented in Table 1.

2.4. Meta-analysis

2.4.1. Effect size

Hedges'g was calculated for each study, as it shows lower levels of bias, even with small samples (Borenstein et al., 2009). In the current analysis, Hedges'g was calculated as follows: $g = (\text{Mean}_{\text{positive}} - \text{Mean}_{\text{negative}}) / SD_{\text{pooled}}$. If the related statistics of this formula were lacking, Hedges' g would be derived from t or p values and sample sizes. Similar to previous studies, if the reported results were significant, but p values were not provided, one-tailed p values were assumed to be 0.025. If results were reported as $p < 0.05$, $p < 0.01$ or < 0.001, two-tailed p values were assumed to be 0.05, 0.01 or 0.001, respectively. If results were reported as insignificant, but no data were provided to calculate exact p values, the results were conservatively assigned a one-tailed p value of 0.50 (Borenstein et al., 2009; Higgins et al., 2003).

The Comprehensive Meta-Analysis (Version 2; CMA; Biostat, Englewood, NJ, USA) software package was used to order, calculate, and compare effect sizes.

2.4.2. Model selection

Most meta-analyses were based on fixed- or random-effects models. Borenstein et al. (2010) suggested that model selection should depend on previous confirmation that included studies shared the same purpose and showed the same effects. If the features (e.g., participants and methods) of the included studies were consistent, and the results of the meta-analysis would not be generalizable to a wider population, the use of a fixed-effects model is appropriate. Otherwise, a random-effects model should be selected (Borenstein et al., 2010). Because the selected articles were inconsistent with respect to participants, methods, and stimulus types, and we expected the results generalizable to a wider population, thus a random-effects model was selected for the current meta-analysis.

2.4.3. Homogeneity

The homogeneity of the distribution of effect sizes was assessed using Q and I^2 tests. In the Q test, a statistically significant Q value ($p < 0.05$) denotes heterogeneity in the distribution of effect sizes. In the I^2 test, I^2 reflects the proportion of the overall variance explained by real effect size differences, and higher I^2 values indicate greater heterogeneity. According to Higgins et al. (2003), 25%, 50%, and 75% should be regarded as low, moderate, and high thresholds for heterogeneity, respectively.

Furthermore, heterogeneity can be used to assess the adequacy of model selection. Some studies have indicated that the use of a random-effects model would be most appropriate if the heterogeneity of effect sizes across studies exceeds the low threshold. Random-effects models are generally more conservative, relative to fixed-effects models, but the two models provide similar results when heterogeneity is low (Little et al., 2012). Therefore, if heterogeneity exceeds the low threshold ($I^2 > 25\%$), a random-effects model should be used in meta-analyses.

Based on the detection of significant moderators, the follow-up analyses used Z-test to examine whether the weighted effect sizes for each level of the moderator, as measured by Hedges'g, is statistically different from zero. A Z-value significantly above zero indicates a reliable positivity offset while that significantly below zero indicates a reliable negativity bias.

2.4.4. Publication bias

Publication bias was assessed via visual inspection of funnel plots, Egger's regression test (De Maria et al., 2015), and Duval and Tweedie's trim-and-fill method. In the funnel plot, a symmetrical, inverted cone-shaped distribution of effect sizes centered around the weighted overall effect size suggests the absence of publication bias. In Egger's regression test, Egger's intercept and a 95% CI should be calculated, and intercepts that do not differ significantly from zero ($p > .05$) indicate the absence of publication bias. In Duval and Tweedie's trim-and-fill method, the distribution of the effect sizes in included studies is trimmed or filled on the left or right to provide symmetrical distribution, and insignificant differences between adjusted and observed effect sizes indicate the absence of publication bias.

3. Results

In total, 49 effect sizes from 38 articles fulfilled the inclusion criteria (Fig. 1). The total number of participants was 1263. A forest plot of the effect size and 95% CI for each study is presented in Fig. 2.

3.1. Overall effect size

The overall effect size was statistically non-significant, $g = -0.06$, CI: -0.21 to 0.10, $Z = -0.72$, $p = 0.47$. Heterogeneity analysis showed a moderate heterogeneity across the included studies, $Q(48) = 173.01$, $p < 0.001$, $I^2 = 72.26$, suggesting that random-effects model was appropriate and there were significant moderators affecting emotional bias.

3.2. Moderator analysis

The moderator of arousal (high/low) was statistically significant, $Q(1) = 6.70$, $p < 0.05$. The overall effect size for high arousal stimuli ($g = -0.27$, CI: -0.48 to -0.05) was significantly more negative compared to that for low arousal stimuli ($g = 0.12$, CI: -0.08 to 0.32). Specifically, the high-arousal stimuli are linked with reliable negativity bias ($Z = -2.46$, $p < 0.05$), whereas the emotional bias of low-arousal stimuli was not statistically significant ($Z = 1.17$, $p = 0.24$).

The moderator of stimulus type (scenic/verbal) was statistically significant, $Q(1) = 13.33$, $p < 0.001$. Specifically, the overall effect size of the scenic studies ($g = -0.30$, CI: -0.49 to -0.12) was significantly more negative compared to that of verbal studies ($g = 0.21$, CI: 0.01 to 0.41). Specifically, scenic stimuli are linked with reliable negativity bias ($Z = -3.22$, $p < 0.01$), whereas verbal stimuli are linked with

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Table 1
Study Characteristics in the meta-analysis.

Study	Age mean	Age SD	Female %	Sample size	positive valance	positive arousal	negative valance	negative arousal	Stimuli type	Task setting	Country	Calculation format	Arousal division
Bayer and Schacht (2014)-picture condition	25.4	4.9	NM	24	7.3	5.5	2.9	5.4	picture	implicit	Germany	Sample size, p-value	low
Bayer and Schacht (2014)-word condition	25.4	4.9	NM	24	7.84	5.94	2.44	6.3	word	implicit	Germany	Sample size, p-value	low
Bayer et al. (2012)-high arousal condition	23.1	3.4	50	24	7.07	6.48	2.7	6.66	word	implicit	Germany	Sample size, p-value	high
Bayer et al. (2012)-low arousal condition	23.1	3.4	50	24	7.07	4.5	2.7	4.5	word	implicit	Germany	Sample size, p-value	low
Chen et al. (2015)- first language condition	22.47	1.84	47.06	17	7.86	6.96	2.49	7.08	word	implicit	China	Sample size, p-value	high
Citron et al. (2013)-high arousal condition	24	5	51.61	31	NM	NM	NM	NM	word	implicit	Britain	Sample size, p-value	high
Citron et al. (2013)-low arousal condition	24	5	51.61	31	NM	NM	NM	NM	word	implicit	Britain	Sample size, p-value	low
Delplanque et al. (2006)	21.47	2	100	17	7.3	6.1	2.2	6	picture	explicit	France	Mean, SD, Sample size	low
van Dongen et al. (2016)	21.08	NM	58.3	24	7.36	6.19	2.05	6.19	picture	implicit	Dutch	Sample size, p-value	high
Feng et al. (2014)-high arousal condition	21.3	NM	40	25	10	6.61	6.34	1.88	picture	implicit	China	Mean, SD, Sample size	high
Feng et al. (2014)-low arousal condition	21.3	NM	40	25	10	6.15	4.87	2.82	picture	implicit	China	Mean, SD, Sample size	low
Flaisch et al. (2008)	24.5	NM	52	25	7	6.2	2.4	6.4	picture	implicit	Germany	Sample size, p-value	high
González-Villar et al. (2014)-explicit emotion task	45.3	9.4	100	57	7.7	6.8	2.2	6.4	word	explicit	Spain	Sample size, p-value	high
González-Villar et al. (2014)-implicit emotion task	45.3	9.4	100	57	7.7	6.8	2.2	6.4	word	implicit	Spain	Sample size, p-value	high
Grzybowski et al. (2014)-zero contexts condition	20.5	1.2	78.57	14	6.62	3.18	3.11	3.48	word	implicit	Poland	Sample size, p-value	low
Hajcak et al. (2007)	NM	NM	61.9	21	7.07	5.42	2.42	6.19	picture	implicit	America	Sample size, t-value	low
Herbert et al. (2006)	26	NM	38.46	26	6.6	5.3	2.9	5.5	word	explicit	Germany	Mean, SD, Sample size	low
Herbert et al. (2008)	27	NM	50	16	6.6	5.5	2.7	5.7	word	implicit	Germany	Sample size, p-value	low
Hinojosa et al. (2009)-exp1	21	NM	95	20	7.6	7.1	2.1	7.2	word	implicit	Spain	Mean, SD, Sample size	high
Hinojosa et al. (2009)-exp2	21	NM	75	28	7.6	7.1	2.1	7.2	picture	implicit	Spain	Mean, SD, Sample size	high
Hinojosa et al. (2010)	23	NM	87.5	32	7.8	6.7	2.3	6.8	word	implicit	Spain	Sample size, p-value	high
Huang and Luo (2006)	20.7	NM	50	16	7.03	6.14	2.9	6.21	picture	explicit	China	Sample size, p-value	high
Ito and Cacioppo (2000)-explicit emotion task	NM	NM	47.83	23	7.52	NM	2.43	NM	picture	explicit	America	Mean, SD, Sample size	high
Ito and Cacioppo (2000)-implicit emotion task	NM	NM	47.83	23	7.52	NM	2.43	NM	picture	implicit	America	Mean, SD, Sample size	high
Ito et al. (1998)-exp1	NM	NM	NM	25	8.31	7.43	1.89	7.34	picture	explicit	America	Mean, SD, Sample size	high
Ito et al. (1998)-exp2	NM	NM	NM	14	7.81	6.71	2.1	6.22	picture	explicit	America	Mean, SD, Sample size	high
Kaestner and Polich (2011)-high arousal condition	21.1	2.1	100	24	7.2	6.4	2.1	6.8	picture	implicit	America	Sample size, p-value	high
Kaestner and Polich (2011)-low arousal condition	21.1	2.1	100	24	7.2	4.4	2.8	4.6	picture	implicit	America	Sample size, p-value	low
Kissler et al. (2009)	23.9	NM	50	20	7.1	5.35	2.61	5.47	word	implicit	Germany	Sample size, p-value	low
Li et al. (2014)	25.56	NM	NM	20	6.8	5.1	3.1	4.9	word	implicit	China	Sample size, p-value	low
Liu et al. (2010)	20.1	1.32	50	18	7.19	5.03	2.01	5.1	picture	explicit	China	Sample size, p-value	low
Olofsson and Polich (2007)	NM	NM	100	18	6.98	6.47	2.03	6.47	picture	implicit	America	Sample size, p-value	high
Rohr and Rahman (2015)	25	NM	100	22	7.02	4.68	3.42	5.22	word	implicit	Germany	Sample size, p-value	low
Rozenkrants et al. (2008)-high arousal condition	NM	NM	50	32	7.33	6.68	2.48	6.67	picture	implicit	America	Sample size, p-value	high
Rozenkrants et al. (2008)-low arousal condition	NM	NM	50	32	7.36	4.45	2.63	4.46	picture	implicit	America	Sample size, p-value	low
Schacht and Sommer (2009)-exp2	23.5	3.3	58.33	24	7.71	6.66	2.31	6.84	word	implicit	Germany	Sample size, p-value	high

(*continued on next page*)

Table 1 (*continued*)

Study	Age mean	Age SD	Female %	Sample size	positive valance	positive arousal	negative valance	negative arousal	Stimuli type	Task setting	Country	Calculation format	Arousal division
Schindler and Kissler (2016)	25.16	4	68	25	17	7.06	5.51	2.68	word	implicit	Germany	Mean, SD, Sample size	low
Smith et al. (2005)-young participants condition	NM	NM	NM	57	6.6	5.06	2.19	5.61	picture	explicit	American	Sample size, t-value	low
Solomon et al. (2012)	6.27	0.5	44	39	7.45	4.76	3.32	5.79	picture	explicit	America	Mean, SD, Sample size	low
van Strien et al. (2009)	23.7	NM	100	21	NM	5.19	NM	4.79	picture	implicit	Dutch	Sample size, p-value	low
Wang et al. (2011)	21.2	NM	50	18	7.05	6.07	2.04	6.1	picture	implicit	China	Sample size, p-value	low
Wangelin et al. (2012)-low anxity condition	NM	NM	NM	30	NM	6.1	NM	6.3	picture	implicit	America	Mean, SD, Sample size	high
Weinberg and Hajcak (2010)	NM	NM	60.94	64	7.43	5.58	1.9	6.26	picture	implicit	America	Mean, SD, Sample size	low
Yang et al. (2013)	23.05	NM	50	16	6.64	5.2	3	5.2	word	implicit	China	Mean, SD, Sample size	low
Yao et al. (2016)-exp1-high arousal condition	21.9	1.2	48.72	19	7.28	6.91	2.42	6.78	word	implicit	China	Mean, SD, Sample size	high
Yao et al. (2016)-exp1-low arousal condition	21.9	1.2	48.72	19	6.62	5.86	3.04	5.56	word	implicit	China	Mean, SD, Sample size	low
Yao et al. (2016)-exp2-high arousal condition	22.3	2.1	45	20	7.24	6.79	2.34	7.07	word	implicit	China	Mean, SD, Sample size	high
Zhang et al. (2014)	20.8	NM	50	20	6.75	4.82	2.87	4.84	word	explicit	China	Mean, SD, Sample size	low
Zhao et al. (2018)	20.8	NM	50	18	9	6.75	4.84	2.87	word	implicit	China	Sample size, p-value	low

SD = standard deviation; Mean age is reported in years; "NM" represents "Not mentioned".

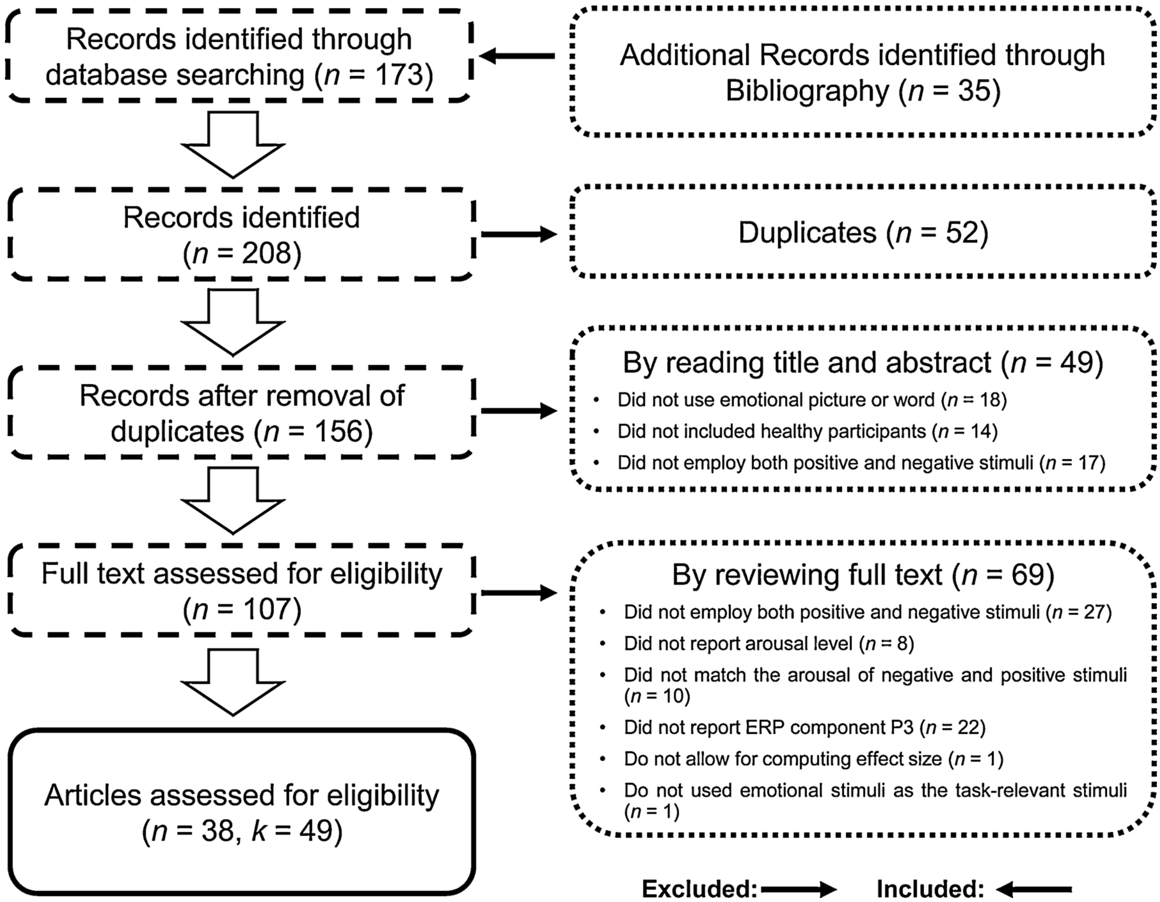

Fig. 1. Flowchart of the study selection process. Note: *n* represents the number of articles, and *k* represents the number of independent effect sizes.

significant positivity offset ($Z = 2.01$, $p < 0.05$).

The moderator of task setting (explicit/ implicit emotion task) was also statistically significant, $Q(1) = 6.72$, $p < 0.05$. The overall effect size of the explicit emotion task ($g = -0.37$, CI: -0.62 to -0.11) was significantly more negative compared to that of implicit emotion task ($g = 0.04$, CI: -0.14 to 0.22). Specifically, explicit emotion task is linked with a reliable negativity bias ($Z = -2.84$, $p < 0.01$), whereas implicit emotion task exhibits no reliable emotional bias ($Z = 0.46$, $p = 0.65$).

However, the moderator of cultural background (Eastern/Western) was statistically insignificant, $Q(1) = 0.03$, $p = 0.86$, indicating that cultural background does not significantly moderate emotional bias.

3.3. Publication bias

The publication bias was assessed via visual inspection of funnel plots, Egger's regression test, and Duval and Tweedie's trim-and-fill method. The funnel plot was roughly symmetrical (Fig. 3). Egger's regression test indicated an absence of publication bias, $t(47) = 0.80$, $p = 0.43$. Duval and Tweedie's trim-and-fill showed the adjusted effect size for 5 missing effect sizes to the left of the overall effect size ($g = -0.15$, CI: -0.31 to -0.01) was not significantly different from the observed overall effect size ($g = -0.06$, CI: -0.21 to 0.10), indicating there was no obvious publication bias.

3.4. Additional analyses of arousal and valence

The current meta-analysis found significant moderation effects of arousal and stimulus type. However, some studies pointed out that scenic stimuli are associated with more extreme levels of emotional arousal and valence than is verbal stimuli (Keil, 2006; Carretié et al., 2008; Marvan, 2003; Mogg and Bradley, 1998). It is necessary to compare whether the scenic and verbal studies included in the current meta-analysis differ in arousal and valence. Although different studies used emotional materials taken from different stimulus systems (e.g., IAPS, CAPS, CAWS, BAWL-R, and ANEW), these stimulus systems were established by the same method (i.e., Self-Assessment Manikin, SAM; Lang, 1980; Bradley and Lang, 1994). Thus, the data for emotional materials of different studies should be comparable. These comparisons would clarify whether the effect of stimulus type is independent of arousal and valence differences between scenic and verbal stimuli.

Two analysis of variance (ANOVA) with valence (positive, negative) and stimulus type (scenic, verbal) as independent variables were run for arousal and valence value, respectively. The ANOVA for arousal found no significant main effect or interaction, $Fs < 0.22$, $ps > 0.64$, $\eta_p^2s < 0.01$. The ANOVA for valence found a main effect of valence, with a higher overall value observed for positive (7.20 ± 0.44) than for negative (2.50 ± 0.40) stimuli, $F(1,86) = 2820.50$, $p < 0.001$, $\eta_p^2 = 0.97$. However, the main effect of stimulus type or the interaction between valence and stimulus type was not significant, $Fs < 2.88$, $ps > 0.09$, $\eta_p^2s < 0.04$. These results suggest the arousal value and the valence value were matched in the scenic and the verbal studies. Consequently, the stimulus type effect reported above should be independent of the arousal effects.

The studies that didn't report arousal (Ito and Cacioppo, 2000; Van Strien et al., 2009) or valence (Citron et al., 2013; Van Strien et al., 2009; Wangelin et al., 2012) were excluded from above analyses.

4. Discussion

The aim of the current meta-analyses was to quantitatively assess the effect of stimulus arousal (high/low), stimulus type (scenic/verbal), cultural background (Eastern /Western), and task setting (explicit/

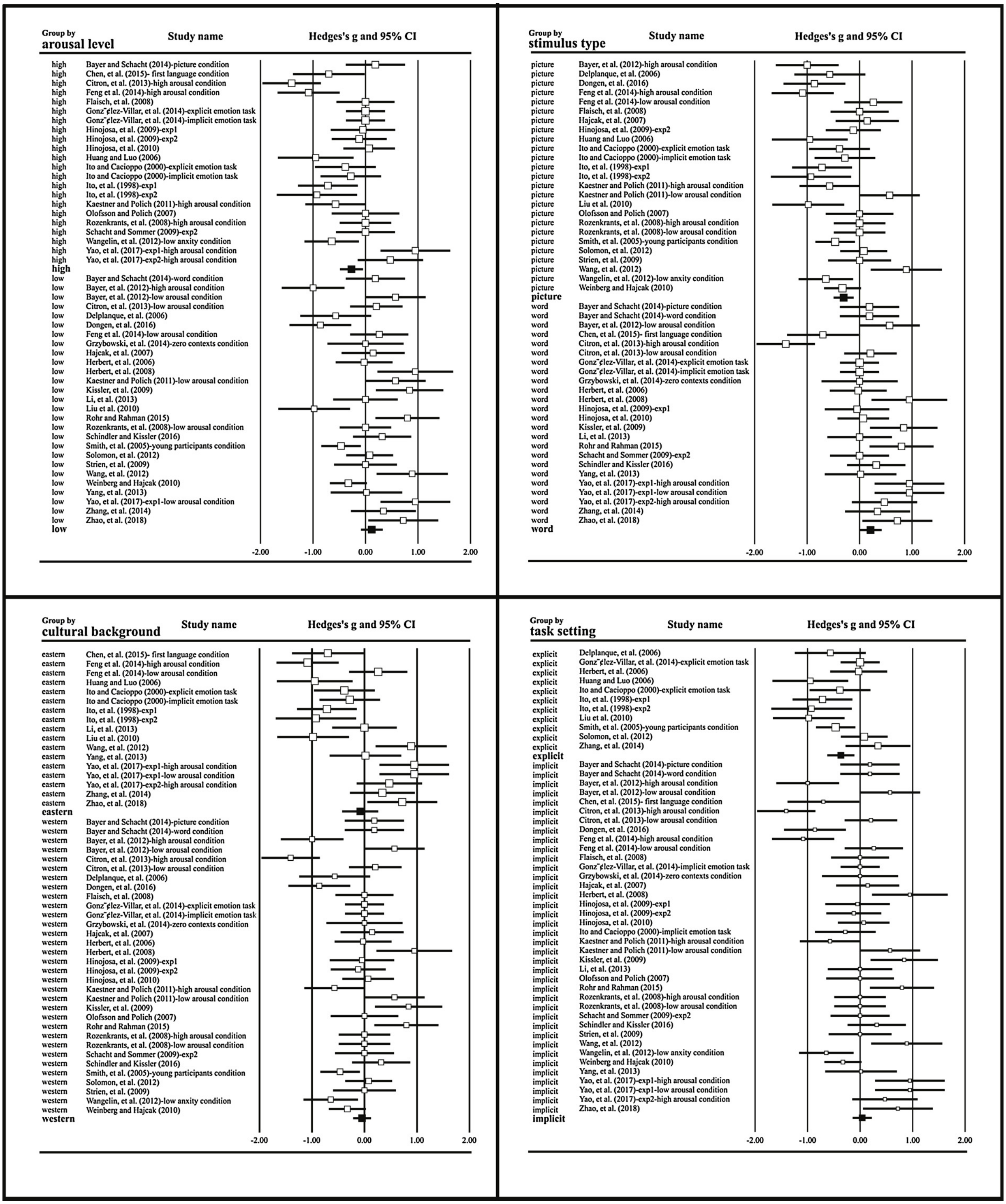

Fig. 2. Effect sizes and corresponding forest plot.

implicit emotion task) on the emotional bias based on the P3 amplitudes induced by emotional stimuli. The results highlighted the moderation effects of stimulus arousal, stimulus type and task setting on emotional bias.

4.1. Meaning of emotional bias

Although emotions can be symmetrically divided into positivity and negativity (Lang et al., 1998; Russell, 1980), human's processing of emotional stimuli is usually asymmetrical as positivity offset or negativity bias. The former describes that the brain is more sensitive to positive over negative stimuli, while the latter shows that the brain responds more strongly to negative over positive stimuli (Cacioppo, 2004; Keil, 2006; Carretié et al., 2008; Marvan, 2003).

Some researchers indicate that the emotional bias derives from the activation of the motivational system, which evolutionarily shapes human's adaptive function of reward pursuit and threat avoidance. Specifically, there are two main motivational systems, appetitive and aversive (Schupp et al., 2004). If the activation of the appetitive motivational system plays a leading role, the brain would show positivity offset and allocate more cognitive resources to positive emotional processing, which is conducive to approach behavior, such as seeking

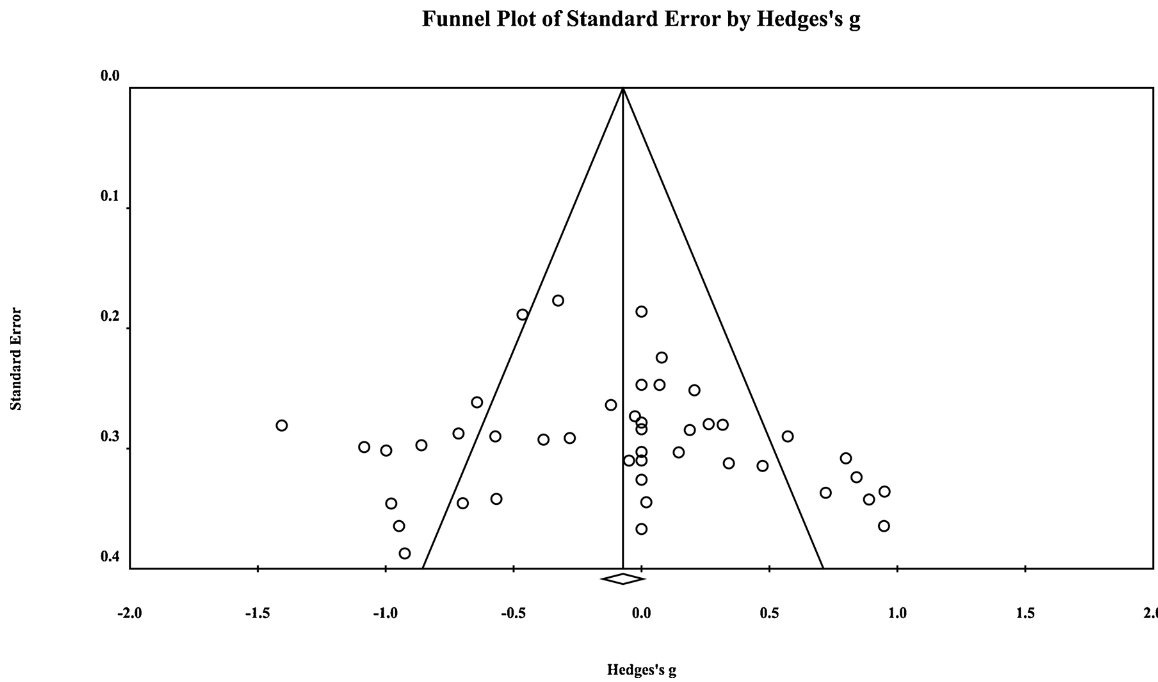

Fig. 3. Funnel plots of publication bias analysis.

food and exploring outside world. By contrast, if the activation of aversive motivational system is predominant, the brain would show negativity bias and allocate more resources to negative emotional processing, which helps to detect environmental danger and mobilize defensive behavior, such as escaping from danger and maintaining vigilance. Both forms of emotional bias reflect human's adaptive behaviors for survival in the changing environment, according to the idea of natural selection in evolution theory (Nisbett, 1990; Tooby and Cosmides, 2005).

4.2. *Moderation effects in emotional bias*

Our moderator analyses show that arousal, stimulus type and task setting play roles of moderator in emotional bias, whereas cultural background does not significantly affect emotional bias.

4.2.1. *Arousal*

As stated above, high-arousal stimuli result in a significant negativity bias, which is significantly more negative than the emotional bias of low-arousal stimuli. This suggests that the emotional bias varies with the activation inputs of the stimuli, which is embodied by stimulus arousal. Previous studies have proposed that arousal and valence are interacting, leading organisms to respond asymmetrically to emotional stimuli (Cacioppo and Berntson, 1994; Ito and Cacioppo, 2005; Lang et al., 1998). The bipolar structure theory of emotion (Cacioppo and Berntson, 1994; Cacioppo and Gardner, 1999) posits that the increased stimulus arousal is associated with a more intense responding in defensive compared to appetitive motivational systems, as it is evolutionarily important to avoid a threatening event faster than to approach a rewarding target (Peeters and Czapinski, 1990; Taylor, 1991). Consequently, elevated arousal is linked with prioritized processing of negative over positive stimuli throughout the information processing stream. This asymmetry could be reflected by the differences in functional mobilization of cognitive resources to negative compared to positive stimuli (Bradley et al., 2007; Schupp et al., 2007). Therefore, in the current meta-analysis, the negativity bias is observed by high arousal instead of low arousal stimuli.

4.2.2. *Stimulus type*

The moderation effect of stimulus type is manifested by the significant positivity offset in verbal stimuli, and a reliable negativity bias in scenic stimuli. This indicates that the emotional bias shifts from verbal to scenic stimuli. A theoretical perspective concerning the cognitive processing differences between picture and word suggests that words require additional processing before access to its emotional aspects, while picture processing does not (Glaser and Glaser, 1989; Wilhelm, 1992). This additional processing involves the top-down processing, which generates the psychological representation to help us access emotional aspects of stimuli through mental imagery, propositions, or both (Chen, 1993; Collins and Quillian, 1969; Kanske and Kotz, 2007; Levelt et al., 1999; West and Holcomb, 1991). However, the psychological representation of word is changeable. For example, the word "blood" could be represented as a bloody situation, a scene of a hospital, or a neutral proposition "the red liquid that your heart pumps around your body". On the other hand, the involvement of more processing of word compared to picture materials suggests that picture elicits faster emotional processing in the brain compared to words (Hinojosa et al., 2009). Empirical evidence suggests that negative pictures receive prioritized attentional allocation relative to positive or neutral pictures (Feldmann-Wüstefeld et al., 2011; Pourtois et al., 2006; Raz et al., 2014), and it is difficult to disengage attention from negative scenic stimuli (Fox et al., 2001; Salemink et al., 2007; Van Damme et al., 2008). Therefore, in contrast to verbal stimuli that exhibit a positive emotional bias, the scenic stimuli elicit reliable negativity bias. This stimulus type effect has an implication for emotion regulation, in that selecting verbal compared to scenic situations to receive emotional information relieves negative emotional bias and facilitates the generation of positive emotional experiences. Future studies should compare picture and word stimuli in a single study, with valence and arousal controlled, in order to obtain a more direct conclusion.

4.2.3. *Cultural background*

The current meta-analysis did not show a significant moderation effect of cultural background. Specifically, the emotional bias of Western participants is not significantly different from that of Eastern participants. Cultural background (Western *v.s.* Eastern) has been considered to modulate emotion processing for decades (Matsumoto et al., 2008). Also, empirical evidence confirms that cultural background indeed affects many aspects of emotional processing, such as, valuation for emotion (Tsai et al., 2006), preference for the emotional situation (Heine et al., 2001), and strategy for emotional regulation (Mauss et al., 2008). However, the current meta-analysis indicates a cross-cultural consistency in the phenomenon of emotional bias. One possible explanation is that emotional bias may reflect an evolutionary, adaptive function rather than a sociocultural shaped, higher-order emotional function (Ito et al., 1998a,b; Ito and Cacioppo, 2000; Nisbett, 1990). Irrespective of cultural background people live in, it is evolutionarily important for humans to pursue goals or avoid threat similarly. Thus, the rules of emotional processing bias should be applicable to humans in general, irrespective of cultural background. Another possible explanation is the cultural globalization effect. Globalization has been recognized as a promoter of cultural homogeneity, and the "culturally erosive" effects of globalization would reduce cultural differences, making different cultures more and more similar (see Chiu et al., 2011).

4.2.4. Task setting

The moderation effect of task setting is significant, indicating more pronounced negativity bias during explicit (i.e., perform explicit emotional judgment) relative to implicit (i.e., non-emotional judgment) tasks. Specifically, the explicit emotion tasks result in a reliable negativity bias, while there is no significant emotional bias in implicit emotion tasks. This indicates that the emotional bias varies with the task setting.

One of the most salient difference between explicit and implicit emotion tasks is whether participants were required to perform the emotion-relevant response (e.g., rate emotional valence, classify emotional category, or estimate the arousal of stimuli). Explicit emotion tasks require participants to make explicit emotional judgment, where emotional processing entails top-down attention derived from the task specification or previous knowledge (Uncapher et al., 2011; Xu et al., 2009). By contrast, the implicit emotional tasks require participants to perform non-emotional judgment, wherein emotional processing involves bottom-up attention elicited by salient stimulus. As explicit emotional tasks lead to more top-down attention resources being allocated to emotional processing, the explicit tasks often enhanced emotional processing relative to implicit tasks (Hajcak et al., 2006). On the other hand, threat avoidance is usually more important and urgent than reward pursuit due to the instinct of self-preservation (Janssen et al., 2012; Nisbett, 1990). Thus, the enhanced emotional processing during explicit tasks may prioritize one's detection and coping of threat over goal information. In this regard, it is reasonable that explicit emotional tasks induced greater negativity bias relative to implicit emotional tasks.

4.3. Limitations and future research directions

Several important issues warrant consideration in the interpretation of current results. Firstly, we used a bisection method for arousal classification during extracting the data for each study. Although the current meta-analysis observed a significant moderation effect of arousal, this effect may be underestimated as stimulus arousal in most included studies was above the midpoint of a 9-point scale (i.e., 5). Secondly, the included studies used stimuli from different material systems. It needs to be noted that these material systems used different Likert-scales (e.g. 5-point, 7-point, or 9-point) which, as indicated (Matell and Jacoby, 1972), are distinct in validity to represent raters' power of discrimination. In this regard, the approach of converting all the rating data uniformly to the 9-point Likert-scale should be considered tentative, and caution should be taken with this approach. Thirdly, the current meta-analysis didn't take processing load into account due to the lack of reliable method to quantify this variable across studies. However, the processing load has been found to affect emotional processing (Erthal et al., 2005). Future studies should try to resolve this issue and examine whether processing load moderates emotional bias in meta-analysis. Fourthly, we did not find sufficient eligible studies that used emotional stimuli as task-irrelevant distracters, the current analysis did not consider the moderator of task-relevance. Fifthly, it has been indicated that low-level visual features, such as spatial frequency or visual complexity, should be tested and controlled in exploring emotional processing via pictorial stimuli, as these visual features may influence early visual processing (Delplanque et al., 2007). However, few included studies in this work have tested these low-level features for positive relative to negative stimuli. Future empirical studies need to take these attributes into account, particularly when pictorial stimuli are used. Lastly, the current analysis included only word and picture studies, as it allowed the assessment of a consistent ERP indicator (P3 amplitude) for emotional bias. However, sounds, sentences, and videos are also considered to represent verbal or scenic stimuli. Future studies should confirm the present findings via sound, sentence, and video studies with appropriate indicators.

5. Conclusion

In contrast to the ambiguous findings of empirical studies with small sample sizes, the current meta-analysis, using P3 amplitude as an indicator, clarified the moderation effect of arousal (high/low), stimulus type (scenic/verbal), task setting (explicit/implicit emotion task), and background setting (Eastern/Western) on emotional bias. Specifically, high arousal stimuli result in a negativity bias relative to low arousal stimuli; scenic stimuli lead to a negativity bias, whereas verbal stimuli result in a positivity offset; explicit emotion tasks lead to negative emotional bias, while implicit emotion tasks do not show reliable emotional bias; cultural background does not affect emotional bias.

Declaration of Competing Interest

The authors declare no conflict of interest.

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References

Amrhein, C., Mühlberger, A., Pauli, P., Wiedemann, G., 2004. Modulation of event-related brain potentials during affective picture processing: a complement to startle reflex and skin conductance response? Int. J. Psychophysiol. 54, 231–240. https://doi.org/10.1016/j.ijpsycho.2004.05.009.

Bayer, M., Schacht, A., 2014. Event-related brain responses to emotional words, pictures, and faces–a cross-domain comparison. Front. Psychol. 5, 1106.

Bayer, M., Sommer, W., Schacht, A., 2012. P1 and beyond: functional separation of multiple emotion effects in word recognition. Psychophysiology 49, 959–969. https://doi.org/10.1111/j.1469-8986.2012.01381.x.

Blair, R.J.R., Mitchell, D.G.V., 2009. Psychopathy, attention and emotion. Psychol. Med. 39, 543–555.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H.R., 2010. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res. Synth. Methods 1, 97–111. https://doi.org/10.1002/jrsm.12.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., Rothstein, H.R., 2009. Meta-analysis methods based on direction and p-values. Introd. to Meta-Analysis. https://doi.org/10.1002/9780470743386.ch36.

Bradley, M.M., Codispoti, M., Sabatinelli, D., Lang, P.J., 2007. Handbook of psychophysiology. Emotion 1, 300–319. https://doi.org/10.1017/CBO9780511546396.

Bradley, M.M., Lang, P.J., 1994. Measuring emotion: the self-assessment manikin and the

semantic differential. J. Behav. Ther. Exp. Psychiatry 25, 49–59.
Cacioppo, J.T., 2004. Asymmetries in affect-laden information processing. Perspect. Soc. Psychol. Yin Yang Sci. Prog. 85–95. https://doi.org/10.1037/10750-007.
Cacioppo, J.T., Crites, S.L., Berntson, G.G., Coles, M.G.H., 1993. If attitudes affect how stimuli are processed, should they not affect the event-related brain potential? Psychol. Sci. 4, 108–112.
Cacioppo, J.T., Berntson, G.G., 1994. Relationship between attitudes and evaluative space: a critical review, with emphasis on the separability of positive and negative substrates. Psychol. Bull. 115, 401–423. https://doi.org/10.1037/0033-2909.115.3.401.
Cacioppo, J.T., Gardner, W.L., 1999. Emotion. Annu. Rev. Psychol. 50, 191–214.
Campanella, S., Gaspard, C., Debatisse, D., Bruyer, R., Crommelinck, M., Guerit, J.M., 2002. Discrimination of emotional facial expressions in a visual oddball task: an ERP study. Biol. Psychol. 59, 171–186.
Carretié, L., Hinojosa, J.A., Albert, J., López-Martín, S., De La Gándara, B.S., Igoa, J.M., Sotillo, M., 2008. Modulation of ongoing cognitive processes by emotionally intense words. Psychophysiology 45, 188–196.
Carretié, L., Mercado, F., Tapia, M., Hinojosa, J.A., 2001. Emotion, attention, and the "negativity bias", studied through event-related potentials. Int. J. Psychophysiol. 41, 75–85. https://doi.org/10.1016/S0167-8760(00)00195-1.
Chen, B., 1993. An experimental study of collins' semantic hierarchical network model. Acta Psychol. Sin. 25, 25–31.
Chen, P., Lin, J., Chen, B., Lu, C., Guo, T., 2015. Processing emotional words in two languages with one brain: ERP and fMRI evidence from Chinese-English bilinguals. Cortex 71, 34–48. https://doi.org/10.1016/j.cortex.2015.06.002.
Chiu, C.Y., Gries, P., Torelli, C.J., Cheng, S.Y.Y., 2011. Toward a social psychology of globalization. J. Soc. Issues 67, 663–676.
Citron, F.M.M., Weekes, B.S., Ferstl, E.C., 2013. Author's personal copy neuroscience letters effects of valence and arousal on written word recognition : time course and ERP correlates. Neurosci. Lett. 533, 90–95.
Collins, A.M., Quillian, M.R., 1969. Retrieval time from memory. J. Verbal Learning Verbal Behav. 8, 240–247.
Cuthbert, B.N., Schupp, H.T., Bradley, M.M., Birbaumer, N., Lang, P.J., 2000. Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. Biol. Psychol. 52, 95–111. https://doi.org/10.1016/S0301-0511(99)00044-7.
De Leersnyder, J., Kim, H., Mesquita, B., 2015. Feeling right is feeling good: psychological well-being and emotional fit with culture in autonomy- versus relatedness-promoting situations. Front. Psychol. 06, 630. https://doi.org/10.3389/fpsyg.2015.00630.
De Maria, G., Falco, P., Natale, C., Pirozzi, S., 2015. Integrated force/tactile sensing: the enabling technology for slipping detection and avoidance. Proc. IEEE Int. Conf. Robot. Autom. 3883–3889. https://doi.org/10.1109/ICRA.2015.7139740. 2015–June.
Delaney-Busch, N., Wilkie, G., Kuperberg, G., 2016. Vivid: how valence and arousal influence word processing under different task demands. Cogn. Affect. Behav. Neurosci. 16, 415–432.
Delplanque, S., N'diaye, K., Scherer, K., Grandjean, D., 2007. Spatial frequencies or emotional effects?: a systematic measure of spatial frequencies for iaps pictures by a discrete wavelet analysis. J. Neurosci. Methods 165, 144–150.
Delplanque, S., Silvert, L., Hot, P., Rigoulot, S., Sequeira, H., 2006. Arousal and valence effects on event-related P3a and P3b during emotional categorization. Int. J. Psychophysiol. 60, 315–322.
Delplanque, S., Silvert, L., Hot, P., Sequeira, H., 2005. Event-related p3a and p3b in response to unpredictable emotional stimuli. Biol. Psychol. 68, 107–120.
Donchin, E., 1981. Surprise!… surprise? Psychophysiology 18, 493–513.
Donchin, E., Coles, M.G., 1988. Is the P300 component a manifestation of context updating? Behav. Brain Sci. 11, 357–374.
Erthal, F.S., Oliveira, L.D., Mocaiber, I., Pereira, M.G., Machado-Pinheiro, W., Volchan, E., et al., 2005. Load-dependent modulation of affective picture processing. Cogn. Affect. Behav. Neurosci. 5, 388–395.
Feng, C., Li, W., Tian, T., Luo, Y., Gu, R., Zhou, C., et al., 2014. Arousal modulates valence effects on both early and late stages of affective picture processing in a passive viewing task. Soc. Neurosci. 9, 364–377.
Feldmann-Wüstefeld, T., Schmidt-Daffy, M., Schubö, A., 2011. Neural evidence for the threat detection advantage: differential attention allocation to angry and happy faces. Psychophysiology 48, 697–707. https://doi.org/10.1111/j.1469-8986.2010.01130.x.
Flaisch, T., Stockburger, J., Schupp, H.T., 2008. Affective prime and target picture processing: an ERP analysis of early and late interference effects. Brain Topogr. 20, 183–191. https://doi.org/10.1007/s10548-008-0045-6.
Fox, E., Russo, R., Bowles, R., Dutton, K., 2001. Do threatening stimuli draw or hold visual attention in subclinical anxiety? J. Exp. Psychol. Gen. 130, 681–700. https://doi.org/10.1037/0096-3445.130.4.681.
Glaser, W.R., Glaser, M.O., 1989. Context effects in stroop-like word and picture processing. J. Exp. Psychol. Gen. 118, 13–42. https://doi.org/10.1037/0096-3445.118.1.13.
González-Villar, A.J., Triñanes, Y., Zurrón, M., Carrillo-De-La-Peña, M.T., 2014. Brain processing of task-relevant and task-irrelevant emotional words: an ERP study. Cogn. Affect. Behav. Neurosci. 14, 939–950. https://doi.org/10.3758/s13415-013-0247-6.
Gross, J.J., Jazaieri, H., 2014. Emotion, emotion regulation, and psychopathology: an affective science perspective. Clin. Psychol. Sci. 2, 387–401. https://doi.org/10.1177/2167702614536164.
Grzybowski, S.J., Wyczesany, M., Kaiser, J., 2014. The influence of context on the processing of emotional and neutral adjectives - an ERP study. Biol. Psychol. 99, 137–149. https://doi.org/10.1016/j.biopsycho.2014.01.002.
Hajcak, G., Dennis, T.A., 2010. NIH public access. City 80, 333–338. https://doi.org/10.1016/j.biopsycho.2008.11.006.Brain.
Hajcak, G., Dunning, J.P., Foti, D., 2007. Neural response to emotional pictures is unaffected by concurrent task difficulty: an event-related potential study. Behav. Neurosci. 121, 1156–1162.
Heine, S.J., Kitayama, S., Lehman, D.R., Takata, T., Ide, E., Leung, C., et al., 2001. Divergent consequences of success and failure in Japan and North America: an investigation of self-improving motivations and malleable selves. J. Pers. Soc. Psychol. 81, 599–615.
Herbert, C., Kissler, J., Junghofer, M., Peyk, P., Rockstroh, B., 2006. Processing of emotional adjectives: Evidence from startle EMG and ERPs. Psychophysiology 43, 197–206.
Herbert, C., Junghofer, M., Kissler, J., 2008. Event related potentials to emotional adjectives during reading. Psychophysiology 45, 487–498.
Hajcak, G., Moser, J.S., Simons, R.F., 2006. Attending to affect: appraisal strategies modulate the electrocortical response to arousing pictures. Emotion 6, 517–522.
Higgins, J.P., Thompson, S.G., Deeks, J.J., Altman, D.G., 2003. Measuring inconsistency in meta-analyses. BMJ 327, 557–560.
Hinojosa, J.A., Carretié, L., Valcárcel, M.A., Méndez-Bértolo, C., Pozo, M.A., 2009. Electrophysiological differences in the processing of affective information in words and pictures. Cogn. Affect. Behav. Neurosci. 9, 173–189. https://doi.org/10.3758/CABN.9.2.173.
Hinojosa, J.A., Mendez-Bertolo, C., Pozo, M.A., 2010. Looking at emotional words is not the same as reading emotional words: Behavioral and neural correlates. Psychophysiology 47, 748–757.
Huang, Y.X., Luo, Y.J., 2006. Temporal course of emotional negativity bias: an erp study. Neuroscience Letters 398, 91–96.
Huang, Y.X., Luo, Y.J., 2007. Attention shortage resistance of negative stimuli in an implicit emotional task. Neurosci. Lett. 412, 134–138. https://doi.org/10.1016/j.neulet.2006.10.061.
Ishai, A., 2010. Seeing faces and objects with the "mind's eye.". Arch. Ital. Biol. 148, 1–9. https://doi.org/10.3410/b2-34.
Ito, T.A., Cacioppo, J.T., 2005. Variations on a human universal: individual differences in positivity offset and negativity bias. Cogn. Emot. 19, 1–26. https://doi.org/10.1080/02699930441000120.
Ito, T.A., Cacioppo, J.T., 2000. Electrophysiological evidence of implicit and explicit categorization processes. J. Exp. Soc. Psychol. 36, 660–676. https://doi.org/10.1006/jesp.2000.1430.
Ito, T.A., Cacioppo, J.T., Lang, P.J., 1998a. Eliciting affect using the international affective picture system: trajectories through evaluative space. Pers. Soc. Psychol. Bull. 24, 855–879. https://doi.org/10.1177/0146167298248006.
Ito, T.A., Larsen, J.T., Smith, N.K., Cacioppo, J.T., 1998b. Negative information weighs more heavily on the brain: the negativity bias in evaluative categorizations. J. Pers. Soc. Psychol. 75, 887–900. https://doi.org/10.1037/0022-3514.75.4.887.
Iwaihara, Y., Ishikura, S., Doi, K., Tsunoda, T., Fujimoto, T., Okamura, T., Shirasawa, S., 2015. Marked reduction in FoxO1 protein by its enhanced proteasomal degradation in zfat-deficient peripheral T-Cells. Anticancer Res. 35, 4419–4424. https://doi.org/10.1371/journal.pmed.1000097.
Janssen, D.J.A., Engelberg, R.A., Wouters, E.F.M., Curtis, J.R., 2012. Advance care planning for patients with COPD: past, present and future. Patient Educ. Couns. 86, 19–24. https://doi.org/10.1016/j.pec.2011.01.007.
Johnson, R., 2010. On the neural generators of the p300 component of the event-related potential. Psychophysiology 30, 90–97.
Kaestner, E.J., Polich, J., 2011. Affective recognition memory processing and event-related brain potentials. Cogn. Affect. Behav. Neurosci. 11, 186–198. https://doi.org/10.3758/s13415-011-0023-4.
Kanske, P., Kotz, S.A., 2007. Concreteness in emotional words: ERP evidence from a hemifield study. Brain Res. 1148, 138–148. https://doi.org/10.1016/j.brainres.2007.02.044.
Keil, A., 2006. Chapter 11 macroscopic brain dynamics during verbal and pictorial processing of affective stimuli. Prog. Brain Res. 156, 217–232. https://doi.org/10.1016/S0079-6123(06)56011-X.
Keil, A., Bradley, M.M., Junghöfer, M., Russmann, T., Lowenthal, W., Lang, P.J., 2007. Cross-modal attention capture by affective stimuli: evidence from event-related potentials. Cogn. Affect. Behav. Neurosci. 7, 18–24. https://doi.org/10.3758/CABN.7.1.18.
Kissler, J., Herbert, C., Winkler, I., Junghofer, M., 2009. Emotion and attention in visual word processing-an ERP study. Biol. Psychol. 80, 75–83. https://doi.org/10.1016/j.biopsycho.2008.03.004.
Kosslyn, S.M., Shephard, J.M., Thompson, W.L., 2007. Spatial processing during mental imagery: a neurofunctional theory. Spatial Processing in Navigation, Imagery and Perception. Springer, pp. 1–15. https://doi.org/10.1007/978-0-387-71978-8_1.
Lang, P.J., 1980. Behavioral Treatment and Bio-behavioral Assessment: Computer Applications. Technology in Mental Health Care Delivery Systems. pp. 119–137.
Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1998. Emotion, motivation, and anxiety: brain mechanisms and psychophysiology. Biol. Psychiatry 44, 1248–1263. https://doi.org/10.1016/S0006-3223(98)00275-3.
Levelt, W.J.M., Roelofs, A., Meyer, A.S., 1999. A theory of lexical access in speech production. Behav. Brain Sci. 22, 1–75. https://doi.org/10.1017/S0140525X99001776.
Li, W., Jiang, Z., Liu, Y., Wu, Q., Zhou, Z., Jorgensen, N., et al., 2014. Positive and negative emotions modulate attention allocation in color-flanker task processing: evidence from event related potentials. Motiv. Emot. 38, 451–461.
Little, M.P., Azizova, T.V., Bazyka, D., Bouffler, S.D., Cardis, E.S.C., Chekin, S., Chumak, V.V., Cucinotta, F.A., de Vathaire, F., Hall, P., Harrison, J.D., Hildebrandt, G., Ivanov, V., Kashcheev, V.V., Klymenko, S.V., Kreuzer, M., Laurent, O., Ozasa, K., Schneider, T., Tapio, S., Taylor, A.M., Tzoulaki, I., Vandoolaeghe, W.L., Wakeford, R., Zablotska, L.B., Zhang, W., Lipshultz, S.E., 2012. Systematic review and meta-analysis of

circulatory disease from exposure to low-level ionizing radiation and estimates of potential population mortality risks. Environ. Health Perspect. 120, 1503–1511. https://doi.org/10.1289/ehp.1204982.

Liu, B., Jin, Z., Wang, Z., Hu, Y., 2010. The interaction between pictures and words: evidence from positivity offset and negativity bias. Exp. Brain Res. 201, 141–153. https://doi.org/10.1007/s00221-009-2018-8.

Long, Q., Yang, J., Lou, Y., Cai, A., Yuan, J., 2015. Humans' emotional habituation to pleasant stimuli: behavioral and electrophysiological evidence. Chin. Sci. Bull. 60, 3594–3605. https://doi.org/10.1360/N972015-00285.

Lu, Y., Zhang, W.N., Hu, W., Luo, Y.J., 2011. Understanding the subliminal affective priming effect of facial stimuli: an ERP study. Neurosci. Lett. 502, 182–185. https://doi.org/10.1016/j.neulet.2011.07.040.

Luck, S.J., 1998. Sources of dual-task interference: evidence from human electrophysiology. Psychol. Sci. 3, 223–227.

Matell, M.S., Jacoby, J., 1972. Is there an optimal number of alternatives for likert-scale items? Effects of testing time and scale properties. J. Appl. Psychol. 56, 506–509.

Manzoni, D., Pompeiano, O., Srivastava, U.C., Stampacchia, G., 1983. Responses of forelimb extensors to sinusoidal stimulation of macular labyrynth and neck receptors. Arch. Ital. Biol. 121, 205–214. https://doi.org/10.3389/fnhum.2012.00305.

Marslen-Wilson, W.D., Welsh, A., 1978. Processing interactions and lexical access during word recognition in continuous speech. Cogn. Psychol. 10, 29–63. https://doi.org/10.1016/0010-0285(78)90018-X.

Matsumoto, D., Yoo, S.H., Nakagawa, S., 2008. Culture, emotion regulation, and adjustment. J. Pers. Soc. Psychol. 94, 925–937.

Mauss, I.B., Bunge, S.A., Gross, J.J., 2008. Culture and automatic emotion regulation. Regulating Emotions: Culture, Social Necessity and Biological Inheritance. Blackwell Publishing, London.

Mogg, K., Bradley, B.P., 1998. A cognitive-motivational analysis of anxiety. Behav. Res. Ther. 36, 809–848. https://doi.org/10.1016/S0005-7967(98)00063-1.

Nisbett, R.E., 1990. Evolutionary psychology, biology, and cultural evolution. Motiv. Emot. 14, 255–263.

Olofsson, J.K., Polich, J., 2007. Affective visual event-related potentials: arousal, repetition, and time-on-task. Biol Psychol 75, 101–108.

Palazova, M., Mantwill, K., Sommer, W., Schacht, A., 2011. Are effects of emotion in single words non-lexical? Evidence from event-related brain potentials. Neuropsychologia 49, 2766–2775. https://doi.org/10.1016/j.neuropsychologia.2011.06.005.

Peeters, G., Czapinski, J., 1990. Positive-negative asymmetry in evaluations: the distinction between affective and informational negativity effects. Eur. Rev. Soc. Psychol. 1, 33–60. https://doi.org/10.1080/14792779108401856.

Phavichitr, N., Theamboonlers, A., Poovorawan, Y., 2008. Insulin-like growth factor-1 (IGF-1) in children with postoperative biliary atresia: a cross-sectional study. Asian Pacific J. Allergy Immunol. 26, 57–61. https://doi.org/10.1111/j.1469-8986.2007.00638.x.

Polich, John, 2004. Clinical application of the p300 event-related brain potential. Phys. Med. Rehabil. Clin. N. Am. 15, 133–161.

Pourtois, G., Schwartz, S., Seghier, M.L., Lazeyras, F., Vuilleumier, P., 2006. Neural systems for orienting attention to the location of threat signals: an event-related fMRI study. Neuroimage 31, 920–933. https://doi.org/10.1016/j.neuroimage.2005.12.034.

Raz, S., Dan, O., Zysberg, L., 2014. Neural correlates of emotional intelligence in a visual emotional oddball task: an ERP study. Brain Cogn. 91, 79–86. https://doi.org/10.1016/j.bandc.2014.09.003.

Rohr, L., Rahman, R.A., 2015. Affective responses to emotional words are boosted in communicative situations. Neuroimage 109, 273–282. https://doi.org/10.1016/j.neuroimage.2015.01.031.

Rostami, H.N., Ouyang, G., Bayer, M., Schacht, A., Zhou, C., Sommer, W., Rostami, H.N., Ouyang, G., Bayer, M., Schacht, A., Zhou, C., Sommer, W., 2016. Dissociating the influence of affective word content and cognitive processing demands on the late positive potential. Brain Topogr. 29, 82–93. https://doi.org/10.1007/s10548-015-0438-2.

Rozenkrants, B., Polich, J., 2008. Affective ERP processing in a visual oddball task: arousal, valence, and gender. Clin. Neurophysiol. 119 (10), 2260–2265.

Rozenkrants, B., Olofsson, J.K., Polich, J., 2008. Affective visual event-related potentials: arousal, valence, and repetition effects for normal and distorted pictures. Int. J. Psychophysiol. 67, 114–123. https://doi.org/10.1016/j.ijpsycho.2007.10.010.

Russell, J.A., 1980. A circumplex model of affect. J. Pers. Soc. Psychol. 39, 1161.

Salemink, E., van den Hout, M.A., Kindt, M., 2007. Selective attention and threat: quick orienting versus slow disengagement and two versions of the dot probe task. Behav. Res. Ther. 45, 607–615. https://doi.org/10.1016/j.brat.2006.04.004.

Schacht, A., Sommer, W., 2009. Time course and task dependence of emotion effects in word processing. Cogn. Affect. Behav. Neurosci. 9, 28–43. https://doi.org/10.3758/CABN.9.1.28.

Schindler, S., Kissler, J., 2016. Selective visual attention to emotional words: early parallel frontal and visual activations followed by interactive effects in visual cortex. Hum. Brain Mapp. 37, 3575–3587.

Schupp, H.T., Cuthbert, B.N., Bradley, M.M., Hillman, C.H., Hamm, A.O., Lang, P.J., 2004. Brain processes in emotional perception: motivated attention. Cogn. Emot. 18, 593–611. https://doi.org/10.1080/02699930341000239.

Schupp, H.T., Stockburger, J., Codispoti, M., Junghofer, M., Weike, A.I., Hamm, A.O., 2007. Selective visual attention to emotion. J. Neurosci. 27, 1082–1089. https://doi.org/10.1523/JNEUROSCI.3223-06.2007.

Smith, D.P., Hillman, C.H., Duley, A.R., 2005. Influences of age on emotional reactivity during picture processing. J. Gerontol. Ser. B Psychol. Sci. Soc. Sci. 60, P49–56. https://doi.org/10.1093/geronb/60.1.P49.

Solomon, B., Decicco, J.M., Dennis, T.A., 2012. Emotional picture processing in children: an erp study. Dev. Cogn. Neurosci. 2, 110–119.

Tapia, M., Carretié, L., Sierra, B., Mercado, F., 2008. Incidental encoding of emotional pictures: affective bias studied through event related brain potentials. Int. J. Psychophysiol. 68, 193–200. https://doi.org/10.1016/j.ijpsycho.2008.01.009.

Taylor, S.E., 1991. Asymmetrical effects of positive and negative events: the mobilization-minimization hypothesis. Psychol. Bull. 110, 67–85. https://doi.org/10.1037/0033-2909.110.1.67.

Tooby, J., Cosmides, L., 2005. The theory of evolution by natural selection has revolutionary implications for was. Handb. Evol. Psychol. pp. 5.

Tsai, J.L., Knutson, B., Fung, H.H., 2006. Cultural variation in affect valuation. J. Pers. Soc. Psychol. 90, 288–307. https://doi.org/10.1037/0022-3514.90.2.288.

Uncapher, M.R., Hutchinson, J.B., Wagner, A.D., 2011. Dissociable effects of top-down and bottom-up attention during episodic encoding. J. Neurosci. 35, 12613–12628.

Van Damme, S., Crombez, G., Notebaert, L., 2008. Attentional Bias to threat: a perceptual accuracy approach. Emotion 8, 820–827. https://doi.org/10.1037/a0014149.

van Dinteren, R., Arns, M., Jongsma, M.L., Kessels, R.P., 2014a. Combined frontal and parietal P300 amplitudes indicate compensated cognitive processing across the lifespan. Front. Aging Neurosci. 6, 294.

van Dinteren, R., Arns, M., Jongsma, M.L., Kessels, R.P., 2014b. P300 development across the lifespan: a systematic review and meta-analysis. PLoS One 9, e87347. https://doi.org/10.1371/journal.pone.0087347.

van Dongen, N.N.N., Van Strien, J.W., Dijkstra, K., 2016. Implicit emotion regulation in the context of viewing artworks: ERP evidence in response to pleasant and unpleasant pictures. Brain Cogn. 107, 48–54. https://doi.org/10.1016/j.bandc.2016.06.003.

van Schie, H.T., Wijers, A.A., Mars, R.B., Benjamins, J.S., Stowe, L.A., 2005. Processing of visual semantic information to concrete words: temporal dynamics and neural mechanisms indicated by event-related brain potentials. Cogn. Neuropsychol. 22, 364–386. https://doi.org/10.1080/02643290442000338.

van Strien, J.W., Langeslag, S.J.E., Strekalova, N.J., Gootjes, L., Franken, I.H.A., 2009. Valence interacts with the early ERP old/new effect and arousal with the sustained ERP old/new effect for affective pictures. Brain Res. 1251, 223–235. https://doi.org/10.1016/j.brainres.2008.11.027.

Verleger, R., 1988. Event-related potentials and cognition: a critique of the context updating hypothesis and an alternative interpretation of P3. Behav. Brain Sci. 11, 343–356.

Vogel, E.K., Luck, S.J., 2002. Delayed working memory consolidation during the attentional blink. Psychon. Bull. Rev. 9, 739–743.

Vogel, E.K., Luck, S.J., Shapiro, K.L., 1998. Electrophysiological evidence for a post-perceptual locus of suppression during the attentional. J. Exp. Psychol. Hum. Percept. Perform. 24, 1656–1674.

Wang, Y., Yang, J., Yuan, J., Fu, A., Meng, X., Li, H., 2011. The impact of emotion valence on brain processing of behavioral inhibitory control: spatiotemporal dynamics. Neurosci. Lett. 502, 112–116. https://doi.org/10.1016/j.neulet.2011.07.039.

Wangelin, B.C., Bradley, M.M., Kastner, A., Lang, P.J., 2012. Affective engagement for facial expressions and emotional scenes: the influence of social anxiety. Biol. Psychol. 91, 103–110. https://doi.org/10.1016/j.biopsycho.2012.05.002.

Weinberg, A., Hajcak, G., 2010. Beyond good and evil: the time-course of neural activity elicited by specific picture content. Emotion 10, 767–782.

West, W.C., Holcomb, P.J., 1991. Processing of concrete and abstract words : an electrophysiological investigation. J. Cogn. Neurosci. 12, 1024–1037.

Wilhelm, G.R., 1992. Picture naming. Cognition 42, 61–105.

Xu, T., Chenkov, N., Kühnlenz, K., Buss, M., 2009. Autonomous switching of top-down and bottom-up attention selection for vision guided mobile robots. October In: 2009 IEEE/RSJ International Conference on Intelligent Robots and Systems. IEEE. pp. 4009–4014.

Yang, J., Zeng, J., Meng, X., Zhu, L., Yuan, J., Li, H., Yusoff, N., 2013. Positive words or negative words: whose valence strength are we more sensitive to? Brain Res. 1533, 91–104. https://doi.org/10.1016/j.brainres.2013.08.020.

Yao, Z., Yu, D., Wang, L., Zhu, X., Guo, J., Wang, Z., 2016. Effects of valence and arousal on emotional word processing are modulated by concreteness: behavioral and ERP evidence from a lexical decision task. Int. J. Psychophysiol. 110, 231–242.

Yuan, J., Meng, X., Yang, J., Yao, G., Hu, L., Yuan, H., 2012. The valence strength of unpleasant emotion modulates brain processing of behavioral inhibitory control: neural correlates. Biol. Psychol. 89, 240–251.

Zhang, D., He, W., Wang, T., Luo, W., Zhu, X., Gu, R., Li, H., Luo, Y.J., 2014a. Three stages of emotional word processing: an ERP study with rapid serial visual presentation. Soc. Cogn. Affect. Neurosci. 9, 1897–1903. https://doi.org/10.1093/scan/nst188.

Zhang, D., Liu, Y., Wang, X., Chen, Y., Luo, Y., 2014b. The duration of disgusted and fearful faces is judged longer and shorter than that of neutral faces: the attention-related time distortions as revealed by behavioral and electrophysiological measurements. Front. Behav. Neurosci. 8, 1–9. https://doi.org/10.3389/fnbeh.2014.00293.

Zhao, W., Chen, L., Zhou, C., Luo, W., 2018. Neural correlates of emotion processing in word detection task. Front. Psychol. 9, 832.

Zurrón, M., Ramos-Goicoa, M., Díaz, F., 2013. Semantic conflict processing in the color-word Stroop and the emotional Stroop: event-Related Potential (ERP) correlates. J. Psychophysiol. 27, 149–164. https://doi.org/10.1027/0269-8803/a000100.